A report on
Potential Best Management Practices
-
Commercial Dishwashers

Prepared for

The California Urban Water Conservation Council
716 Tenth Street, Suite 200
Sacramento, CA 95814
(916) 552-5885

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By
Koeller and Company
5962 Sandra Drive
Yorba Linda, California 92886-5337
koeller@earthlink.net
(714) 777-2744

and
H.W.(Bill) Hoffman & Associates, LLC
9013 Texas Sun Drive
Austin, Texas 78748
billhoffmantx@earthlink.net
(512) 280-0199

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NOTE: For a full introduction to the
Council's Potential Best Management Practice (PBMP) process,
refer to the Year Three report that details the purpose and
status of that process since its inception in 2004:
http://www.cuwcc.org/products/pbmp-reports.aspx

I. Introduction

Background

The warewashing (dishwashing) industry is multifaceted. It produces equipment for both the food service industry and for medical and laboratory facilities. This report will focus only on dishwashing equipment found in the food service industry. NSF International, a certifying body that provides a directory of commercial dishwashers, currently lists approximately 900 individual machine models in today's marketplace. These machines are found in diverse settings ranging from conventional restaurants to health care and other institutional food service facilities, as well as to catering and similar food preparation operations. Equipment has been designed for specific purposes such as general dish, pot and pan, and glass washing.

Purpose

The purpose of this document is to describe the place that warewashing has in the overall restaurant and food service operation's water use profile and to describe how water efficiency thresholds and technologies for this equipment are changing.

Topics

In order to fully describe water use characteristics of warewashing within the context of overall food service operations, a number of topics are covered, including:

1. A brief overall of water use in scullery operations
2. The role of warewashing in these operations
3. Type and classification of warewashing equipment
4. Description of equipment operations
5. Trends in equipment water use
6. Dishwashing equipment size considerations
7. Dishwasher market dynamics
8. Regulations and incentives
9. Water use characteristics
10. Potential future water savings for California

II. Restaurant and Food Service Business in California

According to information from the National Restaurant Association and the 2003 Census, California has more restaurants than any other state. Table 1 shows the ranking and restaurants per capita for each state based on that study. California, New York, Texas and Florida have one third of all restaurants in the United States.

Table 1. Top Five States by Number of Restaurants In 2003

State	Number of Establishments	Restaurants per 1,000 Population
California	87,225	2.41
New York	58,027	3.01
Texas	53,631	2.35
Florida	41,901	2.36
Pennsylvania	31,466	2.53
National Totals	**714,232**	**2.41**

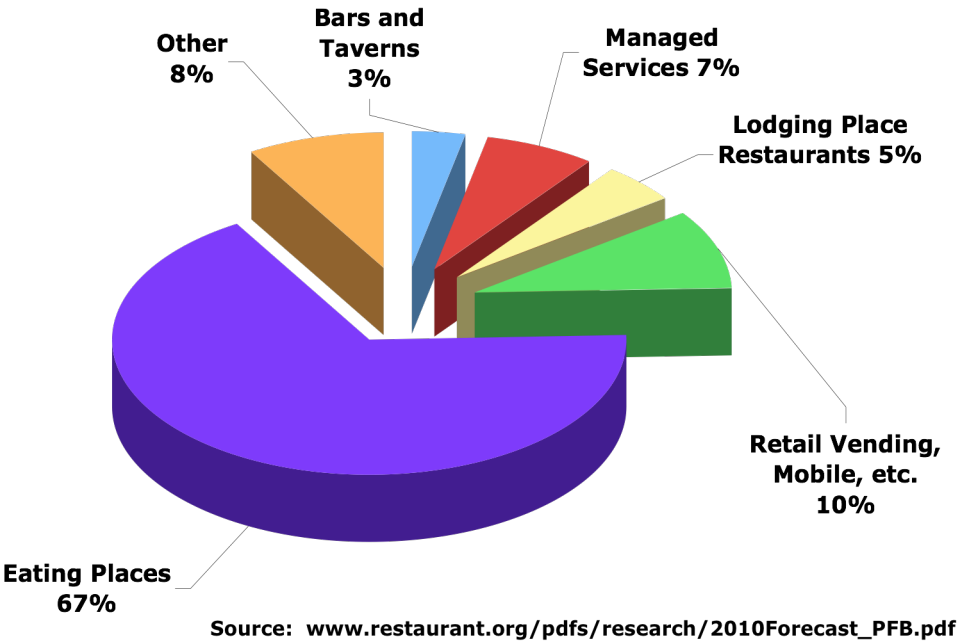
Source: National Restaurant Association and 2003 U.S. Census information
(http://en.wikipedia.org/wiki/List_of_US_states_by_number_of_restaurants_per_capita)

As Table 1 shows, California had approximately12 percent of the restaurants in the United States in 2003. The estimated population of California in 2003 was 36.1 million, but by January 1, 2009, it had grown to an estimated 38.3 million. Based upon the above table and the six-year increase in population, there may be as many as 92,000 restaurants in the state in 2009. According to the National Restaurant Association Pocket Fact Book, there are 966,000 eating and drinking places in the United States employing 13 million people. National sales are projected to top $565 billion in 2009[1].This number includes prepared food sales in restaurants, bars, "lodging place restaurants," managed services, mobile and vending facilities, and other retail concerns.

Based on California's restaurant fraction of 12 percent of the total number of restaurants in the United States, this would place the total for the state at about 121,000 establishments in 2009, including restaurants and other outlets. However, this number includes bars, managed services and other categories, etc. The National Restaurant Association report entitled "California Restaurant Industry at a Glance"[2] reported that there were 61,336 restaurants in California in 2007 and that 1.45 million people were employed in these businesses in 2009. Figure 1 shows national sales by type of facility. Approximately 72 percent of national revenues were from "eating places" or restaurants (including those restaurants in lodging facilities). This would mean that of the 121,000 total establishments, some 87,000 were restaurants. Based on the above discussion, it is obviously difficult to obtain a precise number, but for the purposes of this report, we estimate that, as of 2009, there were some 80,000 to 90,000 restaurants in California. However, it should be noted that not all of these restaurants use dishwashers of the types described in this report.

