Equipoise Consulting, Inc.

Energy Analysis

Project Management

Training

Final Report for

Pacific Gas and Electric Company's Non-Energy Benefits of Energy Efficient Washing Machines Assessment

Submitted by:

Equipoise Consulting Incorporated

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Table of Contents

Table of Exhibits

1. EXECUTIVE SUMMARY

This report provides results of the study of the non-energy benefits of Energy Star® clothes washers and dishwashers rebated under Pacific Gas and Electric's (PG&E's) residential programs.

This assessment is based on an extensive review of literature and Internet sources, telephone interviews with persons knowledgeable about clothes washer and dishwasher efficiency, and primary data collection on detergent recommended dosages and costs. The data were analyzed to estimate the monetary benefits that resulted from changes in the non-energy costs associated with the retrofit of high efficiency appliances. For clothes washers, monetary savings were determined for the reduction of water and sewer use, decreased dryer energy use based on lower remaining moisture content in the clothing washed in Energy Star® washers, and reduced detergent use. For Energy Star® dishwashers, only savings from decreased water and sewer water were calculated. Savings were determined both annually and for the life of the appliance. The life cycle calculation used an effective useful life of 14 years for clothes washers and 13 years for dishwashers. Exhibit 1.1 provides the results of this study.

Exhibit 1.1
Non-Energy Monetary Savings from Energy Star® Washer Retrofits

Appliance	*Item*	*Annual Savings*	*Life Cycle Savings*
Clothes Washer	Water & Sewer	$ 18.06	$ 187.67
	Dryer	$ 10.85	$ 112.78
	Detergent	$ 23.95	$ 248.88
	Total	**$ 52.85**	**$ 549.34**
Dishwasher	Water & Sewer	$ 1.65	$ 16.28

This report fully discusses how the savings were calculated and how the data were generated and used. However, the following provides a short discussion on each savings category.

In the PG&E service territory, water and sewer rates are currently low.[1] With the marginal water/sewer costs at less than one cent per gallon, savings are minimal unless there is a large reduction in the amount of water used. The Energy Star® clothes washer saves up to 50% of the water used by a regular clothes washer. The typical clothes washer is used approximately 392 times a year. Annually, this measure saves about 5%-6% of the water typically used at a residence. The Energy Star® dishwashers can also use less water than conventional dishwashers. However, they often have soil sensors that can substantially reduce water savings. The average difference in water use between an Energy Star® and a conventional dishwasher is slight and is reflected in the monetary savings.

Dryer savings occur because Energy Star® clothes washers leave less water in clothes than conventional washers. For this analysis, it was estimated that about 20% less water was left

[1] Water rates from a survey performed in 2000 for 90% of the water service companies were used to determine the current rate.

in the clothing to be subsequently removed by the dryer. A small amount of dryer motor savings also occurs in dryers with moisture sensors that cause the appliance to turn off as soon as the clothes are dry.

Clothes washer detergent savings are controversial. Savings depend purely on whether a customer uses the new high efficiency (HE) soaps or the older "regular" detergent. If the customer continues to use their regular detergent, it was estimated that they use about ½ of the regular dose to keep sudsing at acceptable levels. There are obvious savings for this scenario. However, the HE detergents are actually more expensive to use per load than regular detergent. If a customer uses HE detergent exclusively, they will spend more money on detergent than if they had a conventional washer. The cost reduction from using a ½ dosage of the regular detergent is about equal to the spending increase when using the HE detergent at its recommended dosage. However, a 1998 survey of Energy Star® clothes washer users showed that 77% continued to use their regular detergent with the Energy Star® washer. This study did not ask what dosage of the regular detergent was used; however, Energy Star® washers will over suds with a full dosage of regular detergent. Since the most common recommendation currently available in the industry is ½ dosage when using regular detergent in Energy Star® washers, this dosage was used, along with the 77% customer usage rate, to estimate the savings shown in this study.

2. INTRODUCTION

Pacific Gas and Electric Company's (PG&E's) overall goal was to obtain sound estimates of the non-energy benefits of rebated clothes and dishwashing machines. In this case, non-energy benefits included measurable monetary savings from reduced water usage, clothes dryer operation, and detergent usage. This project was not tasked with revisiting the existing program estimates of motor savings or the hot water heating savings of these appliances.

PG&E has been offering rebates on high efficiency clothes washers since the mid-1980's, but only in recent years has market penetration increased. PG&E has been offering rebates for energy efficient dishwashers since 1999. Rebates on these machines have recently increased, according to the PG&E program manager.

This report outlines the assessment methodology and data sources employed to complete the analysis and presents the results of study.

2.1 Study Issues

Equipoise Consulting Incorporated (Equipoise) identified the following issues as relevant to this study:

- **Dispersed Information Sources.** Information sources on water rates, detergent recommendations and types, and wastewater disposal costs are dispersed widely. Gathering information and finding centralized sources of information was anticipated to be a challenge.
- **Data Time Delay.** PG&E requires estimates for the machines that are currently being rebated, which are the most recent machines. Published data are often on older models, somewhat limiting their usefulness.

