

**Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development**

**Analysis of Standards Options
for
Water Dispensers**

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1 Introduction

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for water dispensers that provide cooled, or cooled and heated water.

2 Product Description

Three types of conditioned water dispensers are reviewed in this report: bottled water dispensers, point-of-use (POU) dispensers, and pressurized water dispensers (Figure 1 provides an example of each and Table 1 characterizes them by type and function). Both bottled water and point-of-use dispensers are freestanding appliances that dispense cold and sometimes hot water. The key distinction between “bottled” and POU relates to how water is provided to the dispensers. The bottled water dispenser requires manual replacement of water containers as the water source, while the POU device uses line pressure activated by a float valve to maintain water level. From an energy perspective, the bottled water and POU types are functionally identical. Several key manufacturers have indicated that the components affecting energy use are identical in these two product lines (Cadmus, 1999). Water dispensers are either room temperature appliances or are actively cooled (and heated). Units providing only ambient or room temperature water do not use any energy and are therefore not further addressed. The critical factor affecting energy consumption is whether the appliances provide “cold water only” or both “hot and cold water”. Bottled water dispensers typically have an internal storage volume of about 3 quarts and a cold water recovery rate of 0.5 to 1 gallon per hour (of 50°F water).

Figure 1: Bottled, POU, and Pressurized Water Dispensers



Source: Sunroc

Analysis of Standards Options for Water Dispensers

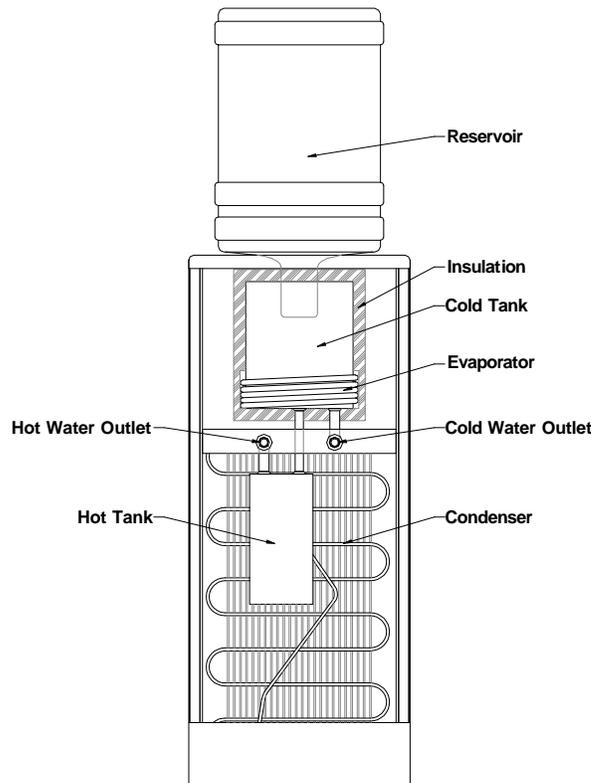
Pressurized water dispensers, also known as refrigerated water fountains, are typically installed in non-residential buildings and are usually purchased at time of construction. They come in a number of configurations including freestanding, flush-to-wall, remote, wall-hung, and fully recessed, and dispense only cold water. These devices can typically provide 3-10 gallons of 50°F water per hour.

Table 1: Characterization of Water Dispenser Types

<i>Dispenser type</i>	<i>Provides cold water?</i>	<i>Provides ambient temp water?</i>	<i>Provides hot water?</i>
Bottled dispenser	Most (“cold” unit)	Some (“cook & cold”)	Some (“hot & cold”)
POU dispenser	Most (“cold” unit)	Some (“cook & cold”)	Some (“hot & cold”)
Pressurized	Always	Rarely	Rarely

A generic “hot-and-cold” dispenser is shown in Figure 2. The point of use dispenser is identical except for the water supply. The “cold” and “cook and cold” dispensers are of the same arrangement, but without the water heating system. Key components include the hot and cold water tanks, insulation, immersion heater (in the hot water tank), and refrigeration components (compressor, evaporator, and condenser).

