Serving Up Savings:
The New Value Equation for Energy Efficient Vending Machines

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ABSTRACT

The more than 3 million refrigerated beverage vending machines operating nationwide consume more than 12 billion kWh of electricity annually, twice the energy used by the entire state of Delaware. Methods of reducing this energy use include aftermarket devices and more efficient (e.g. ENERGY STAR® qualified) vending machines. ENERGY STAR Tier 1 machines, for example, use 40% less energy than comparable standard machines and ENERGY STAR Tier II (effective January 2007) vending machines will use 50 percent less energy than standard models. Onboard user-programmable software that controls lighting and storage temperature can deliver additional energy savings of 25 percent.

This paper:

- Examines the often complicated vending market and develops the value equation for each market actor.
- Compares a number of common energy efficiency measures and discusses the effectiveness and applications of each
- Draws samples from actual "pouring rights" contracts and procurement practices to provide concrete examples of market correction and transformation.

Using field data from numerous machines to support the value equation, the paper illustrates the savings from ENERGY STAR venders, the promises and pitfalls of software control, and the real benefit of aftermarket energy-saving devices.

The authors provide the tools for energy-efficiency programs to supplement or revitalize their energy-saving strategies for vending machines in order to deliver more savings for fewer program dollars.

Introduction

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.

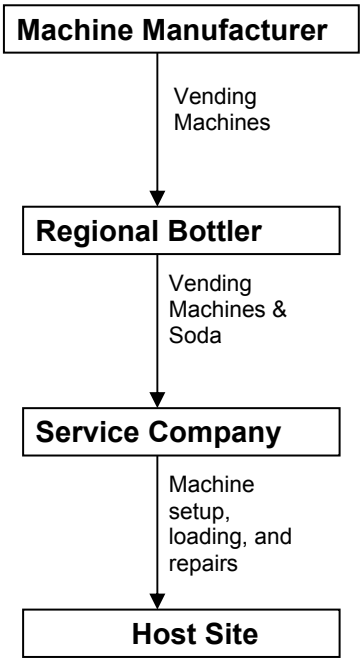
The biggest market barriers are a split incentive between machine owners and host sites, placing the incremental cost of energy-efficient machines on machine owners while host sites

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.

The Cold Drink Vending Market

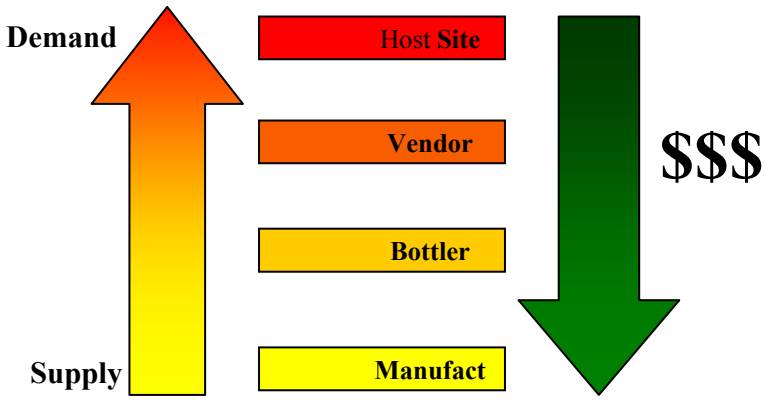
The machine owners (generally bottlers) and the host sites are the two major decision-making groups in the vending marketplace who have the power to demand more energy-efficient vending machines. They are supported by a number of related actors who are intermediaries or pure suppliers. The most important 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.

Figure 1: Basic Market Structure



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, 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 and beverage contract. A site that is profitable and near the end of its contract will have much more influence than one that is less profitable or has just signed a contract and is therefore "stuck" with the current operator.

Figure 2: Supply Chain and Cash Flow



The **machine owner** is typically the regional bottler (e.g., Coca Cola Bottling Company) or, less frequently, a service company. 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 75 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. 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.

In addition, there are several common relationships which tie these actors together.

Pouring rights contracts, for example, are agreements between a host site (often a school or university) and a beverage company (e.g. Coca Cola). This agreement gives the beverage company exclusive rights to sell their products at the host site, often in return for

favorable commissions, athletic sponsorship, or other benefits. For the life of the contract, only bottlers providing allowed products will be able to place machines or sell products at the host site.