[1] http://www.restaurant.org/research/ind_glance.cfm
[2] http://www.restaurant.org/pdfs/research/state/california.pdf

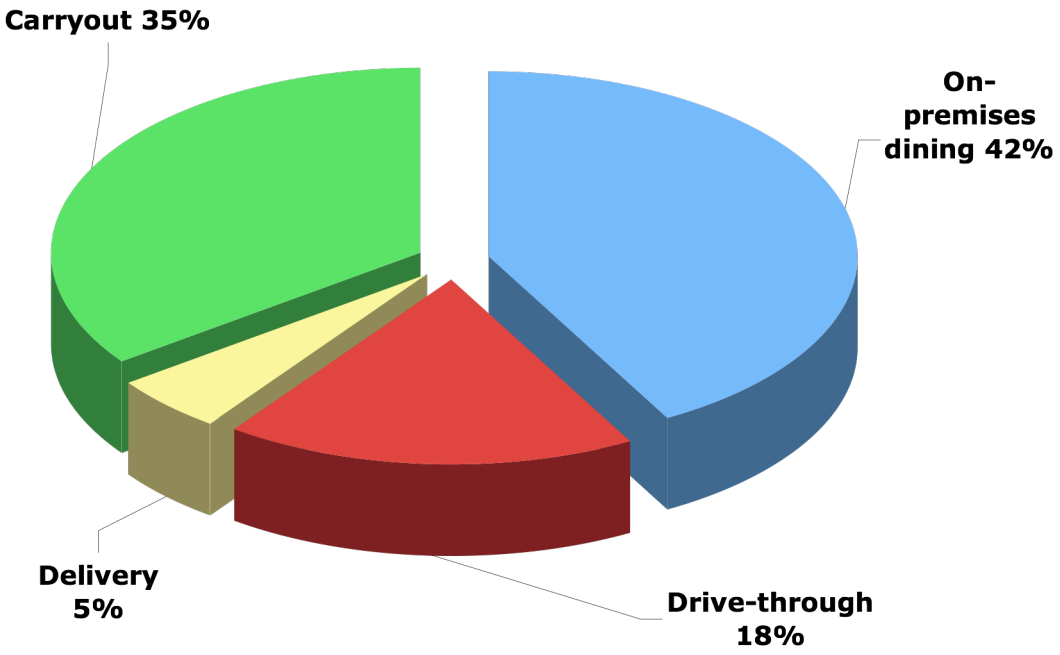
Figure 1. U.S. National Sales - 2010 Forecast



Source: www.restaurant.org/pdfs/research/2010Forecast_PFB.pdf

There are approximately 75 major fast food chains (e.g., Mc Donald's, Burger King, Taco Bell, etc.) operating in the United States. Figure 2 shows the distribution of restaurant customer traffic by type of establishment. As the chart shows, only 42 percent is on-premises dining. This would indicate that fast food and take-out traffic dominates over half of the market; none of these establishments uses full automatic dishwashers.

Figure 2. U.S. Distribution of Restaurant Customer Traffic - 2001



Source: University of Georgia, Business Outreach Services, 2002

In addition to the restaurant traffic shown in Figure 2, there are numerous institutional food service establishments for schools, prisons, municipal buildings, military mess halls, etc., most of which have commercial dishwashers. In California, there are 9,972 public schools, 3,782 private schools, over 200 universities and colleges, and several hundred jails and prisons according to State data. Military facilities include 21 Army, Navy, Marine, and Air Force installations, and several dozen Coast Guard facilities. Many of the food service operations in these facilities are operated by the "managed services companies," but a large percent are self-operated. Add to this the bars, and the number of food service facilities easily exceeds 100,000 in the state, portions of which contain commercial dishwashers.

III. Water Use in Scullery Operations

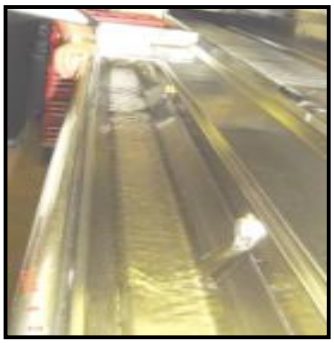
Although the focus of this study is the commercial dishwashing machine, it is important to be aware of how the whole warewashing (scullery) process works and how it may impact total water use for a food service establishment. First, some smaller food service establishments and many fast food restaurants that serve on disposable ware do not have a dishwasher. Instead, they depend on the “three-compartment sink” to wash their pots and pans and other cooking utensils. However, almost all other restaurants and food service establishments of any size do use commercial dishwashers.

Water use in the scullery operations can include:

1. Garbage disposal with grinders, pulpers and similar equipment;
2. Waste transport in sluice troughs;
3. Pre-rinsing of dishes prior to washing;
4. Soaking of pots and pans in special equipment;
5. Washing pots and pans either by hand or in a dishwasher; and
6. Cleaning and sanitation of the scullery work area.

One water-using area found in almost every restaurant is the three-compartment sink. Many use these sinks for washing pots and pans or "pre-cleaning" them prior to placing them in a dishwasher.

The first scullery step in most restaurants and food service establishments is to scrape the dish, pot, pan, or tray into a garbage can. However, some facilities only remove the silverware and paper and cloth items and then use sluice troughs. Sluice troughs feed into a garbage disposer. Flow rates in these troughs can range from 2.0 gallons per minute (gpm) to over 15 gpm depending on how many nozzles flow into the trough to wash the food waste towards the disposal.