Equipoise clearly understood these issues and strove to implement compensating approaches. The methodology was designed to minimize the effects of the evaluation issues listed above.

3. METHODOLOGY

This section provides an overview of the methods used for assessing the non-energy benefits of clothes and dishwashing machines. PG&E does not track rebates by brand and model for either clothes washers or dishwashers. Since some of the water and dryer savings data were available by brand/model, the review attempted to find and use market share information by brand/model to establish proportional savings. However, this data could not be located and simple averages of the values obtained were used to develop "typical" per machine estimates of savings. The project addressed water usage savings, clothes dryer savings, and detergent usage savings.

3.1 Data Sources

The majority of the data for this analysis were extracted from existing data sources through an exhaustive review of literature and Internet sources. A complete bibliography, consisting of more than 70 items, is presented in Appendix A. Equipoise also conducted informal telephone discussions with various persons involved in clothes washer and dishwasher energy efficiency research. Primary data on detergent costs were gathered at Albertson's, Safeway, and Costco.

Water Savings – Water savings estimates came from the review of literature/Internet sources. To convert gallons of water saved information into dollars saved, information on water rates was obtained for the PG&E service territory. The California Water Charge Survey and the California Sewer Rate Survey, each conducted bi-annually by Black and Veatch, were the sources of information used in the analysis.

Dryer Saving – Energy efficient clothes washers are more efficient at extracting water from the clothes after the final rinse. This results in less energy being required to dry the clothes. Dryer savings estimates came from the literature/Internet review and average PG&E energy rates (kWh and therm) for the past twelve months.

Detergent Savings – Energy Star® clothes washers are typically horizontal axis machines. Using the same amount of regular detergent that would be used in a vertical axis machine in a horizontal axis machine causes over-sudsing. While two companies sell detergent specifically designed to eliminate this problem in high efficiency machines, not all consumers can find or choose to purchase that type of detergent. While much effort was put towards finding quantitative amounts of detergent use in actual households with Energy Star® clothes washers, nothing unequivocal was found. Equipoise quantified the cost savings associated with reduced detergent use by gathering cost of detergents from Albertson's, Safeway, and Costco, purchasing selected detergents to identify actual dosages, and using information from the literature/Internet review.

As stated earlier, this project did not revisit the motor savings or hot water heating savings since they are already captured in the current program savings estimates.

3.2 Analysis Approach

While the literature/Internet review spread a wide net for any bits of useful information, the analysis was specific to type of appliance and savings. Each of the appliance and savings

categories will be discussed in detail. Discussion of the approach used to convert the water or energy savings into monetary savings follows that detail.

3.2.1 Clothes Washer Analysis

Non-energy benefits from Energy Star® clothes washers come from several different sources. One source is the water savings seen when moving from the conventional vertical axis washer to a horizontal axis washer. Most of the current Energy Star® washers use a horizontal axis. This design allows the clothes to tumble into and out of a small amount of water rather than being fully submersed in water as in the vertical axis machine. The horizontal axis configuration also allows for a faster spin, resulting in less water left in the clothing. This decreases the dryer energy requirement as well as the time needed to dry the clothes. Lastly, the tumbling action in the horizontal axis machine causes the regular detergent to over-suds if used in the same amount as in a vertical axis machine. Two detergent manufacturers have addressed this issue by formulating "high efficiency" (HE) detergents designed for the low water use/energy efficient machines. However, clothes can also be washed using smaller dosages of the regular detergent, leading to savings from less detergent use.

Details of the three areas of the clothes washer analysis follows next.

3.2.1.1 Water Savings Analysis

The water savings analysis determined the difference in water usage between conventional washers and Energy Star® washers. Water use for the conventional washer was estimated from data in the Federal Register of gallons/cycle of clothes washers in use today.[2] A list of qualifying appliances was downloaded from the Energy Star® site and used to calculate the average gallons of water used per cycle for Energy Star® washers. The average number of cycles per year used in testing for the energy factor was used in this analysis to determine annual water savings per machine. [3] The algorithm used to calculate savings is shown in Exhibit 3.1.

Exhibit 3.1
Clothes Washer Water Savings Algorithm

$$\text{Water Savings per Machine} = \left(\left(\frac{\text{Gallons}}{\text{Cycle}} \right)_{\text{Conventional}} - \left(\frac{\text{Gallons}}{\text{Cycle}} \right)_{\text{EnergyStar}} \right) * \frac{\text{Cycles}}{\text{Year}}$$

3.2.1.2 Dryer Savings Analysis

The Energy Star® washer spins faster than a conventional washer, extracting more water from the clothing prior to using the dryer. In the industry vernacular this is referred to as the Remaining Moisture Content (RMC). The RMC is lower for Energy Star® washers. Most of the savings seen at the dryer are based on the fact that less water must be subsequently

[2] Appendix A. Item 15.
[3] Ibid.

removed from the clothes. However, if a dryer uses moisture sensing equipment to turn off the appliance as soon as the clothes are dry, there will also be some savings seen in the motor from a shorter drying time. This analysis used data from multiple sources to estimate the kWh and therm savings seen by a typical dryer when used to dry clothes washed in a typical Energy Star® washer.