Figure 2: Schematic of Typical “hot and cold” Water Dispenser



Design features affecting energy use include:

- Amount of insulation between hot and cold reservoirs (the cold reservoir is typically insulated to avoid condensation, but the hot tank is often uninsulated, especially in older models)
- Location of the hot reservoir (typically below the cold reservoir)
- The hot water reservoir inlet line may come from the chilled water outlet resulting in heating chilled water.
- Frequently there is a metal pathway between the hot and cold reservoirs allowing heat conduction between the two tanks.

3 Market Status

3.1 Market Penetration

It is important to understand the evolution of the water dispenser market. The ambient temperature water fountain was first on the market, followed by the chilled water version, and today units have evolved to combinations of ambient, chilled, and hot water dispensers. As part of this process, dispenser design evolved from ambient temperature to chilled water through the addition of cooling components. Hot water versions evolved with the addition of electric heating capability to the chilled water design. The latest modification is the addition of a small refrigerator compartment in the base of the dispenser (not addressed as part of this proposal).

The water dispenser market has been undergoing a modest change, with manufacturers concentrating on reduced first-cost by using more plastic components and moving manufacturing to other countries. This low first-cost has enabled manufacturers to expand their market by selling to the consumer through retail outlets in addition to the traditional lease arrangement from bottled water distributors. Cadmus estimates an annual 6% growth rate due to population and demand growth (Cadmus, 1999). The market is competitive but dominated by three privately held companies (Elkay, Oasis, and Sunroc) who do not publicly report sales volumes.

We have found no data available on water dispenser saturation and very little on sales, either nationally or in California. The U.S. Department of Commerce Current Industrial Reports lists total sales of water dispensers at one million per year (USCB 2001). Cadmus disaggregated national sales into “cold only” and “hot and cold” and pressurized dispensers (Cadmus 2000). Starting with this data we estimated California sales and stock (summarized in Table 2).

Table 2: Estimated Water Dispenser Stock and Sales

<i>Service</i>	<i>Type</i>	<i>Annual U.S. Sales</i>	<i>Annual California Sales¹</i>	<i>California Stock²</i>
Hot and cold	Bottled and POU	210,000	23,100	184,800
Cold only	Bottled and POU	490,000	53,900	431,200
Cold only	Pressurized	297,000	32,670	457,380
TOTAL		997,000	109,670	1,073,380

3.2 Market Penetration Of High Efficiency Options

Based on our market survey and understanding of typical unit design, it seems that manufacturers are not currently focusing extensive effort on improving the energy efficiency of their product. The inherent conflict between first cost and operating cost is apparent in a market where the equipment owner, typically a bottled water vendor, pays the first cost and another party leases the equipment and pays the operating cost. In 2000 the EPA established eligibility criteria for water dispensers in its Energy Star program. Manufacturer participation was initially slow, with the first product not listed until 2002, but has recently picked up, with eleven manufacturers now listing 77 “hot and cold” dispensers. Only 30 “cold only” dispensers from three manufacturers have been listed so far, indicating that it may be harder to meet the Energy Star criterion for cold-only dispensers

4 Savings Potential

4.1 Baseline Energy Use

Studies estimating water dispenser energy use are very few. Table 3 summarizes the large range in daily energy use found in the field. The two Energy Star water dispensers were tested using the Energy Star test procedure and as such are for standby usage only. Subsequent to these products being listed on the Energy Star site, EPA has chosen to list only that water dispensers have qualified and not to list their actual consumption. DEG #1 is a new water dispenser monitored in our office. The Cadmus estimates for baseline energy use are based on their monitoring of a small sample of water dispensers. DEG #2 and #3 are older water dispensers that did not have insulation on the hot tank.

¹ California market share is assumed to be 11% of U.S. total sales.

² Stock calculated using bottled and pressurized lifetimes of 8 and 14 years respectively.