Garbage grinders (disposers) are also found in many restaurants. The purpose of a grinder is to break the food waste into small particles that are then mixed with water. This mixture is discharged to the sanitary sewer. The use of grinders does increase the loading on wastewater treatment plants and, as such, wastewater utilities vary on their support of the use of these scullery appliances. Also, solids will build up more rapidly in a grease trap if the waste passes through the grease trap. Because of this, some cities have either banned disposers or placed excessive sewer charges on the operations using grinders. However, grinders *do* remove food waste from the solid waste disposal stream, an advantage in some cities. On the other hand, some jurisdictions are concerned with food waste being placed in dumpsters that may draw rodents and flies and add to solid waste disposal volume. They, therefore, encourage grinders. Others encourage composting of food scraps.

Food waste pulpers are used by some entities to collect the food scraps and extract water from the disposal process. They are located where a grinder would otherwise be located. These systems can also recover the extracted water so that it can be reused to pre-rinse dishes and act as a sluice trough where food wastes are dumped. When a recirculation system is used, pulpers recirculate from 5.0 to 15 gpm through the system; fresh makeup water rates are typically below 2.0 gpm.

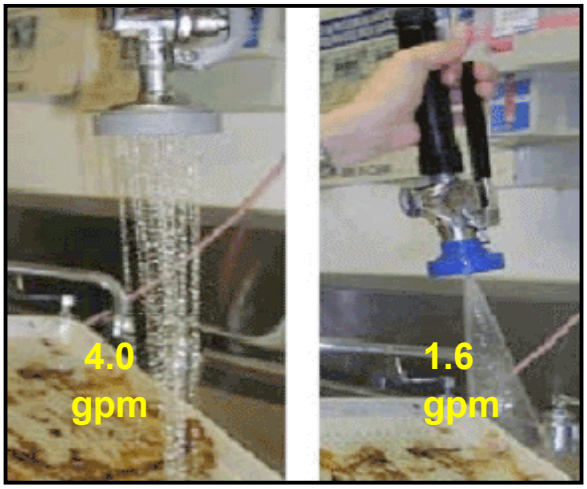
Another system called a Salvajor works similarly to a pulper and can recirculate water for sluicing of food scraps, but it uses a strainer basket system to collect food waste for disposal as a solid waste.

An alternative to the mechanical systems discussed above is the simple scrap basket or strainer basket system. Strainer baskets can either be an under-the-sink type as the one pictured here or simply a basket with holes or slots in it placed in a sink. Food scraps are emptied into a garbage can for solid waste disposal or composting.

The choice waste disposal methods also impacts energy and water use in the scullery operations. Table 2 summarizes the water, energy and solid waste considerations for each disposal method.

Table 2. Summary of Four Waste Disposal Methods

Parameter	Grinder	Salvajor	Pulper	Strainer Basket
Solids to Sewer	Yes	No	No	No
Recirculate	No	Yes	Yes	No
Strain Solids	No	Yes	Yes	Yes
Compost Produced?	No	Yes	Yes	Yes
Solid Waste Produced?	No	Yes	Yes	Yes
Flow Restrictor?	Yes	No	No	N/A
Horse Power	1-10	0.75-7.5	3-10	0
Potable Water Use (gpm)	3-8	1-2	1-2	0
Sluice Trough (gpm)	2-15	2-15	2-15	0



Pre-rinse spray valves (PRSVs) are used to rinse dishes prior to being placed in the dishwasher. Since 2005, the Federal energy code has required that spray valves use no more than 1.6 gpm. New models have even lower flow rates[3]. The picture on the left shows an old type spray valve using four gallons per minute while the picture on the right shows one using only 1.6 gallons per minute.

[3] Anecdotal information from the field indicates that, in some cases, PRSV flow rates below 1.3 gpm result in longer cleaning times and the additional water use may offset any predicted water savings. The U.S. EPA's WaterSense program will be releasing a draft specification for PRSVs that will likely set the maximum flow rate near 1.3 gpm.

Another water-using device found in some larger facilities is a powered pot-soaking tank. Pots and pans are placed in the tank containing hot water with a special detergent. Pumps circulate the water around the tank softening cooked-on food deposits. These tanks are normally filled at the beginning of the day and dumped down the drain at the end of the day. In especially busy restaurants, it may need dumping and filling more often.

As the above equipment examples show, washing and sanitizing dishware in commercial food service involves much more than just a dishwasher. The amount of water used to clean and sanitize involves the total water use of all of this equipment. Although the focus of this report is only on dishwashing equipment, it is important to keep the above uses in mind.

IV. Types of Equipment

In food service establishments, the dishwasher is one of the busiest pieces of water-using equipment in the facility. Commercial dishwashers are very different from those found typically in a home. Residential dishwashers use from 3.0 to 10 gallons per load and the wash cycle lasts for half hour or more[4]. Commercial dishwashers, on the other hand, have run times that are from one to three minutes and may wash many hundreds of loads per day.

Furthermore, the commercial dishwasher market is different from that of other commercial food service equipment. Many dishwashers are not owned by the individual restaurant or food service operator and instead are leased to the operation by chemical sales companies. Most institutional facilities, however, tend to purchase equipment. Most machines are used five to six hours per day, many of which are operating 365 days a year.

The equipment described here includes both standard dishwashing machines and those designed for washing trays, glassware only, and pots and pans. To understand the technologies available, three equipment variants are described.

1. Fill-and-dump machines: dump water after each wash (as opposed to the type that house holding tanks and supply make-up water through the rinse cycle). For those with holding tanks, the number of tanks can vary from one to three. These holding tanks allow dishwashers to recycle water from one load to the next and reduce energy use by reducing the need for water heating.

2. The second variant relates to how dishes are sanitized.

    - Most commonly found in small restaurants is the chemical type machine, also known as the low-temperature machine. This type typically uses a chlorine-based disinfectant to sanitize the dishes. These chemicals can often damage plastic and flat ware but the lower temperatures are desired for items that have low heat tolerance.

    - The other type is the high temperature machine. The high-temperature machine uses water at 180^{o} F (82^{o} C) or higher for sanitation and employs a booster heater to achieve these high water temperatures. These machines do not require the addition of chlorine-containing chemicals and do not damage flatware or plastic dishes.