The first effort was to determine what the RMC was for a conventional washer and for an Energy Star® washer. The RMC value for conventional machines came from the Consortium for Energy Efficiency (CEE) site.[4] The data from the Energy Star® site on qualifying appliances were used to calculate the RMC for each qualifying machine. This was then averaged to develop the RMC for the typical Energy Star® washer. The values for each Energy Star® machine are provided in Appendix B.

After the RMC values were known, a calculation of the actual difference in water was needed. The CEE site program description provided an average dry weight of clothing that corresponded well to other figures found throughout the literature.[5] A wet weight was calculated using this dry weight and the RMC. Then the pounds of water difference between a conventional washer and Energy Star® washer was determined. The California Energy Commission (CEC) specifies a minimum efficiency for dryers in pounds/kWh unit (for both electric and natural gas dryers). Combined with the difference in water weight from previous calculations, a kWh/cycle or therm/cycle was determined. As with the clothes washer, the average number of dryer cycles per year used in testing for the dryer energy factor was used in this analysis to determine annual dryer savings per clothes washing machine.

The algorithm used to calculate dryer savings is shown in Exhibit 3.2.

Exhibit 3.2
Annual Dryer Savings Algorithm

$$\text{Annual Dryer Savings}_{\text{electric}} = \left[\frac{\Delta \text{ pounds of water removed per cycle}}{\text{efficiency of dryer (lb/kWh)}} + \frac{\text{motor kWh savings}}{\text{cycle}} \right] * \frac{\text{cycles}}{\text{year}}$$

$$\text{Annual Dryer Savings}_{\text{natural gas}} = \left(\frac{\Delta \text{ pounds of water removed per cycle}}{\text{efficiency of dryer (lb/kWh)}} * C_1 * \frac{\text{cycles}}{\text{year}} \right) \text{AND}$$

$$\left(\frac{\text{motor kWh savings}}{\text{cycle}} * \frac{\text{cycles}}{\text{year}} \right)$$

Where:

C1 = the conversion from kWh to therms, 0.03412 therms/kWh.

As is illustrated in Exhibit 3.2, a gas dryer also sees some kWh savings from the motor.

[4] Appendix A. Item 53.
[5] Appendix A. Item 24.

The residential saturation study[6] values of percentage of electric and natural gas dryers were used to calculate the savings from each type of dryer.

3.2.1.3 Detergent Savings Analysis

This analysis used primary data gathering to obtain costs for a load of laundry for both powder and liquid forms of regular and HE detergents. These were then combined to approximate the cost savings between regular and HE detergent, regardless of whether the detergent was liquid or powder. Lastly, data from existing studies were used to approximate how people use detergent in Energy Star® clothes washers. All of these data were combined to calculate the detergent monetary savings attributable to Energy Star® clothes washers.

The Equipoise team collected costs from Albertson's, Safeway, and Costco for powder and liquid detergents. Ten different types of detergents were purchased to determine whether the dosage for a load of laundry differed between regular and HE detergents. These ten detergent choices were made based on the market share of each and represented more than 60% of the market share for powders and liquids. Exhibit 3.3 presents the products purchased and subsequently measured. Liquid Wisk HE and both liquid and powder Tide HE were purchased in addition to regular Wisk and Tide.

Exhibit 3.3
Detergents Purchased

Brand	Percent of the Market	
	Liquid	Powder*
Tide	32.5	44
All	10.7	2.4
Purex	8.7	3.5
Wisk	8.6	2.9
Era	5.5	0
Cheer	5.3	8.8
Xtra	4.8	0
Arm & Hammer	3.3	5
Surf	3.1	7.1
Gain	3	10.4
Dreft	0	1.8
Private Labels	14.5	2
Overall Market	*58*	*42*
Total Market Percent Purchased	60.5	63.2

*This is the reported data. It is known that this column does not add to 100%

Purchased Detergents

Ultimately, determining the price per load of each of these detergents was the goal. However, the necessary information was not equally available. For example, Albertson's provided a price/ounce ratio for their products, while Safeway and Costco provided a price/load ratio. One cannot go directly from a price/ounce ratio for powder using the weight of the box as

[6] Appendix A. Item 68.

shown because the actual weight of ½ cup of powdered detergent (a typical amount for a "medium" load of laundry) varied across the four powders purchased. Therefore, a different approach was taken for powder cost estimates. Data were gathered for powders by obtaining cost and number of loads per box (as described on the box itself). Twenty-eight different data points were gathered to create a cost/load ratio for regular powder, as shown in Exhibit 3.4, and one data point for HE powder. It should be noted that only Tide's HE powder was sold in any of these three stores.