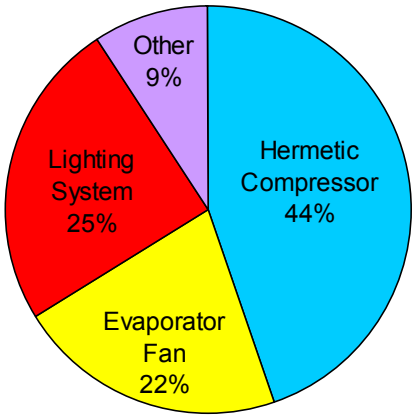
There are also typical differences between small and large sites. In a small site, the vendor operator often owns the vending machines (along with snack/candy machines, arcade games, etc) and may actually dispense both Coke and Pepsi products from the same machine. This allows the operator to meet customer needs with only a single machine.

In larger sites, the machines are generally owned by a bottler and placed directly at the host site. Even without a pouring rights contract, machines from one bottler are never used to dispense the products of a competitor. In these situations, there may be several bottlers involved, in addition to a service company and the host site itself.

Energy Use and Life Cycle Costs of Vending Machines

There is wide variation in the amount of energy used by vending machines. Variables such as can or bottle capacity, component efficiency, and lighting all contribute to this variation. Figure 3 shows a typical (non-ENERGY STAR qualified) vending machine's 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

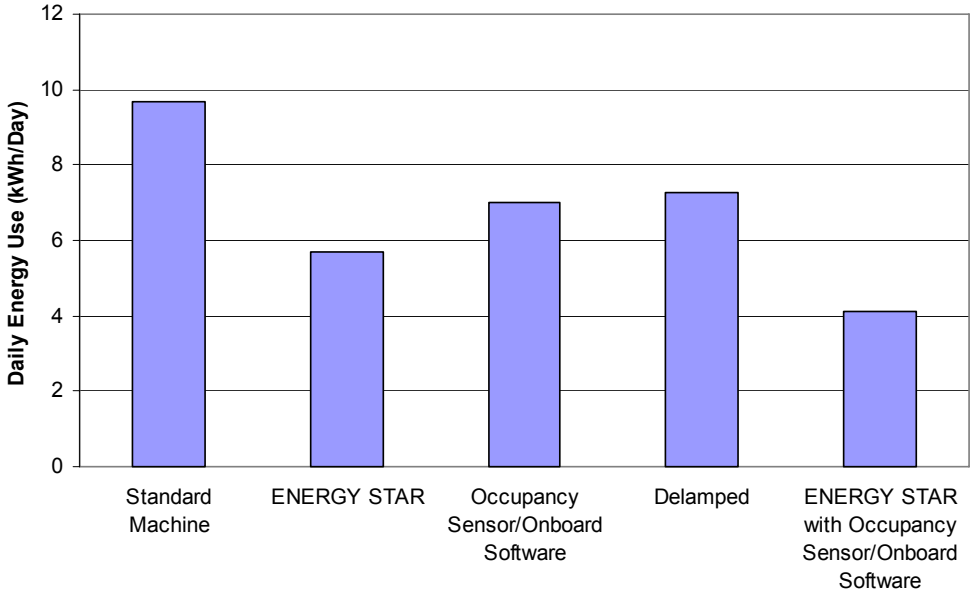


Source: CCAP

There are a number of potential measures to reduce the energy consumption of vending machines, compared in Figure 4:

1. Replace existing machines with ENERGY STAR qualified models.
2. Activate energy-saving onboard software or install an aftermarket occupancy-based controller
3. Delamp or install aftermarket devices on remaining machines.
4. Combine an ENERGY STAR qualified vending machine with onboard software or aftermarket occupancy-based controller.

Figure 4: Comparison of Energy Efficiency Measures on a Typical ~400 Can Vending Machine



Derived from published data from CEC, EPA, and field measurements of vending machine energy use

ENERGY STAR Qualified Vending Machines

Vending machines that meet the ENERGY STAR program requirements are, on average, 40-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 II 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 II machine and considerably less for a Tier I qualified machine. 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 January 2007)*