3. The third variant has to do with the basic design of the washer. Four fairly distinct types of equipment exist:

[4] Refer to previous PBMP report on residential dishwashers dated October 31, 2006. Report may be found at www.cuwcc.org/WorkArea/showcontent.aspx?id=7964

Under-counter types are commonly found in bars where only glassware is washed or in small restaurants serving fewer than 60 persons per day. They generally use heat to sanitize and are the closest to residential dishwashers in design.

The door- or hood-types are primarily found in restaurants that serve fewer than 150 customers a day. Racks holding dishes[5] are either hand loaded into the machine or loaded with an automatic system.

The C-Line or conveyor-type machine pulls the rack of dishes through the washer and pushes the clean rack out the other side. Larger restaurants serving between 150 and 300 people a day commonly use this type.

The flight-type machine is designed for service to many hundreds or even thousands of people per day. They are typically found in large institutional facilities, hospitals and large hotels with banquet facilities. These machines have a continuously moving belt with pegs or fingers onto which the dishes are placed.

[5] Generally of 20-in. by 20-in. size, roughly the size of those commonly found in most residential dishwashers.

Most dishwashers use dish racks of some type to hold the dishes so that they can be effectively cleaned and sanitized as they pass through the machine. (The exception is the flight-type that instead uses moving pegs.) As noted earlier, these racks are normally 20-in. by 20-in. in size. The amount of dishes and utensils fitting into a standard rack depends upon the size of that dishware. Typically, two to three place settings[6] can be loaded in one rack for a sit-down type restaurant. However, if it is a cafeteria or buffet where individual dishes may be used for each serving, this ratio will decrease. According to Champion[7], a major dishwasher manufacturer, the typical 20-in. by 20–in. rack will hold 14 plates, or 25 glasses and 100 pieces for flatware[8].

Equipment not considered: As a final note on types of equipment considered, lab ware, surgical instrument washers, and laboratory animal cage washers look much like the dishwashing equipment described above but are designed for very different purposes and operate differently as well. This latter equipment is not a part of this discussion or analysis.

[6] A place setting includes plates, saucers, cups glasses and silverware.

[7] Personal communication: Ms. Suzanne Painter-Supplee, Director of Consulting Services, Champion Industries

[8] Flatware must be run twice, so that is equivalent to 50 pieces of flatware.

V. Market Dynamics

The commercial dishwasher market has several interesting facets not found with other equipment. First, much of the equipment available on the market is leased to the restaurant or food service operator. This is especially true for door- and hood-type units. The companies selling chemicals to the restaurant operator lease machines that use their chemicals and detergents.

According to a U.S. Environmental Protection Agency (EPA) estimate, there were 505,000 commercial dishwashers in the United States in 2001. Table 3 summarizes the number and sales of commercial dishwashers based on the U.S. EPA information. Considering the ratio of 2009 to 2001 population for the United States, there are estimated to be about 540,000 dishwashers in the United States today.

In 2009, the U.S. EPA market analysis of Energy Star® dishwasher market penetration reported that in 2008, approximately 23,550 machines were sold and that 83 percent met Energy Star® criteria to qualify for inclusion on the Energy Star® list[9]. See Figure 3. This shows a very different sales distribution than that reported by the North American Association of Food Equipment Manufacturers (NAFEM) in Table 4. Based on Table 3 and Figure 3, national sales are in the range of 20,000 to 40,000 units a year. California sales are, therefore, estimated to be in the range of 2,000 to 4,500 units a year.

Table 3. Commercial Dishwashers and Sales Estimates

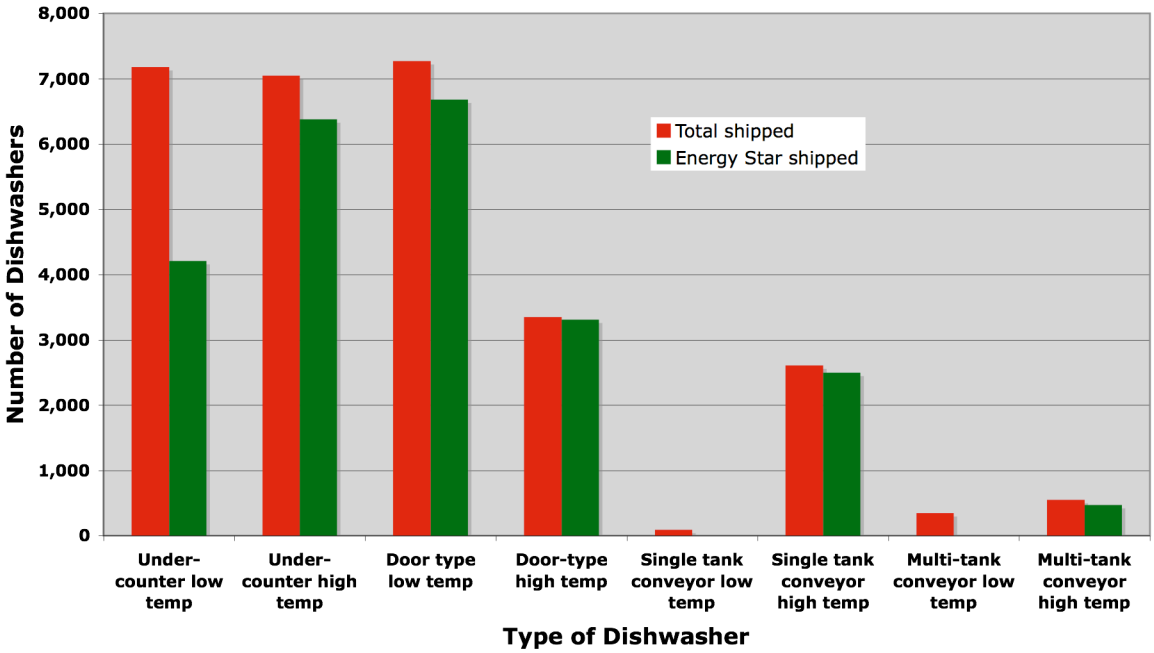
Dishwasher Type	Number of Units Installed as of 2001*	Percent of Total Installed	2003 Sales of New Units**	Percent of 2003 Sales
Under Counter	60,000	12%	12,206	33%
Door Type	325,000	65%	17,949	48%
Conveyor Type	90,000	18%	6,700	18%
Flight Type	25,000	5%	465	1%
TOTALS	**505,000**	**100%**	**37,320**	**100%**