Table 3: Monitored Total Dispenser Energy Consumption

<i>Water Dispenser</i>	<i>Energy Use (kWh/day)</i>	
	<i>Cold only</i>	<i>Hot and Cold</i>
Energy Star #1	N/A	0.7
Energy Star #2	N/A	1.0
DEG #1	0.24	1.4
Cadmus baseline	0.18	1.9
DEG #2	N/A	2.6
DEG #3	N/A	3.3

Energy consumption for water dispensers is comprised of two components: the useful energy to cool and/or heat the water and the energy required to offset standby losses that occur when the device is not in active use. Table 4 describes useful energy and standby losses for cooling and or heating water in relative terms. The amount of useful energy will vary with the demand for water and here is assumed to be 3 gallons per day. Table 4 clearly shows the inefficiency of combining “hot” and “cold” functions as the standby loss increases from 0.18 to 1.93 kWh/day.

Table 4: Typical Dispenser Energy Components (kWh/day)

<i>Dispenser Type</i>	<i>Useful Cooling Energy</i>	<i>Useful Heating Energy</i>	<i>Standby Losses (cold only unit)</i>	<i>Standby Losses (hot and cold unit)</i>
Bottled	0.18	0.23	0.18	1.93
POU	0.18	0.23	0.18	1.93
Pressurized	0.18	---	0.15	---

Source: (Cadmus, 2000)

4.2 Proposed Test Method

The US EPA issued an Energy Star performance specification for water dispensers in 2000 focusing on standby energy use (EPA 2000). As part of the program requirements EPA specified test criteria for water dispensers. We propose to use these test criteria with the exception of section D of the memorandum that allows for the use of timers:

1. *Power Measurement:* Energy use shall be measured as the total true energy use (kilowatt-hours) consumed in one 24-hour period.
2. *Starting Conditions:* Before starting the energy measurements, the unit shall be at operating conditions, with water temperatures as defined in section E.
3. *Water Withdrawal:* No water may be withdrawn from the unit during the test.
4. *Ambient Temperature:* Ambient air and water temperature must be $75^{\circ} \pm 2^{\circ}\text{F}$.
5. *Dispensed Water Temperatures:* Cold water temperature shall not exceed 50°F and hot water temperature shall be at least 165°F . These temperatures shall be

measured before conducting the standby energy use test when the respective function, compressor, or heating element turns on.

6. *Cooler Location*: The unit must be no more than 6 inches from a wall at least 7 feet high and extending horizontally at least 2 feet from each side of the unit.
7. *Airflow*: Airflow around the unit must be natural; no artificial means of increasing the airflow are permitted. Airflow created by components integral to the unit, such as internal fans, is permitted.

4.3 Efficiency Measures

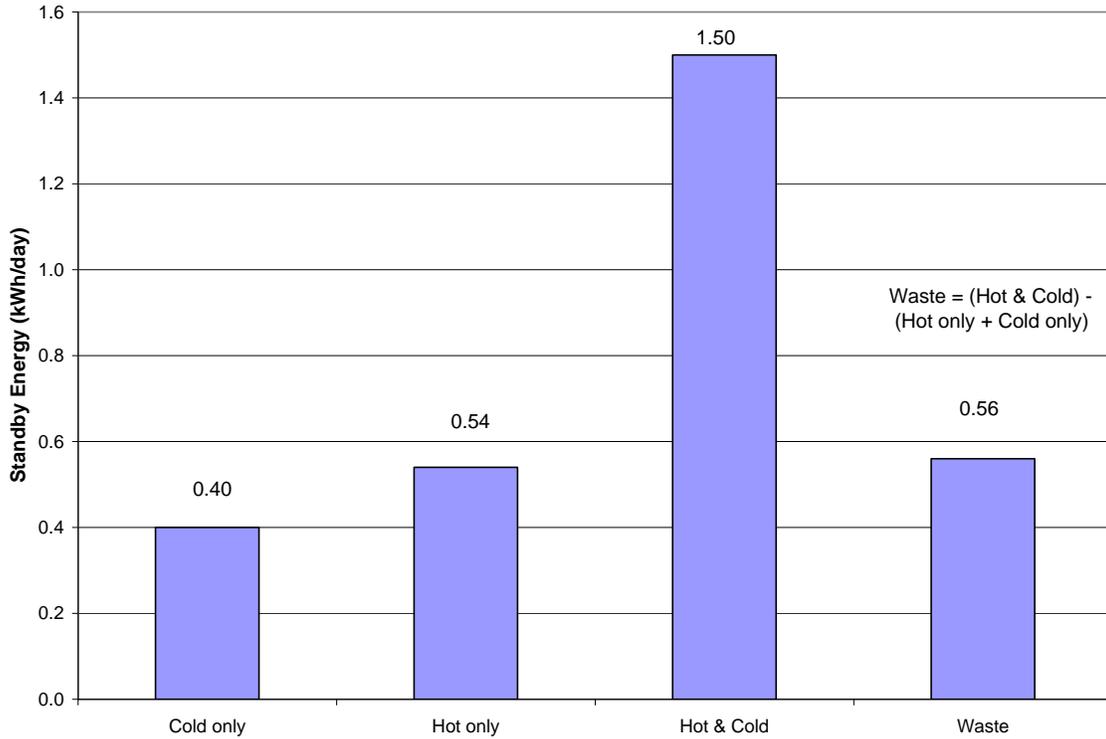
There are several efficiency measures currently available that could improve overall energy use of water dispensers. Combined “hot and cold” dispensers represent the primary target because of the much larger savings potential. Potential measures include:

- adding insulation between the hot and cold reservoirs and increasing the insulation level on the reservoirs
- redesign the configuration to reduce conduction between the two reservoirs
- adding a timer to minimize standby losses during unused periods
- higher efficiency compressors

Cadmus identified the timer as the best option for “hot and cold” units, since it effectively shortens the length of the standby period. Testing completed by Cadmus demonstrated that disabling operation for 10 hours would result in 36% reduction in standby energy consumption. No manufacturers are using timers to qualify for Energy Star. Although timers offer significant savings potential, a hard-wired timer could be problematic for applications with shift work or extended workdays. It is important that the timer have some override option to allow the user to fine-tune the operating scheduling, however this would adversely affect the persistence of the savings. Alternatives to timers include motion and light sensors. PG&E’s CASE study on Refrigerated Beverage Vending Machines shows little use of timers by consumers, on machines so equipped. This makes timers a good opportunity that may be underutilized on account of behavioral issues.

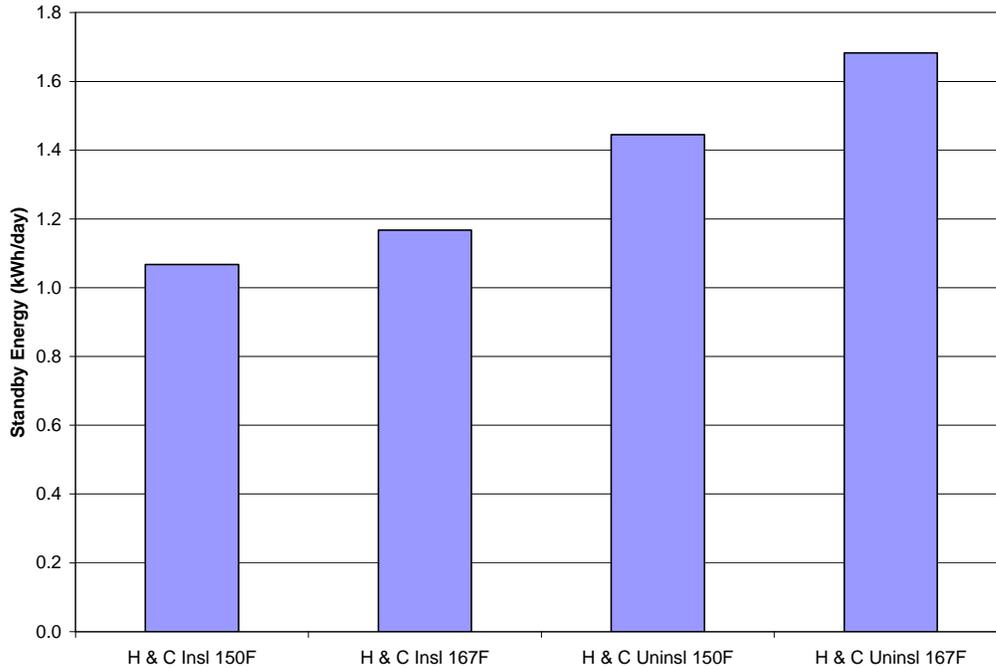
To assess the potential for energy savings from isolating the hot and cold tanks, we monitored a new “hot and cold” bottled dispenser located at our office. During monitoring, cold water reservoir temperature was held constant at 50°F and hot water temperature was maintained at a 167°F setting. Both the hot and cold water tanks were insulated by approximately 0.5 inch of foam insulation. Figure 3 plots daily standby energy usage for “cold only”, “hot only”, and combined “hot and cold” modes. Note that the “hot only” and “cold only” losses do not sum up to the combined “hot and cold” losses. The explanation is poor thermal isolation between the hot and cold reservoirs leading to excessive heat transfer from the hot reservoir to the cold reservoir. The impact of this added heat transfer is to increase standby energy use by about 60%. Clearly this is an area where significant improvements can be made.

