Put Another Nickel In:
Market Opportunities for ENERGY STAR Vending Machines
Overcoming the Barriers of Leased Equipment

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ABSTRACT

Vending machines are an untapped resource for energy savings. The national stock of 3.2-4 million vending machines consumes about 12 billion kWh annually, more than the State of Delaware. Despite this opportunity, the efficiency community has had only a limited suite of options to capture these savings.

In this paper, the authors will examine:

Lessons learned from past and current vending machine programs: Programs to date have focused on aftermarket control devices, generally installed by the host site. In some cases, these programs have met with limited success, resulting in low persistence and/or reliability of energy savings.

Potential energy and demand savings of ENERGY STAR qualified vending machines: ENERGY STAR vending machines use efficient components (e.g. T-8 lighting and ECM motors) to cut energy use by 40-50% compared to standard models.

Barriers to market penetration of ENERGY STAR: Despite high savings, the market penetration of ENERGY STAR vending machines remains low. The major market barriers are a low sales/stock ratio and a split incentive between machine owners (equipment costs) and host sites (energy costs).

New Opportunities to Save Energy: As of August 2006, machine owners may refurbish existing vending machines to meet ENERGY STAR requirements. These retrofits reduce the incremental cost barrier while addressing the persistence issues of previous aftermarket control-based programs.

Based on the authors' extensive experience in working with the national ENERGY STAR program, regional efficiency organizations, and the vending market, this evaluation will provide program managers with the necessary tools to implement, manage, and evaluate a cost-effective energy efficiency/DSM program promoting ENERGY STAR vending machines.

Background

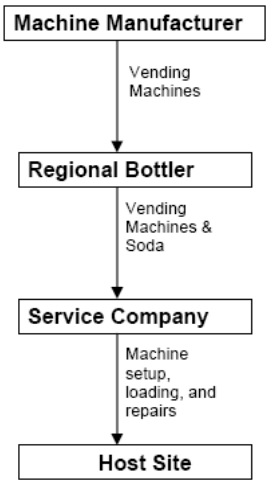
There are over 3 million cold drink vending machines operating in the United States today. A typical vending machine annually consumes $300 worth of energy and is responsible for over 2 tons of

annual carbon dioxide emissions. Fortunately, there are many opportunities to reduce this energy consumption.

Machine owners can purchase energy-efficient new machines that qualify for the ENERGY STAR label, displayed on energy-efficient appliances across the country. Host sites can purchase aftermarket devices or activate onboard software to reduce the energy use of their machines. There are even ways to modify the machines themselves to use less energy. The biggest market barriers are a split incentive between machine owners and host sites, placing the incremental cost of energy-efficient machines on machine owners while host sites reap energy savings, and the slow turnover rate of the national vending machine stock. These barriers can be overcome, but doing so will require the help of the energy-efficiency community to increase demand for energy-efficient vending machines and pave the way for machine owners to purchase new equipment.

Market Overview

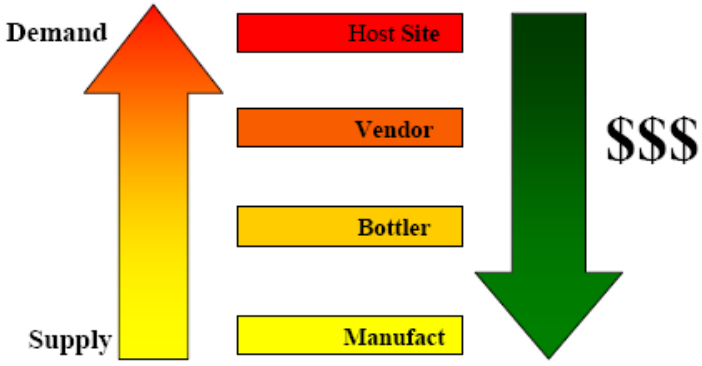
Figure 1: Basic Market Structure



The machine owners (generally bottlers) and the host sites are the two major decision-making groups in the vending marketplace who have the power to demand more energy-efficient vending machines. They are supported by a number of related actors who are intermediaries or pure suppliers. The most important of these are the service companies, followed by manufacturers and soda consumers. These actors, with the flow of vending machines, services, and soda, are shown in Figure 1.