Sources:
U.S. EPA, 2006, Energy Star® for Commercial Dishwashers: Sizing up the Savings Opportunity, by Rachel Schmeltz, U.S. EPA, June 14
* Food Service Technology Center, 2005, Food Service Technology Center, Todd Bell
**NAFEM 2004 – "Size and Shape of the Industry"

[9] Source: ICF International, 2009. Breakdown of 2008 Energy Star® Unit Shipment Data, October

Figure 3. Commercial Dishwashers - 2008 Unit Shipments

(Total shipped and Energy Star® shipped)



Source: ICF International, 2009. Breakdown of 2008 Energy Star® Unit Shipment Data, October

Based on the 2009 estimate of 540,000 machines in the United States and California's percent of the total U.S. population, it is estimated that there are approximately 65,900 commercial dishwashing machines in California. If the distribution of machines is assumed to be the same as that shown in Table 3, the breakdown by type would be as represented by Table 4.

Table 4. Estimated Number of Commercial Dishwashers in California

Dishwasher Type	Numbers in California
Under-counter	7,900
Door-Type – High Temp	26,300
Door-Type – Low Temp	16,500
Conveyor- Type	11,900
Flight Type	3,300
Total	65,900

The cost of dishwashing equipment varies based on type, size, and efficiency. In recent years, the cost difference between average and efficient dishwashing equipment has grown smaller. The Consortium for Energy Efficiency (CEE) estimates that Energy Star® dishwashers are some 20 percent to 25 percent more expensive than the conventional product on the market. However, as Figure 3 shows, the market is closing as larger percentage of models sold are Energy Star® qualified. Table 5 is from the CEE report entitled "Program Design Guidance - Commercial Dishwashers".

Table 5. Cost Difference for Energy Star® Commercial Dishwashers

Dishwasher Type	Number of CEE/ENERGY STAR Qualified Products Offered	Estimated Standard Equipment Cost	Estimated CEE High Efficiency /ENERGY STAR Equipment Cost	Estimated Incremental Cost
High Temperature, Multiple Tank Conveyor	23	$20,000	$24,000	$4,000
High Temperature, Single Tank Conveyor	41	$12,000	$15,000	$3,000
High Temperature, Door Type	24	$6,900	$9,000	$2,100
High Temperature, Under Counter	6	$5,000	$6,000	$1,000
Low Temperature, Multiple Tank Conveyor	0	$18,000	$22,000	$4,000
Low Temperature, Single Tank Conveyor	3	$11,000	$14,000	$3,000
Low Temperature, Door Type	11	$6,500	$8,500	$2,000
Low Temperature, Under Counter	19	$4,800	$5,800	$1,000
High/Low Temperature, Multiple Tank Conveyor	7	Use high temp cost	Use high temp cost	Use high temp cost
High/Low Temperature, Single Tank Conveyor	15	Use high temp cost	Use high temp cost	Use high temp cost
High Low Temperature, Door Type	4	Use high temp cost	Use high temp cost	Use high temp cost

The life expectancy of dishwashing equipment as established by CEE is summarized in Table 6.

Table 6. Typical Life Expectancy for Commercial Dishwashers

Dishwasher Type	Years
Under Counter	10
Door Type	15
Conveyor	20
Flight Type	20+

Source: Consortium for Energy Efficiency "Program Design Guidance - Commercial Dishwashers"

Another factor to consider is that dishwashing equipment is often rebuilt for the secondary sales and lease market, largely because rebuilding and re-selling an older, existing machine is much less costly to the food service operator than the purchase of a new machine. This means that many older, inefficient models are still in use and will remain so.

VI. Water Use Characteristics

The primary use of water by commercial dishwashers is for washing and rinsing dishes. The amount of water used for this process varies with the type, model and method of sanitation. In some cases, however, potable water can *also* be used for drain water tempering where code requirements set a maximum temperature of 140 °F (60°C) for drain water.

Drain Water Tempering

Drain water tempering kits are now being installed in some cases. They work by opening a potable water valve whenever the water being discharged from a dishwashing machine exceeds the code maximum. For example the Uniform Plumbing Code, 2009, paragraph 810.1 reads as follows[10]:

> *"No steam pipe shall be directly connected to any part of a plumbing or drainage system, nor shall any water having a temperature above 140°F (60°C) be discharged under pressure directly into any part of a drainage system."*

The following information is from the Hobart web page describing their information on water tempering[11].

> ***Requirement:*** *If water at or above 140 degrees Fahrenheit will be drained in cooking equipment with steamers and warewashers, a drain-water-tempering kit must be installed in the equipment to ensure the water does not soften the plastic piping.*
> ***Avoid the violation:*** *Prior to ordering cooking equipment, find out if draining water temperatures will be at or will exceed 140 degrees Fahrenheit. It is easier and more cost efficient to install the drain-water-tempering kit during the installation process rather than to add the kit after the equipment has been installed. If the water temperature is unknown, it is recommended that a measurement be taken. Though the final rinse water temperature on a conveyor dishwasher is 180 degrees Fahrenheit, it cools rapidly when sprayed through the final rinse nozzle and therefore might not exceed 140 degrees Fahrenheit by the time it enters the drain.*

Drain water tempering devices should not be installed unless absolutely necessary, since they usually lead to excessive water waste. Check with code officials and the dishwasher machine manufacturer before installing such devices.