Figure 3: Monitored Standby Energy Consumption (50°F cold tank, 167°F hot tank)



To assess the impact of hot tank insulation and temperature on standby performance, a series of tests were completed measuring “hot and cold” standby loss at two different hot tank temperatures (150 and 167°F). At each temperature, standby energy use was measured with and without factory installed insulation on the hot tank. Figure 4 plots average daily energy usage for the four cases. The key conclusion to be drawn from the data is the impact of insulation on standby energy and the potential savings available from increasing existing insulation levels.

Figure 4: Insulation Impact on Hot and Cold Standby Energy Consumption



4.4 Standards Options

Both prescriptive and performance standards are feasible for water dispensers. Because of the numerous efficiency measures available and the ease of testing for standby energy use, however, a performance standard is more appropriate. In this analysis, we have analyzed a standard equivalent to the Energy Star specification: Maximum energy use for “hot and cold” and for “cold only” dispensers is 1.2 kWh/day and 0.16 kWh/day, respectively. The standby energy levels specified by Energy Star are an appropriate level at which to start the standard given that a significant number of products are all ready available which meet this level and that no significant design changes will be needed to attain this performance level.

4.5 Energy Savings

Table 5 summarizes the potential energy savings available from reducing water dispenser standby energy. For “hot and cold” dispensers, reducing standby energy consumption from the assumed 1.93 kWh per day baseline to 1.2 kWh per day would save nearly 38% of annual consumption. “Cold” only units and pressurized water units are not projected to generate significant savings under the assumption that the proposed standard will not affect these units.

Table 5: Potential Energy Savings

<i>Type</i>	<i>Baseline usage (kWh/yr)</i>	<i>Per unit Savings (kWh/year)</i>	<i>First Year Savings (GWh/year)</i>	<i>Statewide Potential Savings (GWh/year)</i>
Hot and cold	854	266	6.15	49.24
Cold only	131	7	0.39	3.15
Pressurized	120	0	n/a	n/a

5 Economic Analysis

5.1 Incremental cost

Prior research (Cadmus, 2000) identified costs for potential improvements to water dispensers. Table 6 lists these costs relative to current standard practice.

Table 6: Efficiency Measures and Costs

<i>Measure</i>	<i>Increase in Unit Cost</i>
Added insulation	\$1
Added insulation, improve unit layout	\$1
Improve layout, improved baffle design, insulation	\$2
Install timer (10 hour off-cycle)	\$5
More efficient compressor	\$20

5.2 Design Life

Life expectancies of many appliances are published by Appliance magazine (Appliance, 2002). Although water dispensers are not listed, an average life expectancy from eight to 19 years is assumed consistent with the classification of major appliances. Since the bottled and POU water dispenser can have both heating and cooling functions, we selected the eight-year life expectancy from the low end of the range. The pressurized dispenser can be considered a commercial grade appliance and we therefore selected 14 years as an average life expectancy. Most of the pressurized units tested by Cadmus had 20 years of service or more.