Exhibit 3.4
Regular Powder Detergent Cost/Load Calculation

$$\text{Powder \$/Load} = \frac{\sum_{1}^{28} \frac{\text{Cost per Box}}{\text{Loads per Box}}}{28}$$

For the liquid detergent, there were no data on how many loads were assumed to be in each container. For liquid detergents, the amounts of detergent (in ounces) used for "medium" and "heavy" loads were calculated from the four regular detergents and two HE detergents purchased. Fifty-two data points were used to calculate a price/ounce ratio using the cost of the container and number of ounces in the container for the regular liquid. Two data points were used for the HE detergent. A cost/load ratio for liquid detergent was then calculated using the price/ounce ratio, number of ounces per load, and assuming half the loads were "medium" and half were "heavy" loads. The calculation used for regular liquid detergent is shown in Exhibit 3.5 while the two HE detergents were averaged in the same manner.

Exhibit 3.5
Regular Liquid Detergent Cost/Load Calculation

$$\text{Liquid \$/Load} = \frac{\sum_{1}^{52} \left(\frac{\text{ounces}}{\text{med. load}} * 0.5 + \frac{\text{ounces}}{\text{heavy load}} * 0.5 \right)}{52} * \frac{\$}{\text{ounce}}$$

At this point, the cost/load ratios for regular and HE, either powder or liquid, detergents were determined. The next step was to move to a single cost for people who used powder detergent or liquid detergent. First, savings were calculated between the regular and HE detergents. Then the overall market share for powder versus liquid detergent, as shown in Exhibit 3.3, was used as the weight to create a single value for savings. This was calculated as shown in Exhibit 3.6.

Exhibit 3.6
Per Cycle Detergent Savings Calculation

$$\text{Per Cycle Savings} = \left[\begin{array}{l} \left(\frac{\text{Powder Cost}}{\text{Load}}_{\text{Regular}} - \frac{\text{Powder Cost}}{\text{Load}}_{HE\ or\ 1/2\ regular} \right) * 0.42 \\ + \left(\frac{\text{Liquid Cost}}{\text{Load}}_{\text{Regular}} - \frac{\text{Liquid Cost}}{\text{Load}}_{HE\ or\ 1/2\ regular} \right) * 0.58 \end{array} \right]$$

The next step in this analysis was thoroughly researched, yet no definitive answer arose from the research. A 1998 study indicated that 77% of those using an Energy Star® washer continued to use the same detergent with the new clothes washer that they used with their old vertical axis washer.[7] As stated earlier, use of the same amount of detergent causes over-sudsing due to the design of the horizontal axis machine. One of the machines (the Maytag Neptune) has a sensor that detects over-sudsing and automatically drains and adds more water to decrease overall sudsing. The manufacturer's owners' guides, and at least one detergent box, state that less regular detergent should be used. However, the owners' manuals are general and do not specifically state how much less detergent should be used. The one detergent box that provided an exact amount said to use 1 cup of powder detergent for a normal vertical axis load and one-third to one-half cup for a front-loading machine. A number of informal discussions related that people tend to use one-half of the regular detergent they previously used in their vertical axis machine. Therefore, the analysis calculated savings for that 77% of the Energy Star® population that continues to use regular detergent by assuming that half the amount of detergent is used. The algorithm used to estimate annual cost savings for detergent under this scenario is shown in Exhibit 3.7.

Exhibit 3.7
Annual Detergent Savings Algorithm

$$\text{Annual Detergent Savings} = \left[\begin{array}{l} \left(\frac{\text{Savings}}{\text{Cycle}}_{Using\ HE\ Detergent} * 0.23 \right) + \\ \left(\frac{\text{Savings}}{\text{Cycle}}_{Using\ 1/2\ Reg.\ Detergent} * 0.77 \right) \end{array} \right] * \frac{\text{Cycles}}{\text{Year}}$$

3.2.2 Dishwasher Analysis

The water savings analysis consisted of determining the difference in water usage between a conventional dishwasher and an Energy Star® dishwasher.

A slight detour must be taken here to describe the dishwasher testing. Current tests for dishwasher energy efficiency use clean dishes for the test loads. However, many of the newer models use a soil-sensing device (either the level of turbidity in the water or the pressure drop across the filter screens) to select the appropriate cycles for that particular load of dishes. With clean dishes, the dishwashers invariably choose the shortest cycles, use less water, and have high energy factors during the testing. In reality, when soiled dishes are

[7] Appendix A. Item 39.

used, the washer uses more water and energy. An example of an Energy Star® soil-sensing washer shows that water use can vary from 4.9 gallons to 8.5 gallons per cycle, depending on the amount of soil on the dishes. Therefore, dishwashers that are Energy Star® compliant do not automatically use less water per cycle than conventional dishwashers.