Reaching Limits

The U.S. EPA Energy Star® criterion represents the lower end of water use and, in fact, may have already approached what is technologically feasible for the commercial dishwasher. For example, consider the multi-tank conveyor maximum water use threshold level of 0.54 gallons per rack. A rack holds 14 plates, so this is equal to about a half cup of water per plate to thoroughly wash, rinse and heat the plate to the sanitation temperature.

[10] International Association of Plumbing & Mechanical Officials, 2009. 2009 Uniform Plumbing Code, an American National Standard, IAPMO/ANSI UPC 1 -2009

[11] http://www.hobartcorp.com/consultants/SegmentTrends/K12Schools/FoodEquipmentCodes

Water Use Information

Under-counter, door- and conveyor-type machines

The amount of water used to wash a rack of dishes for under-counter, door, and conveyor machines varies with the model of machine and the type of sanitizing process used. Similar factors impact flight-type dishwashers, but since racks are not used in these machines, the parameter for comparison is gallons per dish washed. NSF International publishes dishwasher data for all available models[12].

NSF information was used to establish the U.S. EPA Energy Star® criterion and for analysis by others. The NSF database is updated regularly as new product is developed by manufacturers. That information can be used to calculate water use per rack for all except flight machines. Table 7 displays the U.S. EPA Energy Star® commercial dishwasher criteria for those dishwasher types that it currently specifies.

Table 7. Energy Star® Efficiency Requirements for Commercial Dishwashers

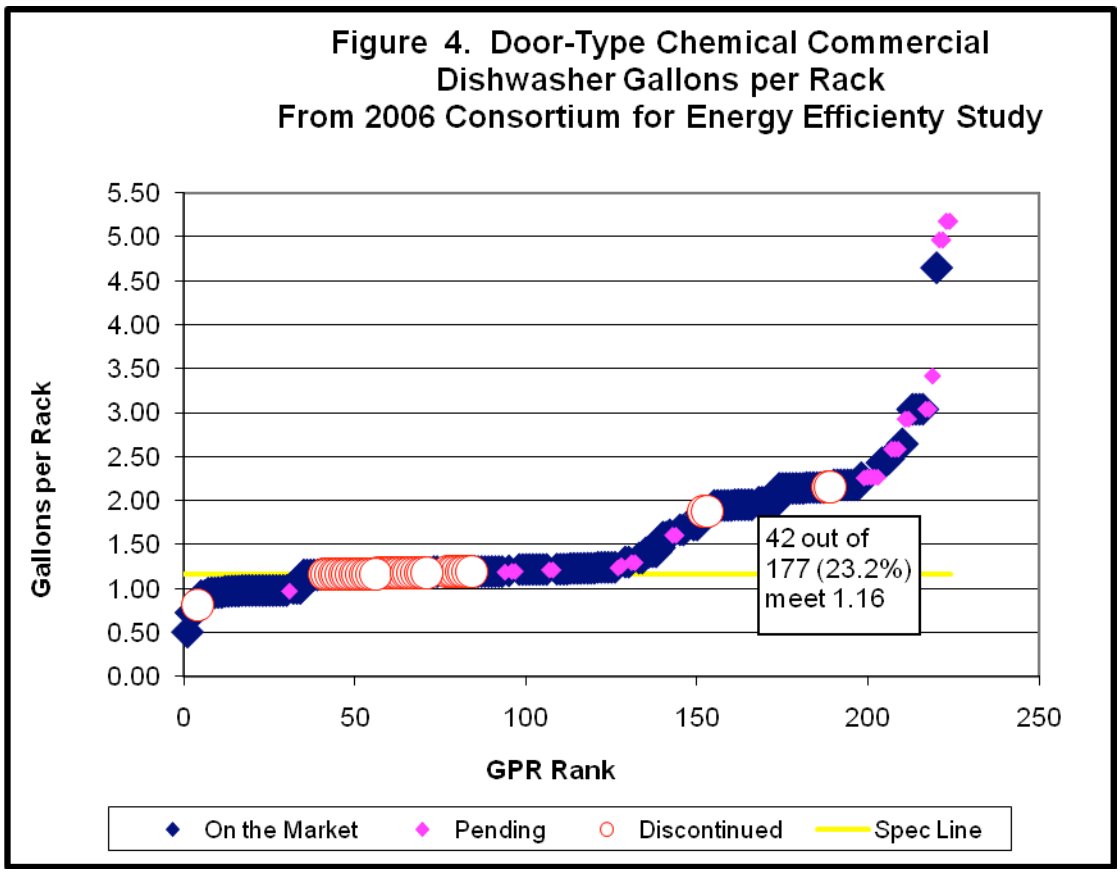
	High Temperature Machine Requirements		Low Temperature Machine Requirements	
Dishwasher Type	Idle Energy Rate*	Water Use**	Idle Energy Rate*	Water Use**
Under-Counter	<= 0.9kW	= 1.00 gal/rack	<= 0.50kW	= 1.70 gal/rack
Stationary Single Tank**	<= 1.0 kW	<=0.90 gal/rack	<= 0.6 kW	<=1.18 gal/rack
Single Tank Conveyor	<= 2.0 kW	<= 0.70 gal/rack	<= 1.6 kW	<= 0.79 gal/rack
Multi Tank Conveyor	<= 2.6 kW	<= 0.54 gal/rack	<= 2.0 kW	<= 0.54 gal/rack

*Idle energy rate measured with door closed and representative of the energy used by the tank heater only.
** Includes pot, pan, and utensil machines.

Energy Star® qualified dishwashers are reported to use at least 41 percent less energy than the Federal minimum standard for energy consumption and much less water than conventional models. Other data has been developed for this study for conveyor and flight type dishwashers using the NSF International December 2009 data.

To develop the water data, water use information from a variety of available sources was examined. For example, the door-type chemical sanitizing data from a 2006 CEE study shows that water use for this type of equipment ranged from 0.5 to over 5.0 gallons per rack. This is shown in Figure 4.