5.3 Life Cycle Cost

Based on the assumed 8-year design life, a life cycle cost savings value of \$.793/kWh was used. The incremental cost listed in Table 7 is estimated as the sum of the first four measure costs shown in Table 6 multiplied by three (to reflect manufacturing and marketing markups).

Table 7: Analysis of Customer Net Benefit

<i>Dispenser Type</i>	<i>Design Life (years)</i>	<i>Annual Energy Savings (kWh)</i>	<i>Present Value of Energy Savings*</i>	<i>Incremental Cost</i>	<i>Net Customer Present Value**</i>
Hot & Cold	8	266	\$211	\$12	\$199
Cold Only	8	7	\$6	\$6	\$0

*Present value of energy savings calculated using a Life Cycle Cost of \$0.793/kWh (CEC 2001).

**Positive value indicates a reduced total cost of ownership over the life of the appliance

6 Acceptance Issues

6.1 Infrastructure issues

The proposed standard levels do not involve the implementation of new technologies. The measures may entail redesigning of the key components and location of storage reservoirs, but it is expected that an increase in insulation levels will be more than adequate to meet the standard level.

6.2 Existing Standards

The following standards and test methods are applicable to water dispensers:

- The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 18-97 provides a standard method of testing to assure that the device operates properly. The standard does not specifically address test conditions and does not address energy consumption.
- The Air-Conditioning and Refrigeration Institute (ARI) Standard 1010-02 (ARI 2002) references ASHRAE 18-97 in its test protocol, and also specifies test conditions
- Canadian Standards Association (CSA) Standard C815-99 (CSA 1999) addresses energy usage in terms of “gallons per kWh” of electricity consumption. This index focuses on useful heating and cooling provided by the device. It does not address standby losses.
- The US EPA issued a product specification for ENERGY STAR rated dispensers in 2000 (EPA 2000). Its focus is on standby energy use. The voluntary performance level for “hot and cold” and for “cold only” dispensers is 1.2 kWh/day and 0.16 kWh/day, respectively. It specifies a 24-hour test with the cold reservoir at 50°F maximum and the hot reservoir at 165°F minimum.
- CEC Title 20 currently has a standard and test method for hot water dispensers. It specifies a 24-hour test at 150°F water temperature. It requires that the standby loss of hot water dispensers shall be not greater than 35 watts.

Energy Star and CSA are the only standards dealing with energy efficiency at this time. Energy Star focuses on standby losses. The CSA standard specifies performance in terms of “gallons per kWh”. The Energy Star approach is simpler and more appropriate for the California appliance standard.

7 Recommendations

7.1 Recommended Standards Options

We recommend adopting the Energy Star qualifying level (standby consumption of no more than 1.2 kWh per day) as a standard level for “hot and cold” water dispensers. Several manufacturers currently meet that standard and data indicates that optimal insulation alone is sufficient to achieve that performance level. For dispensers that only provide cold water, we do not recommend a standard level at this time as there is inadequate information as to the energy savings opportunities available. It is important to set achievable standards levels for all categories to avoid the scenario where a customer is forced to employ a “hot-and-cold” device using five times the energy of a “cold-only” device because the cold-only model cannot be sold in California. Test data for all water dispensers other than those that dispense ambient temperature water only should be added to the list of products in section 1606 that require testing and listing. By targeting “hot and cold” units initially, a standard would address the main problem area. As better data becomes available on bottled and pressurized “cold only” units, a “cold only” standard could also be implemented, if appropriate. While the present Energy Star qualifying level for “cold only” units has merit, it is presently deemed to be too exclusive for adoption as a California State standard.

7.2 Proposed Changes to Title 20 Code Language

The following standards language is recommended for section 1605.3

The standby energy consumption of Bottled and Point of Use Water Dispensers dispensing both hot and cold water manufactured after January 1, 2006, shall not exceed 1.2 kWh/day.

8 References

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