The demand for energy-efficient machines (the market "pull") begins with the **host site**, as shown in Figure 2. The host site is the organization or business where vending machines can be found. As the party responsible for paying energy bills, the host site has the most to gain from more efficient equipment. Based on their negotiating power and visibility, host sites can work with their vendor-operator or bottler (entity providing vending services to the host site) to get newer equipment or energy-saving concessions. The host site's negotiation power is a function of its sales volume, visibility, and beverage contract. Highly visible locations, such as colleges and retail chains, will also tend to be allocated new equipment, while gas stations, factories, and other lower visibility sites will receive old equipment as it is removed from higher profile sites.

Figure 2: Supply Chain and Cash Flow



The **machine owner** is typically (80-90%) the regional bottler (e.g., Coca Cola Bottling Company) or, less frequently (10-20%), a service company. A bottler will typically have 500-10,000 vending machines in their inventory (a few bottler consortiums will control even greater numbers of machines), centered around metropolitan centers.[1] While the host site reaps the rewards of energy efficiency, the machine owner bears the costs of replacing or upgrading its machines. This split incentive is a significant market barrier that must be overcome. Host sites that are committed to energy efficiency and that have sufficient bargaining power can influence machine owners to provide more-efficient equipment (such as ENERGY STAR qualified vending machines), but

machine owners will rarely place more-efficient equipment proactively unless they are forced to do so through regulation or can, in some way, share the energy savings with the host site to recoup the additional cost of the new machines.

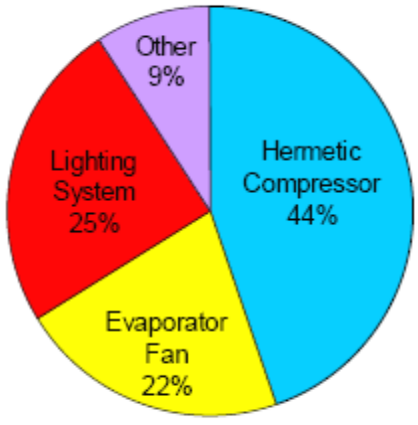
The **service company** or **vendor operator** is responsible for stocking the machine, collecting money from the machine, and performing routine maintenance. The service company typically owns snack and other vending machines, but is less likely to own cold drink machines. Many large bottlers service their own vending machines. In these cases, the service company and the machine owner are the same. Like bottlers, service companies can use more-efficient equipment as a selling point when they bid on new contracts. Unfortunately, an average site will tend to be skeptical of energy savings estimates and less inclined to accept a reduction in other services to compensate.

Other market actors include the **vending machine manufacturers**, **soda buyers**, and **utilities**. Manufacturers have a relatively minor role in transforming the market. Anyone wishing to purchase a new vending machine today is likely to choose an ENERGY STAR model since roughly 80-90% percent of all new vending machines sold today meet the ENERGY STAR Tier 1 requirements and carry a minimal cost premium. The market barrier is that owners are keeping machines for as long as possible, not wishing to give up a working machine in favor of a newer model. Only about 100,000 of the 3.2 million vending machines installed nationwide are new each year, with a typical bottler turning over 5-10% of his stock annually.[2] The soda buyer, too, has a minimal role in market transformation since he typically does not know or care about the energy consumed by vending machines unless he knows it will affect the price of vended snacks and drinks. Utilities and energy-efficiency program sponsors have small roles now, but they have the potential to play greater roles if existing efficiency programs are expanded to include ENERGY STAR qualified vending machines.

The Vending Machine Fleet

There is wide variation in the amount of energy used by vending machines. Variables such as can or bottle capacity, age, component efficiency, and lighting all contribute to this variation. Figure 3 shows a typical (non-ENERGY STAR qualified) vending machine's proportional energy use, by component. Energy use tends to be dominated by components of the cooling system; lighting is another major energy consumer. The remaining components, such as the vend motor, bill exchanger, and control board contribute considerably less to the overall energy consumption.