[12] That data can be found at: http://www.nsf.org/Certified/food/Listings.asp?Standard=003



Flight-type dishwashers

Energy Star® criterion have not yet been developed for flight-type machines, although it is reported that plans exist to do so. Tables 8 and 9 summarize water use characteristics for both single-tank and multi-tank flight-type commercial dishwashers. Three parameters to rank efficiency were developed based on NSF International data. These were the:

- gallons used per square foot of the flight conveyor belt surface moving through the machine,
- gallons used per dish using the NSF International equations to estimate and
- gallons used per rack equivalent based on the standard 20-inch by 20-inch rack.

The gallons per dish is the most common parameter used by the industry to compare flight-type machines; as such, all data was sorted on that parameter. Tables 8 and 9 show the lowest quartile level, which roughly corresponds to where Energy Star® initially sets most of their qualification thresholds.

It is important to note that very efficient flight-type models do exist.

Table 8. Single Tank Hot Water Flight-Type Water Use Characteristics for 17 models			
	Gal. / sq ft	Gal. / Dish	Gal. / Rack Equivalent
Maximum	0.61	0.031	1.70
Average	0.30	0.0185	0.83
Median	0.14	0.013	0.40
Lowest Quartile	0.11	0.009	0.30
Lowest	0.07	0.007	0.21

Table 9. Multi-Tank Hot Water Flight-Type Water Use Characteristics for 83 models			
	Gal. / sq ft	Gal. / Dish	Gal. / Rack Equivalent
Maximum	0.45	0.041	1.26
Average	0.21	0.020	0.58
Median	0.19	0.017	0.52
Lowest Quartile	0.07	0.010	0.20
Lowest	0.05	0.005	0.13

Summary of water use – all machine types

Table 10 summarizes water use information from the various sources. In order to determine what would constitute very wasteful equipment, the 75th percentile figure for water use was chosen as the efficiency threshold. The table identifies what represents the current state of the market and provides insight as to the efficiency of the approximately 65,900 commercial dishwashers currently in use in California.

For the purposes of the study, the medial data for 2006 (or 2009 if the 2006 data is not available) was used to represent the water use for the base case estimates of total water used by commercial dishwashers in California. The 2010 Energy Star median number of qualified equipment was used as the water saving case.

Table 10. Examples of Commercial Dishwasher Use

75th percentile - 75% of machines are lower
Median - half of machines are lower

Hot Water Type Dishwashing Machines

	Units	75th percentile 2006	75th percentile 2009	Median for 2009 Machines	Median for 2006 Machines	Energy Star® Threshold	Energy Star® 2010 Median
Under Counter	Gal/rack	1.75			1.20	1.00	0.79
Door Type	Gal/rack	1.33			1.18	0.95	0.79
Single Tank Conveyor	Gal/rack	1.12	0.95	0.70	0.94	0.70	0.51
Multi-Tank Conveyor	Gal/rack		1.10	0.77		0.54	0.39
Single Tank Flight	Gal/plate		0.031	0.015			
Multi Tank Flight	Gal/ plate		0.032	0.017			

Chemical Type Dishwashing Machines

	Units	75th percentile 2006	75th percentile 2009	Median for 2009 Machines	Median for 2006 Machines	Energy Star® Threshold	Energy Star® 2010 Median
Under Counter	Gal/rack	1.87			1.75	1.70	1.18
Door Type	Gal/rack	1.98			1.22	1.18	1.09
Single Tank Conveyor	Gal/rack	1.22	1.08	0.79	0.95	0.79	0.49
Multi Tank Conveyor	Gal/rack		0.58	0.53		0.54	0.49
Multi Tank Flight	Gal/ plate		0.012	0.12			

Note: Shaded areas indicate that data was not available.
Sources: NSF International for dishwashers for 2006 and 2009, Energy Star, and CEE Commercial Kitchens Study.

Dumping of Wash Tanks

All dishwashers hold water in a reservoir called a wash tank. These tanks are necessary in order to allow the recirculating pumps to operate and to store water between washes. The volume of these wash tanks can range from under two gallons for an under-counter machine to up to 65 gallons for large flight-type systems. According to manufacturer specifications, door-type machines are supposed to be dumped every two hours of operation while others are dumped to drain after each meal. When the dishwasher is started again at the beginning of the next workday, the tanks must be refilled and reheated. If the average volume of these tanks is 15 to 20 gallons, they are dumped from one to three times per day, and there are an estimated 65,900 machines in California, this amounts to estimated water waste in the range of 2,000 to 5,000 acre feet per year.

VII. Potential Future Water Savings for California

Table 11 shows the median values for all machines currently in the marketplace, the median value for those that are listed by Energy Star®, and the difference, all derived from the information in Table 10. In Table 11, the expected savings of the average machine in use today was replaced with the median Energy Star® qualified machine.

Table 11. Estimated Water Savings per Rack or Plate (gallons)

Hot Water Type Dishwashing Machines				
Type	Market Median	Energy Star® Median	Savings	Measurement
Under- Counter	1.20	0.79	0.410	Gallons per rack
Door	1.18	0.79	0.390	Gallons per rack
Single Tank Conveyor	0.94	0.51	0.430	Gallons per rack
Multi-Tank Conveyor	0.77	0.39	0.380	Gallons per rack
Single Tank Flight	0.015	.010	0.005	Gallons per plate
Multi-Tank Flight	0.017	.009	0.008	Gallons per plate
Chemical Type Dishwashing Machines				
Type	Market Median	Energy Star® Median	Savings	Measurement
Under- Counter	1.75	1.18	0.570	Gallons per rack
Door	1.22	1.09	0.130	Gallons per rack
Single Tank Conveyor	0.95	0.49	0.460	Gallons per rack
Multi-Tank Conveyor	0.53	0.49	0.040	Gallons per rack
Multi Tank Flight	0.012	0.009 equivalent	0.003	Gallons per plate

Estimating the average number of racks or plates washed per hour or per day is a guess at best. An analysis was performed with assumed volumes of washer throughput. The Restaurant Report website[13] provides the maximum racks per hour for various types of dishwashing equipment. It is further assumed that the actual number of racks washed is only 50 percent of the maximum and that the machines are in operation for 5.0 hours per day. Table 12 summarizes the results of this analysis.