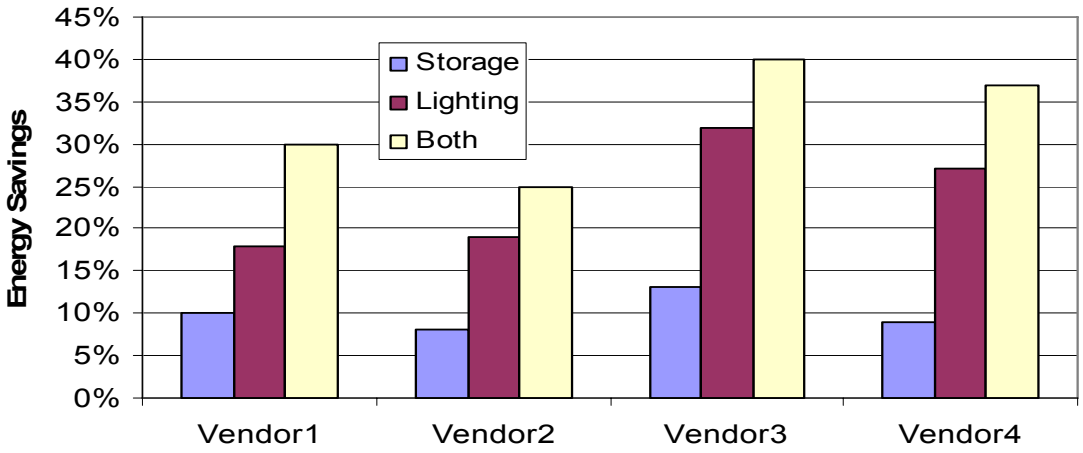
For example, a 600-can capacity vending machine must use less than 7.7 kWh/day to qualify as ENERGY STAR Tier I and less than 6.3 kWh/day to qualify for ENERGY STAR Tier II.

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 5.

Figure 5: Energy Savings on Vending Machines Using Onboard Software Control



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

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.

Delamping

Lighting in a typical vending machine accounts for 25 percent to 30 percent of the energy used by the entire machine. Delamping is the act of removing the fluorescent lamps from the front panel. This option is one of the most common, cheapest, and simplest means of reducing

the energy use of a vending machine. It is quite popular with host sites, but fear of lost sales makes many service companies reluctant to implement this measure. Delamping is a good option for sites with a "captive audience" that will not view the unlit front panel as a sign that the machine is broken.

Aftermarket Devices

Sometimes, obtaining ENERGY STAR qualified vending machines may not be possible for a variety of reasons. In these cases, the host site can purchase and install aftermarket devices to cut energy costs. The most common aftermarket device is the VendingMi$er by USA Technologies. It uses a passive infrared motion sensor to determine occupancy and to turn off power to the machine during periods of inactivity. New equipment recently released by USA Technologies foregoes the motion sensor in favor of an internal unit that adjusts the refrigeration cycle to control energy use based on vending activity and ambient temperature.

Occupancy-based Controls

Controls based on occupancy, such as the VendingMi$er, produce savings of 20 percent to 50 percent, depending on where they are installed. In many cases, the payback period on the device is short (2 to 3 years), and utility rebates can reduce this period further. Small sites that have older vending equipment are ideal locations for VendingMi$er. If a site has a well-defined occupancy pattern, installing a VendingMi$er will save only slightly more energy than implementing onboard software controls. For sites already using ENERGY STAR qualified vending machines, installing VendingMi$er is an excellent way to maximize savings potential, as shown in Figure 4. Care must be taken, however, with cashless vending systems (i.e., debit card readers and similar devices) because these devices have been incompatible with VendingMi$er at a number of sites. Also, some operators feel that an unlit machine may reduce sales volume. Since the VendingMi$er activates the machine when movement is detected nearby, this is not usually a problem at most sites.

Other Controls

In addition to occupancy-based controls, aftermarket devices such as USA Technologies' VM2IQ can be wired directly into vending machines to monitor usage patterns and adjust the refrigeration cycle accordingly. Some manufacturers have expressed concerns over the field modifications required to install the VM2IQ, and machine owners and vendor operators will likely raise similar objections if they are unsure of how the unit will affect their machines' performance. Nevertheless, savings on some machines may be as high as 35 percent, which can be a significant addition to delamping or activating onboard lighting controls.

This type of control can be a viable alternative to occupancy sensors in cases where visibility or loss of sales is a concern. Furthermore, the VM2IQ does not have the same potential for incompatibility with cashless vending systems as does the original VendingMi$er.

Like VendingMi$er, VM2IQ is particularly well suited to older machines. The controller is able to optimize the performance of the less-efficient shaded pole fan motors and other components to cut energy use.

From Potential Savings to Implementation

A number of high-profile sites have replaced their standard machines with ENERGY STAR qualified models and are reaping the rewards. For sites not able to obtain new vending machines, other options such as software settings or aftermarket devices may be a good intermediary option. The various energy saving options are summarized in Table 1.