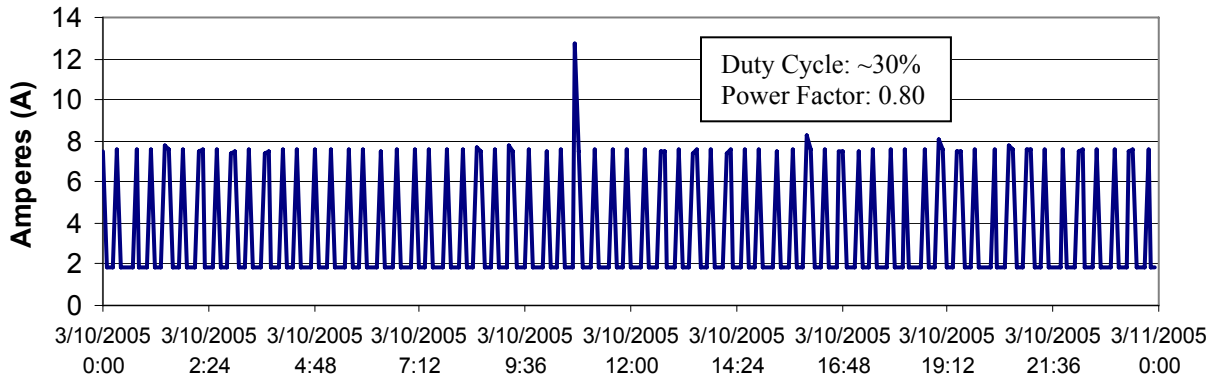
Figure 3: Vending Machine Energy Use by Component



Source: CCAP

Similar to other refrigeration equipment, vending machines operate on a definite duty cycle, alternating between high and low power states. A typical vending machine might vary from 200-600 Watts (instantaneous) when the compressor and condenser fan(s) are operating. [3] The demand profile, over 24 hours, for a typical vending machine is shown in Figure 4.

Figure 4: 24 Hour Demand Profile of Typical Vending Machine



One of the largest market barriers to new machine purchases is the age of the existing vending machine population. As shown in Figure 5, the bulk of the vending machines currently in use were purchased by bottlers between 1996 and 1999. During this time of intense competition between the two major soda manufacturers, bounty programs led to the purchase of large stocks of vending equipment. With the end of those programs, sales of new vending machines began a sharp decline that is only beginning to stabilize over the last 2-3 years, at levels well below those of the late 1990's. [4]

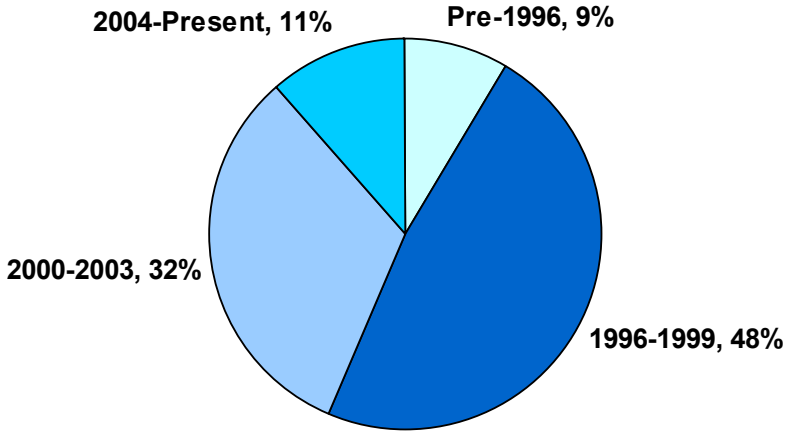


Figure 5: Profile of Vending Machine Market by Equipment Age

Vending machines from the late 1990's were generally characterized by poor efficiency. These machines could typically use 10-15 kWh per day (compared to 6-8 kWh/day for most modern models) and would have inefficient single stage compressors, T12 lighting, no thermostatic controls, no programmable power modes, and shaded pole fan motors. Coupled with poor insulation, many of these machine models present a daunting challenge to the refurbishment community.