While literature and Internet sources were scoured and experts queried, little to no information was found that could provide definitive values of water usage across the span of 235 dishwashers that are Energy Star® compliant. As a result, this assessment decided to use values supplied by the Department of Energy[8], which provided a range for both conventional and Energy Star® dishwashers. The high and low estimates for conventional dishwashers were averaged to develop a typical value for conventional machines. Similarly, the average of the high and low values were averaged to develop a typical value for Energy Star® water usage. The difference between these two average values was used as the water saved per machine per cycle.

The average number of cycles per year used in testing for the energy factor was used in this analysis to determine annual water savings per machine. [9] The algorithm used to calculate savings is shown in Exhibit 3.8.

Exhibit 3.8
Dishwasher Water Savings Algorithm

$$\text{Annual Water Savings per Machine} = \left(\left(\frac{\text{Gallons}}{\text{Cycle}} \right)_{\text{Conventional}} - \left(\frac{\text{Gallons}}{\text{Cycle}} \right)_{\text{EnergyStar}} \right) * \frac{\text{Cycles}}{\text{Year}}$$

3.2.3 Annual Monetary Savings

Once savings were determined for water and sewer and energy, they had to be converted into annual monetary savings. For this, average water rates and average energy rate costs were used.

Water and Sewer Rates - There are more than 575 water utilities in California. Of these, 150 are investor owned and directly regulated by the California Public Utility Commission (CPUC). Eleven of those 150 services greater than 10,000 connections (households), while the majority (109) service less than 500 connections. Most of those utilities servicing large numbers of customers are located outside the PG&E service territory.

On the other hand, the Association of California Water Agencies (ACWA) is a group of more than 435 public water agencies. This group represents more than 90% of the water delivered in California. Extensive surveys have been performed recently of water and sewer rates of the ACWA members. [10] These surveys provided data, by county, for 460 cities or service areas (350 water purveyors) for water rates, and 420 cities and districts for sewer rates. These data were obtained and the counties within the PG&E service territory were pulled for analysis. The water data were available for both a monthly service charge and monthly commodity charge. Using the monthly commodity charge, a marginal cost of each gallon of

[8] Appendix A. Item 60.
[9] Ibid.
[10] Appendix A. Items 46 and 47.

water used was determined. The sewer analysis differed because only 20 cities had a volume rate in which all or a portion of the charge is based on volume (i.e., 86% of the wastewater structures in California are flat rate).[11] For those sites with a volume-based rate charge, the average price per gallon was calculated and then simply added to the water rate to obtain an overall water and sewer rate for that city. The population of each of the cities was then used to calculate a weighted average of marginal water and sewer rates for the PG&E service territory. The average water & sewer rates by county are provided in Appendix B.

Energy Rates – Data were obtained from PG&E that provided monthly electrical and therm rates from January 2000 to June 2001. These rates were the revenue ($) divided by the sales (kWh or therm). The latest twelve months of data were used to calculate an average kWh or therm rate.

3.2.4 Life Cycle Savings

First year savings were estimated in 2001 dollars. For the life cycle savings estimate, the first year savings were escalated at the rate of inflation and a discount rate was applied. Life cycle estimates used the Effective Useful Life (EUL) estimates agreed upon during the CALMAC standardization process conducted in 2000. These EUL values were 14 years for clothes washers and 13 years for dishwashers. The life cycle cost estimates used the same calculation methodology and economic inflation and discount rates used in previous filings[12]. The life cycle cost was calculated using the Excel algorithm labeled "NPV" and was applied as shown in Exhibit 3.9.

Exhibit 3.9
Lifecycle Cost Algorithm

$$\text{Lifecycle Cost} = NPV\left(\text{discount\_rate}, \sum_{n=2}^{EUL}\left[\text{savings}_{n-1} * (1 + \text{inflation\_rate})\right]\right) + \text{savings}_{n=1}$$

[11] Appendix A. Items 46.

[12] The discount rate was chosen to be consistent with the ALJ Bytof ruling, dated October 25, 2000, in Application (A.) 99-09-049, et. al. The inflation rate of 3% was used to develop the discount rate. The following specific values were identified as appropriate for these calculations: (1) The inflation rate that should be used is 3%, (2) The discount rate, if inflation is included, should be 8.15%, (3) The discount rate, if inflation is not included, should be 5%. This derived as follows: Real Discount rate = (1+nominal discount rate) / (1+nominal inflation rate) = (1+0.0815)/(1+0.03) = 1.05.

4. RESULTS

This section discusses the results of the study.

4.1 Clothes Washer Savings

The three items for clothes washer savings are the water savings, dryer savings, and detergent savings. Each will be presented with any data relevant to the results provided. Appendix B provides the details and sources of the results.

4.1.1 Water Savings

This was a relatively straightforward analysis with two of the data points coming directly from the Federal Register. The average gallons/cycle of water used by a washer in the U.S. is 39.2 gallons, while the average gallons/cycle of an Energy Star® compliant washer is 20.8 gallons. There are 392 cycles per year giving a savings of 7,221 gallons of water per year.