[13] http://www.restaurantreport.com/departments/restaurant-dishwasher-buying-guide.html

Table 12. Estimated Dishwasher Use*				
Meals/hour	Dishwasher type	Max racks per hour	Assumed Actual racks per hour	Racks per day based on 5.5 hours of operation
Up to 100	Under-counter	35	17.5	88
100-500	Door	125	62.5	313
500-2000	Conveyor	425	225	1,125
2000+	Flight**	11,450 plates per hour	5,000*** Plates per hour	25,000 Plates per day

* Based on http://www.restaurantreport.com/departments/restaurant-dishwasher-buying-guide.html
** Flight systems measured in plates per hour.
*** The average flight machine can process up to 11,450 plates per hour, but 5,000 is used as a more reasonable estimate of through-put for this analysis

Using the estimated numbers of machines in California shown in Table 4, the estimated number or racks or plates washed per day, and the savings per rack or plate, the total annual savings was calculated. The estimated savings were collapsed into four dishwasher types: under-counter, door, conveyor and flight. Table 13 summarizes these savings.

Table 13. Estimated Total Annual Potential Water Savings in California						
Dishwasher Type	Esti-mated Number in California	Saving per Operation* *(gallons)*	Operations * per day	Market Medial *(acre-feet per year)*	Energy Star® Median *(acre-feet per year)*	Annual Savings *(acre-feet per year)*
Under-counter	7,900	0.49	88	1,149	767	382
Door-Type	42,800	0.26	313	18,007	14,106	3,905
Conveyor-Type	11,900	0.328	1,125	11,959	7,048	4,895
Flight Type*	3,300	0.005	25,000	1,355	863	493
			TOTAL	32,470	22,783	**9,674**

* For flight machines one operation is one dish washed. For all others, it is one rack washed.

The table shows that current machines use a little over 32,000 acre-feet of water per year for washing dishes. Another 4,000 acre-feet are used when the machines are dumped to exchange water. Therefore, total use is in the order of 36,000 acre-feet a year.

The results show that by operating *only* with the median Energy Star® qualified machines, California can save about 10,000 acre-feet of water annually.

VIII. Rebates, Requirements and Incentives

Requirements to Qualify as an Energy Star® Commercial Dishwasher

The U.S. EPA Energy Star® Program began listing commercial dishwashers in 2006. Commercial dishwashers have both energy and a water use criteria. Energy Star® has continuously revised their product list as new, more efficient equipment is developed and introduced to the marketplace. Because many commercial dishwashers now meet the Energy Star® requirements and qualify to be labeled[14], EPA is considering a revision to their requirements in the near future. The current requirements are shown in Table 7 and meet the requirements of Energy Law, Article 5, Section 5-108a and Executive Order No. 111.

To be listed as an Energy Star® Qualified Commercial Dishwasher, the manufacturer must test their equipment using the following test procedures.

- **Water Consumption:** NSF/ANSI 3-2007 Standard, Commercial Dishwashing Equipment.
- **Idle Energy Rate for Hot Water and Chemical Sanitizing Under Counter and Stationary Rack Single Tank Door-Type Dishwashers:** ASTM Standard F1696, Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, Door-Type Commercial Dishwashing Machines.
- **Idle Energy Rate for Hot Water and Chemical Sanitizing Single and Multiple Tank Rack Conveyor Dishwashers:** ASTM Standard F1920, Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines.

Rebates and Incentives

California does not currently have specific water or energy efficiency incentives directed at commercial dishwashers as it does for several other types of commercial food service equipment, such as ice machines and food steamers. However, some local utilities in California do offer rebates for commercial dishwashers within their service area. For example, the Marin Municipal Water Department offers a $500 rebate.

Likewise, several other areas in the U.S. offer modest rebates, such as in Washington State and Southern Minnesota. The Seattle area programs are summarized in Table 15 and the Minnesota programs are summarized in Table 16.

[14] 83 percent of all dishwashers sold in 2008 were Energy Star qualified. See Figure 3.

Table 15. Seattle Washington Area Commercial Dishwasher Rebates ($/Unit)					
Dishwasher Type	Puget Sound Electric	Snohomish County PUD	Tacoma Power	Seattle City Lights	Cascade Natural
ENERGY STAR® Dishwasher, Under-Counter, Low Temp	$250	$250	$250	$250	$100
ENERGY STAR® Dishwasher, Under-Counter, Hi Temp *	$500	$500	$400	$500	$500
ENERGY STAR® Dishwasher, Door Type, Low Temp	$1,000	$1,000	$650	$1,000	$1,000
ENERGY STAR® Dishwasher, Door Type, Hi Temp*	$1,000	$1,000	$1,000	$1,000	$1,000
ENERGY STAR® Dishwasher, Single Tank Conveyor, Low Temp	$1,000	$1,000	$1,000	$1,000	$1,500
ENERGY STAR® Dishwasher, Single Tank Conveyor, Hi Temp*	$1,500	$1,500	$1,500	$1,500	$1,500
ENERGY STAR® Dishwasher, Multi-Tank Conveyor, Low Temp	$1,500	$1,500	$1,500	$1,500	$2,500
ENERGY STAR® Dishwasher, Multi-Tank Conveyor, Hi Temp*	$2,000	$2,000	$2,000	$2,000	$2,500

Table 16. Southern Minnesota Municipal Power Agency Dishwasher Rebates http://www.smmpa.org/members.asp	
Dishwasher Type	Rebate Amount
Undercounted dishwashers	$300
Single tank door dishwashers	$600
Single tank conveyor dishwashers	$800
Multiple tank conveyor dishwashers	$1,000