ENERGY STAR Vending Machines

Vending machines that meet the ENERGY STAR program requirements are, on average, 40-50 percent more efficient than equivalent standard models. The ENERGY STAR units use T8 lighting, improved evaporator fans, and other measures to reduce energy consumption. The newest vending

machines, ENERGY STAR Tier 2 qualified models, also use variable speed compressors to further reduce energy. The added cost of these measures is surprisingly low, about $100 for a Tier 2 machine and considerably less for a Tier I qualified machine. [5] All ENERGY STAR qualified vending machines are equipped with onboard software controls that can turn lighting off or send the vending machine into a low-power "storage" mode based on time of day. When these features are activated, an ENERGY STAR vending machine can use over 60 percent less energy than a standard machine.

The ENERGY STAR specification requires qualified vending machines to meet daily energy use criteria (kWh/day) based on vendible capacity (C), as given in Equations 1 and 2 for Tier I and Tier II, respectively.

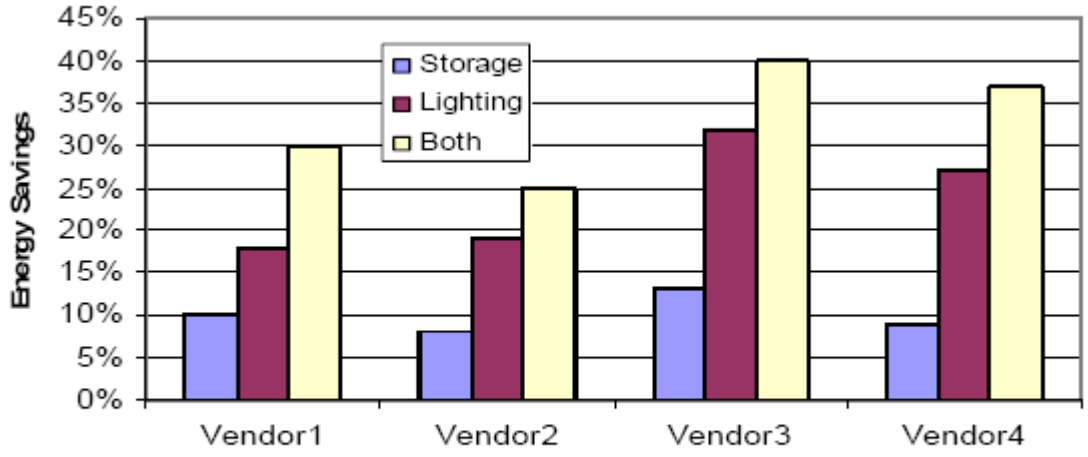
Y (kWh/day)=0.55(8.66 + (0.009C)) *Equation 1. (Effective April 2004)*
Y (kWh/day)=0.45(8.66 + (0.009C)) *Equation 2. (Effective July 2007)*

For example, a 600-can capacity vending machine must use less than 7.7 kWh/day to qualify as ENERGY STAR Tier 1 and less than 6.3 kWh/day to qualify for ENERGY STAR Tier 2.

Onboard Software

Many newer vending machines and all ENERGY STAR qualified models include onboard software that controls lighting and internal temperature. Vending operators can turn off lighting and place the machine in storage mode based on time of day. In storage mode, the machine's internal temperature is allowed to rise to a preset limit before the cooling system is activated. These settings are ideal for sites that have defined hours of operation, such as offices, schools, or some retail locations. The energy savings will be lower at locations with more fluid operating hours, and an occupancy-based control device may be more effective at reducing energy use. For most colleges, K-12 schools, offices, and factories where lighting can be turned off on weekends and on week nights, typical savings will be 400-700 kWh/year (up to 24 percent savings compared to a typical non ENERGY STAR vending machine). Older machines, with less efficient lighting (typically T-12 fluorescent) will generate even greater savings. A study by a major non-carbonated beverage company on machines manufactured in 1999 and 2000 found savings of 30 percent to 40 percent, as shown in Figure 6.

The programming is simple to perform, requiring less than 10 minutes per machine for a knowledgeable operator to make the required changes. Many operators use wireless handheld devices and can change software settings on entire banks of machines very quickly, making the cost and burden of implementing energy-saving software measures relatively minor.