Table 1. Energy Saving Options Summarized

Energy Saving Action	Annual Energy Savings (per Machine) and Simple Payback	Implementation Strategy	Barriers to Implementation
Obtain ENERGY STAR Qualified Beverage Vending Machines	1,500 kWh/year <1 year payback if machine owner passes full cost to host site, otherwise payback is immediate	1. Request from current beverage provider 2. Include ENERGY STAR in future RFBs for vending services 3. Be open to sharing incremental costs with machine owner	• Attachment to existing asset base • Split incentive
Activate software Settings on ENERGY STAR Machines	500 kWh/year Immediate payback	Meet with service provider to identify target machines	• Fear of lost revenue • Ignorance of energy saving features
Purchase and Install Aftermarket Control Devices	1,000 kWh/year (highly location dependent) 1-2 year typical payback	1. Identify appropriate machines and available utility programs 2. Meet with service company 3. Be open to other alternatives if proposed	• Fear of machine damage • Fear of lost revenue • Conflicts with cashless payment systems
Delamp Existing Machines	900 kWh/year Immediate payback	Meet with vending operator to identify eligible machines	• Fear of lost revenue

Host Sites without ENERGY STAR

Host sites that do not have ENERGY STAR qualified equipment typically pay around $300 per machine in annual electricity costs. The host site's best option is to request ENERGY STAR qualified vending machines from its current machine owner or bottler.

Figure 6: Sample Procurement Language

> The vendor must provide vending machines that earn the ENERGY STAR and meet the ENERGY STAR specifications for energy efficiency. The vendor is encouraged to visit www.energystar.gov for complete product specifications and an updated list of qualifying products.

Often, bottlers will be willing to make concessions to sites that have demonstrated a commitment to energy savings. For example, when Dartmouth College entered negotiations with its beverage provider hoping to install VendingMi$ers on Dartmouth's 70 vending machines, the provider instead agreed to gradually replace all of the vending machines on campus with ENERGY STAR qualified models, at no cost to Dartmouth.

The University of Southern Maine has also reached a similar agreement with its beverage providers. The situation is far easier for sites nearing the end of their vending contracts. Adding language to a Request for Bids (RFB) requesting ENERGY STAR qualified vending machines is an easy way to guarantee energy savings. In fact, proactively requesting Tier II ENERGY STAR qualified machines, which are available now, will guarantee that the host site receives the latest and most efficient equipment. ENERGY STAR provides "drop in" language, such as that shown in Figure 6, which purchasers or contracts staff can copy or paste into RFB documents.

Some sites have also used language such as "new state-of-the-art and energy efficient vending machines" and required documented energy use data for the machines provided. This alternative serves the purpose, but specifying ENERGY STAR can minimize guesswork by leveraging a national, well-recognized program. The State University of New York at Buffalo, for example, requested energy-efficient vending machines in a 2003 RFB and is now saving approximately $21,000 annually with new ENERGY STAR qualified vending machines, at no additional cost.

Host Sites Already Using ENERGY STAR Vending Machines

Host sites that have ENERGY STAR qualified vending machines already reap significant rewards. Yet, there are still opportunities for further energy savings. The next steps include activating onboard software, installing aftermarket devices, and delamping. The host site should begin by working with the vendor operator to identify machines suitable for lighting and storage mode controls. Once these controls have been implemented, the remaining machines may be outfitted with VendingMi$ers. Older machines may realize cost-effective savings from the installation of an internal control device such as the VM2IQ. Host sites at this stage will experience tremendous energy savings and might consider specifying ENERGY STAR Tier II vending machines in future RFBs.

Utilities: The Power to Push the Market

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). 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 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 $150. For very old machines, the only disposal option typically is to salvage the machine for about $30 in materials. 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.

Conclusions and Next Steps

The energy-efficiency community has a tremendous opportunity to save energy and cut costs by demanding improved efficiency in vending machines. Manufacturers are able to provide vending machines that can, when properly used, cut energy costs by up to 50 percent compared to standard models. Replacing the existing stock of vending machines with ENERGY STAR Tier I machines would save around 5 billion kWh — almost 6 billion kWh if Tier II machines were used. Though these savings are spread out among over 3 million vending machines, the high benefit-to-cost ratio for host sites makes vending one of the more attractive targets for ongoing and future efficiency efforts.

Addressing vending energy use requires a number of approaches and technologies. ENERGY STAR qualified vending machines, particularly Tier II machines, have the greatest potential for savings. Even more savings are possible by fully using the onboard software or aftermarket devices to match vending machine energy use to site occupancy patterns. If replacing the existing machine(s) is not feasible, installing add-on equipment, changing software settings or delamping can provide significant savings.

Going forward, there are a number of things that the energy-efficiency community can do to drastically reduce the operating costs of the nation's vending equipment, including:

- Promoting ENERGY STAR (especially Tier II) qualified vending machines at colleges, hotels, and other large sites.
- Encouraging machine owners to more rapidly phase out aging machines in favor of newer, more efficient models.
- Activating the onboard software of ENERGY STAR or equivalent vending machines to increase savings at little or no added cost.
- Delamping vending machines where appropriate and installing aftermarket control devices to reduce energy use even further.

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