The gallons/cycle savings value is somewhat higher than what was found in the monitored studies (i.e., Appendix A, items 29, 35, 41, 42, 50, 70). These studies tended to use American brands, such as Maytag and Frigidaire that average around 24 gallons/cycle. However, European manufacturers such as Asko, Miele, and Staber are all Energy Star® compliant washers, are sold in California, and use less than 20 gallons/cycle. It is not surprising that the savings found in the monitored studies are lower those used here since these studies used one to three different manufacturers in their studies, while this study used all the available Energy Star® compliant washers.

To reiterate: This study used the average of all Energy Star® models because the PG&E program does not track rebates by manufacturer and model.

4.1.2 Dryer Savings

The average conventional clothes washer has a Remaining Moisture Content (RMC) of 0.62, while an average Energy Star® compliant washer has an RMC of 0.41. This difference in RMC means that the dryer needs to remove 1.32 pounds less water with an Energy Star® washer. The dryer is used 331 times in a year. (This is less than a clothes washer usage. Since both usage values are from standard testing procedures, the difference is assumed to account for the fact that some people line dry their clothes.) The energy savings from the dryer are shown in Exhibit 4.1.

Exhibit 4.1
Dryer Energy Savings

Type	Savings/ Year	Saturation	Savings/Year at Saturation %	Unit
Electric Dryer	145.26	41%	59.55	kWh
Natural Gas Dryer	5.55	59%	3.27	Therm
Motor Savings, Either Type of Dryer	6.62	100%	6.62	kWh

None of the previous studies monitored the dryer savings due to the decreased RMC in the clothes washer.

4.1.3 Detergent Savings

Detergent cost savings are seen only when half of the regular detergent is used. Exhibit 4.2 and Exhibit 4.3 provide the cost savings from both analyses.

Exhibit 4.2
Detergent Cost Savings using HE Detergent

	Cost per Load			
	Powder		Liquid	
Load Size	Regular	HE	Regular	HE
All Sizes	$ 0.18	$ 0.26		
Medium			$ 0.21	$ 0.34
Heavy			$ 0.30	$ 0.44

	Cost per Load			
Type	Percent of Population Using that Type of Detergent	Savings Med	Savings Heavy	Savings / Load*
Powder	42%			$ (0.08)
Liquid	58%	$ (0.13)	$ (0.14)	$ (0.13)
Weighted Savings				$ (0.11)

* Assumes 50% medium and 50% heavy loads.

Annual Savings Over Regular Washer Using HE Detergent	**$ (43.05)**

Exhibit 4.3
Detergent Cost Savings using Half Regular Detergent

	Cost per Load			
	Powder		Liquid	
Load Size	1/2 Regular	Regular	1/2 Regular	Regular
All Sizes	$ 0.09	$ 0.18		
Medium			$ 0.10	$ 0.21
Heavy			$ 0.15	$ 0.30

	Cost per Load			
Type	Percent of Population Using that Type of Detergent	Savings Med	Savings Heavy	Savings / Load*
Powder	42%			$ 0.09
Liquid	58%	$ 0.10	$ 0.15	$ 0.13
Weighted Savings				$ 0.11

* Assumes 50% medium and 50% heavy loads.

Annual Savings Over Regular Washer Using 1/2 Regular Detergent	**$ 43.96**

When these two values are weighted by the percentage of people using HE detergent (23%) and those using regular detergent (77%), the resulting detergent savings estimate is $23.95 per year.

It should be noted that the savings estimates presented above are highly dependent the percentage of households using HE versus regular detergents. The split used is from a 1998 study performed in the Pacific Northwest. While it is likely that this value has changed, or is different for California, no data was found to support the use of a different value.

4.2 Dishwasher Savings

As mentioned earlier, although a thorough review was performed of literature and Internet data, together with discussions with people in the field, no acceptable data were found to represent the water usage for high efficiency dishwashers over the wide range of soiled dish conditions. Therefore, Department of Energy values were used to estimate the average gallons of water to be 11 gallons/cycle for a conventional unit and 8.5 gallons/cycle for an Energy Star® unit. This 2.5 gallons/cycle savings, along with an average cycles/year of 264 from the Federal Register, gave water usage savings of 660 gallons/year per conversion.

This was considered to be a good estimate of water savings from Energy Star® dishwashers. The one study that retrofitted residential sites with an Energy Star® dishwasher (from a single manufacturer) indicated savings of 3.7 gallons/cycle and 690 gallons/year for a unit without a soil sensor.

4.3 Annual and Lifecycle Savings

The marginal rate for water and sewer that was used to calculate monetary savings was $0.0025/gallon of water. The average PG&E energy rates for the past twelve months that were used for the analysis were $0.109/kWh and $1.11/therm.

The annual and lifecycle non-energy benefits from Energy Star® clothes washers and dishwashers are shown in Exhibit 4.4.