Testing done by a non-carbonated beverage company on four new vending machines in 1999-2000

Figure 6: Measured Energy Savings Due to Onboard Software Features

Refurbishment of Existing Vending Machine Models

In August 2006, ENERGY STAR went in a new direction for vending machines. The sales penetration of Tier 1 qualified vending machines remains quite high (80-90%). However, the low overall sales mean that the penetration of ENERGY STAR vending machines remains low (<10%). In order to address the standing stock of vending machines, ENERGY STAR released a revised specification that allows machine owners to refurbish older machines to meet ENERGY STAR criteria and apply the ENERGY STAR label to those machines.

In order to refurbish a non ENERGY STAR machine into a qualified model, several things must happen:

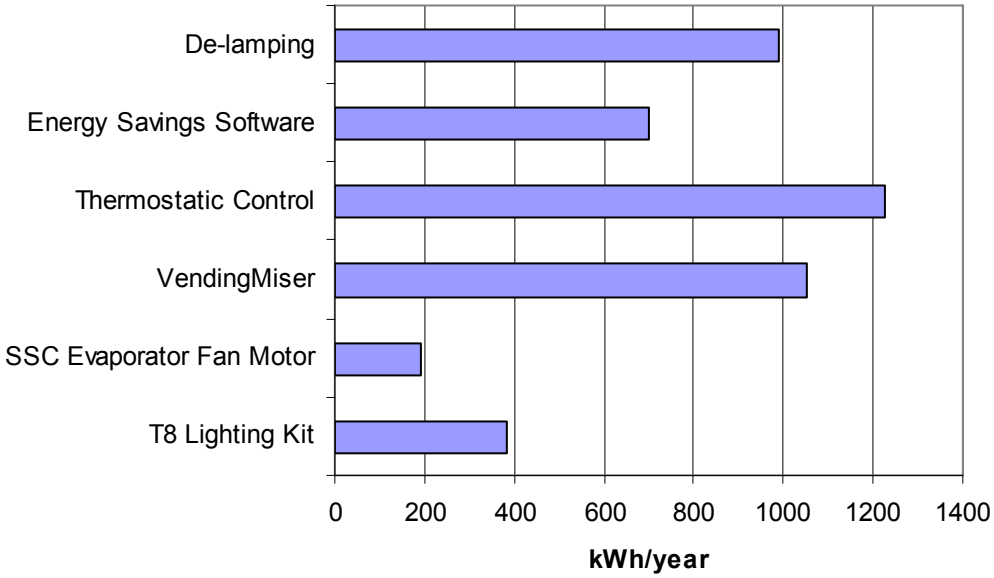
- A refurbishment kit must be developed for the existing machine model to be refurbished and qualified with EPA as a new model, distinguishable from the base machine
- The facility completing the refurbishment must become an ENERGY STAR partner
- The machine must be refurbished with the previously developed kit and have the ENERGY STAR label, and corresponding updated model information, applied.

The refurbishment kits are determined individually for each vending machine model, based on test data submitted to EPA. To develop these kits, a facility would measure the energy consumption of a typical sample of a particular machine model. The facility would then add equipment upgrades (e.g. T8 lighting, SSC or ECM fan motors, thermostat controls) until the machine was able to meet ENERGY STAR criteria. When those criteria are met, the old machine, combined with the components needed to refurbish it, are given a new model number and listed on the ENERGY STAR Qualified Product List. The components typically included in refurbishment kits are shown in Figure **7**, with approximate costs and annual energy savings for each component. Generally, the feedback between component energy savings is low.

As of July 2007, ENERGY STAR Tier 2 goes into effect, meaning that all vending machines (both new and refurbished) that bear the ENERGY STAR label must be manufactured or refurbished to the more efficient Tier 2 standards. While this poses only modest difficulty for new machine designs, the dominant machines in the marketplace, manufactured in the late 1990's cannot so easily be

refurbished to meet the Tier 2 standards. Breakthroughs and more effective aftermarket devices can help to lower this barrier and, in the meantime, tremendous energy savings are possible with continued effort to refurbish vending machines to ENERGY STAR Tier 1 criteria. Figure 7 gives a breakdown of energy savings by component for the most feasible replacement parts in a typical vending machine. A Tier 1 ENERGY STAR refurbishment kit can include one or more of these components, most commonly lighting kits, thermostat controls, and fan motors, to meet the ENERGY STAR criteria.

Figure 7: Energy Savings of Typical Component Replacements



Programs to Support ENERGY STAR Vending Machines

Convincing host sites to use ENERGY STAR or other energy-efficient vending products is comparatively easy. Host sites have the most to gain and least to lose by cutting vending energy use. Others, however, do not always fare as well. The machine owner, who must purchase the new machine and place it at the host site, can incur significant expenses that are not a simple matter to recoup.

The bulk of utility vending programs have supported aftermarket devices. Utilities should consider including ENERGY STAR vending machines in their efficiency programs. The cost differential for a new ENERGY STAR machine, when considering the loss associated with retiring a working older machine, can be significant. Most machine owners depreciate vending machines quickly (about 6 years), but will keep the machine until the end of its useful life (about 12 to 15 years).[6] So, while the cost of replacing a working machine that is only a few (1 to 5) years old with a new machine is relatively high, the added cost quickly drops to less than $100 because purchasing a new machine will reduce or delay the maintenance required on the older unit. Therefore, a moderate rebate or incentive could provide:

- Low-risk annual energy savings of approximately 1,500 kWh per machine.
- Peak demand savings (e.g. 0.1 kW/machine for a typical ~500-can capacity vending machine).

These incentives could be used to reward machine owners not only for purchasing new ENERGY STAR Tier 2 qualified vending machines, but also for refurbishing or turning in older

machines. To accelerate market transformation, the existing stock of machines must be phased out faster than the current rate. These older machines can be remanufactured, using kits available from the manufacturer, to meet ENERGY STAR Tier I criteria. These kits cost about $50-$200, depending on the components in the kit (e.g. fan motors, lighting kit, thermostat control). For very old machines, the only disposal option typically is to salvage the machine for about $30 in materials. [7] A higher incentive could provide the impetus necessary to phase out these older machines more quickly; as machine owners replace these old machines, more-efficient ENERGY STAR qualified machines will enter the marketplace. As with all early retirement programs, there is some danger of free ridership. This can be addressed by careful program design requiring proof of both old machine disposal/decommissioning and purchase of a new efficient model.

Lessons Learned from Past/Current Programs

The vast majority of programs aimed at reducing energy consumption in vending machines, to date, have focused on external aftermarket control devices. These devices typically utilize an infrared motion sensor and control circuitry to cut power to the machine during periods of inactivity. Power is then re-applied when the sensor detects motion near the machine or the onboard temperature sensor and an algorithm determines that the machine's refrigeration system needs to run to maintain product temperature. However, these devices, largely distributed through host sites, have suffered from a number of programmatic drawbacks, limiting their effectiveness as a broad, long-term energy saving solution. These issues include:

- Poor measure persistence: Due to the device's nature as an add-on device, it can be prone to vandalism, loss, and theft. One study examined showed that, after 1 year, only 50% of units installed remained functioning and in-use. [8]
- Low savings reliability: Occupancy based savings are, not surprisingly, difficult to accurately estimate and are subject to change based on changes in building occupancy, machine placement, or other factors which may not be captured by program managers.
- Ineffective at Reducing Peak Cooling Loads: Since the machines remain powered during active periods, it is unlikely that an occupancy-based device will be effective at reducing peak summer demand. This demand coincides with the most active period of the day for commercial buildings-the time when an occupancy sensor will have the least effect in most locations. Obviously, the bulk of the energy savings for these devices will be achieved “after hours” when occupancy levels near the machine are at their lowest.

Program Structure and Cost Effectiveness

Vending machines, like many other devices, are distributed on a lease basis. A successful program must take this into account when assigning rebates and other benefits to promote the purchase of efficient equipment.

Who Gets the Rebates?

There are many ways that benefits could be allocated among market actors to increase market penetration of ENERGY STAR qualified equipment. Table 1 summarizes these options.