Exhibit 4.4
Annual and Lifecycle Savings

Appliance	*Item*	*Annual Savings*	*Life Cycle Savings*
Clothes Washer	Water & Sewer	$ 18.06	$ 187.67
	Dryer	$ 10.85	$ 112.78
	Detergent	$ 23.95	$ 248.88
	Total	**$ 52.85**	**$ 549.34**
Dishwasher	Water & Sewer	$ 1.65	$ 16.28

5. RECOMMENDATIONS

This section provides recommendations based on the analyses performed in this study.

Clothes Washers, Estimating Detergent Usage – The largest non-energy benefit comes from detergent savings, yet it is based on few actual studies. It is recommended that the next time PG&E studies customers with Energy Star® clothes washers that a set of questions be asked regarding the type and amount of detergent they use compared to when they had their old clothes washer. This would allow for a better estimate of the split between HE detergent users and regular detergent users, as well as how much regular detergent is actually used. This information would allow a more California specific estimate of non-energy benefits.

Clothes Washer, Detergent Usage Education – PG&E may wish to consider customer education on detergent usage levels in HE machines. Over sudsing can, in some machines, cause automatic increase in water usage, reducing savings.

Clothes Washers, Average Water Usage – The water usage and RMC of Energy Star® clothes washers varies significantly, and this variation is expected to increase as newer models are introduced. PG&E should track the brand and model of units rebated so a weighted average of water usage and RMC can be used to determine the non-energy benefits of water savings and dryer savings.

Dishwashers – It is recommended that, in the future, PG&E calculate the energy factor of dishwashers using tests that incorporate soiled dishes, thus allowing for the changes in energy use that occur in appliances with soil sensors. The current Energy Star® rating for dishwashers is not a good indicator of the energy or demand savings that PG&E and the customer will see as a result of the retrofit.

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Appendix B
Details of Analysis

Overall Assumptions Used in the Analysis

Name	Value	Unit	Source
Dryer_Load	331	Dryer loads per year	CEE Residential Clothes Washer Initiative Program Description Table 4D, AHAM Test Procedur
Washer_Load	392	Clothes Washer Loads per year	Federal Register Vol. 66, No. 9, January 12, 2001/ Rules and Regulations / Table 1
kWh_cost	$ 0.109	$/kWh	PG&E- avg. rate over past 12 months (Revenue/Sales)
Therm_cost	$ 1.11	$/therm	PG&E- avg. rate over past 12 months (Revenue/Sales)
water_rate	$ 0.0025	$/gallon	Water rate analysis - this is the marginal cost of the water
sewer_rate	$ -	$/gallon	Rolled into water rate, see water analysis worksheet
Dishwasher_Cycle	264	Dishwasher cycles per year	Federal Register Vol. 64, No. 187, September 28, 1999/ Rules and Regulations / Section II.2
discount rate	0.0815	Percent	PG&E
inflation rate	0.03	Percent	PG&E

These data are referenced throughout the analysis using the name as specified

Water Savings from High Efficiency Clothes Washers

Assumptions:	**Values**	**Units**	**Source**
Water Use			
Gallons of water used by standard washers	39.2	gallons / cycle	Federal Register/ Vol 66. No. 9 / January 12, 2001 / Rules and Regulations / Table 1
Gallons of water used by high efficiency washers	20.8	gallons / cycle	See qualifying appliances.xls worksheet - average of qualifying appliances
Gallons Saved	18.4	gallons / cycle	Calculated - (Standard Use - HE Use)
Cycles per year	392	cycles/year	Overall Assumptions
Water Savings per year	7,221	Gallons / year	Calculated - Gallons/Cycle Saved * Cycles/Year
Total Savings			
$ / gallon water & sewer use	$ 0.0025	$ / gallon used	Overall Assumptions
Annual $ saved	**$ 18.06**	$ / year Saved	Calculated - Gallons/year Saved * $/gallon used