Market Actor	Benefits	Drawbacks
Machine Manufacturer	▪ Small number of targets reduces overhead promotional costs	▪ Difficult to assign benefits once machines have left manufacturer ▪ Manufacturers have little impact on efficiency of purchased equipment
Machine Owner	▪ Single organization may control hundreds or thousands of machines ▪ Bears the incremental cost of efficiency improvements ▪ Tracks machine placement and status ▪ Vested interest in machine maintenance and upkeep	
Host Site	▪ Easy to track, if based on number of machines required in RFP ▪ Highest interest in achieving energy savings	▪ Already receives benefit of lower utility bills

Table 1: Incentive Structure and Key Considerations

As shown in Table 1, each market owner presents unique benefits and drawbacks as a potential benefit recipient. The machine owner, however, arises as the most sensible choice, given the high potential impact of outreach efforts and the vested interest machine owners have in tracking assets (i.e. vending machines). In addition, the machine owners bear the incremental cost of efficiency, forcing them to spend more money to meet the growing customer demand for efficient equipment. Finally, based on interviews conducted with bottlers of various sizes, machine owners are best equipped to track equipment and have overwhelmingly expressed that, if the incremental cost could be reduced, would be willing to install more efficient components as part of an efficiency program.[9] Government programs, such as ENERGY STAR, perform outreach to colleges, school districts, state/local governments, and other major vending customers to increase demand for energy efficient vending machines. An incentive provided to machine owners will allow them to meet customer needs and speed the placement of qualified vending machines in the marketplace.

Cost Effectiveness

As discussed previously, the energy savings potential of ENERGY STAR Tier 2 qualified vending machines is significant (~1,700 kWh/year). Research, through interviews with manufacturers, bottlers, and others was conducted to determine the incremental cost of various energy saving technologies. The result of these investigations is summarized in Table 2. Measures such as thermostat controls and evaporator fan motors can be applied to a wide range of machines and present a good opportunity for a component level refurbishment incentive. Alternatively, ENERGY STAR Tier 1 refurbishment kits already exist and are cost effective for the majority of the vending machine fleet. Currently, there are few options to refurbish machines to the strict Tier 2 ENERGY STAR levels, thus the potential market penetration of these kits remains low.

Table 2: Cost Effectiveness of Various Program Options

Energy Saving Measure	Annual Energy Savings (kWh)	Measure Cost	Portion of Market Affected
Component Replacements			
T8 Lighting Kit	385	$50-$100	80%
SSC Evaporator Fan Motor	193	$30-$65	88%
VendingMiser	1,050	$150	100%
Thermostatic Control	1,225	$50-$150	88%
Energy Star Refurbishment Kits			
Tier 1 Refurbishment	700-2400	$50-$365	90%
Tier 2 Refurbishment	700-2900	$200-$615	10%
Other Measures			
Energy Savings Software	700	$13	43%
New Energy Star T2	500	$0	N/A
De-lamping	990	$13	100%
Early Retirement	1700	Varies Widely	100%

Conclusions and Next Steps

Annual energy savings of nearly 5 billion kWh are available in today's vending machine industry, primarily through refurbishment opportunities of existing, non ENERGY STAR qualified units. The greatest barrier against progress for the refurbishment of older machines is the incremental cost (though it is still less expensive than purchasing a new machine to meet a customer's demand for ENERGY STAR qualified equipment) and the lack of qualified refurbishment kits. Demand will remove the latter obstacle but utility support is critical to the elimination of the former. The authors have demonstrated that ENERGY STAR vending machines are a cost effective means of achieving energy savings, it only remains for the efficiency community to step up to support this effort, whether that includes supporting ENERGY STAR refurbishments exclusively or enacting a component by component refurbishment incentive. Refurbishing existing vending machines or accelerating replacement of old equipment, rather than focusing on new equipment purchases, presents a number of program advantages:

- Replacement of a 10+ kWh/day vending machine with a unit using 50% (or greater) less energy
- Potential to leverage national (ENERGY STAR) marketing materials and technical support
- More palatable/cost effective to machine owners
- Transparent to host sites
- Extends existing equipment lifetime, while saving energy, delaying disposal and associated waste

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