Dryer Savings from High Efficiency Clothes Washers

Assumptions:	**Values**	**Units**	**Source**
Efficiency			
Electric standard clothes dryer efficiency	3.01	lb/kWh	CEC Title 20: Division 2, Chapter 4, Article 4, Sections1605.1, Table Q - March 30, 2001 Draft of Draft 15-day language
Gas standard clothes dryer efficiency	2.69	lb/kWh	CEC Title 20: Division 2, Chapter 4, Article 4, Sections1605.1, Table Q - March 30, 2001 Draft of Draft 15-day language
RMC = Remaining Water Content = (moist clothes weight - dry clothes weight)/dry clothes weight			
RMC of Standard Clothes Washer	0.62	Unitless	CEE SEHA Products and Specifications
RMC of Energy Star Clothes Washer	0.41	Unitless	Average of qualifying washers - see Qualifying Appliances.xls worksheet
Dryer Load			
Average dry weight per load (cycle)	6.29	lbs / cycle	CEE Residential Clothes Washer Initiative Program Description Table 4D
Average moist weight per load (cycle) for standard washe	10.19	lbs / cycle	Calculated RMC*Dry Weight + Dry Weight
Average moist weight per load (cycle) for HE washer	8.87	lbs / cycle	Calculated RMC*Dry Weight + Dry Weight
Water removed per load for standard washer	3.90	lbs / cycle	Calculated Moist Weight - Dry Weight
Water removed per load for HE washer	2.58	lbs / cycle	Calculated Moist Weight - Dry Weight
Difference in water removed	1.32	lbs / cycle	Calculated Water Standard - Water HE
Energy Savings per load (cycle)			
Electric standard dryer	0.44	kWh/cycle	Calculated lbs water removed / efficiency
Gas standard dryer	0.0168	Therms/cycle	Calculated lbs water removed / efficiency
Dryer Motor per Load Savings	0.02	kWh/cycle	CEE Residential Clothes Washer Initiative Program Description Table 4D
Total Energy Savings			
Dryer Loads per year	331	cycles/yr	Overall assumptions page
% Electric Dryers	0.41	Percent	RLW Study on Res Saturation, Figure 10
% Gas Dryers	0.59	Percent	RLW Study on Res Saturation, Figure 10
$/kWh	$ 0.11	$/kWh	Overall assumptions page
$/Therm	$ 1.11	$/therm	Overall assumptions page
$ savings per year from the electric dryers	$ 6.51	$ / machine	Calculated kWh/load * loads per year * % Electric * $/kWh
$ savings per year from the gas dryers	$ 3.62	$ / machine	Calculated therms/load * loads peryear * % gas * $/therm
$ savings per year from the dryer motor	$ 0.72	$ / machine	Calculated kWh/load * loads per year * $/kWh
Total $ savings per year from the dryer	**$ 10.85**	$ / machine	Calculated Sum of above values

Detergent Use Analysis

Brand	Type	Loads / Box*	Size (oz.)	Medium Load oz.	Med/Heavy Load oz.	Heavy Load oz.	$ / oz
Wisk	Liquid		100	3		4	
Wisk	HE Liquid		100	4		5	
Tide Free	Liquid	32	100	3		4	
Tide	HE Liquid	39	125	3		4	
Purex	Liquid		100	3		5	
All Free	Liquid		100	3		4	

*As stated on box

Average ounces used in liquid detergent per load

3	Reg Avg	4.25
3.5	HE Avg	4.5

$/load is average of all brands from tab "Laundry Price Data"

	Cost per Load			
	Powder		Liquid	
Load Size	Regular	HE	Regular	HE
All Sizes	$ 0.18	$ 0.26		
Medium			$ 0.21	$ 0.34
Heavy			$ 0.30	$ 0.44

	Cost per Load			
Type	Percent of Population Using that Type of Detergent	Savings Med	Savings Heavy	Savings / Load*
Powder	42%			$ (0.08)
Liquid	58%	$ (0.13)	$ (0.14)	$ (0.13)
Weighted Savings				$ (0.11)

* Assumes 50% medium and 50% heavy loads.

Annual Savings Over Regular Washer Using HE Detergent	**$ (43.05)**

$/load is average of all brands from tab "Laundry Price Data"

	Cost per Load			
	Powder		Liquid	
Load Size	1/2 Regular	Regular	1/2 Regular	Regular
All Sizes	$ 0.09	$ 0.18		
Medium			$ 0.10	$ 0.21
Heavy			$ 0.15	$ 0.30

	Cost per Load			
Type	Percent of Population Using that Type of Detergent	Savings Med	Savings Heavy	Savings / Load*
Powder	42%			$ 0.09
Liquid	58%	$ 0.10	$ 0.15	$ 0.13
Weighted Savings				$ 0.11

* Assumes 50% medium and 50% heavy loads.

Annual Savings Over Regular Washer Using 1/2 Regular Detergent	**$ 43.96**

From the Northwest Energy Efficiency Alliance Washwise: A Second Market Progress Evaluation Report, August 1998 we know that 77% of the purchasers of high efficient washers uses standard detergent.

Percent Using HE Detergent	**23%**

Percent Using Regular Detergent	**77%**

Weighted Average Annual Savings	**$ 23.95**

Water Savings from High Efficiency Dishwashers

Assumptions:	**Values**	**Units**	**Source**
Water Use			
Gallons of water used by standard washers	11	gallons / cycle	EREN data "Why Buy An Energy Efficient Dishwasher"
Gallons of water used by high efficiency washers	8.5	gallons / cycle	EREN data "Why Buy An Energy Efficient Dishwasher"
Gallons saved	2.5	gallons / cycle	Calculated - (Gallons/Cycle Standard - Gallons/Cycle HE)
Cycles per year	264	cycles / year	Overall Assumptions
Water Savings per year	660	Gallons / year	Calculated - (Gallons/Cycle * Cycles/Year)
Total Savings			
$ / gallons water & sewer use	$ 0.0025	$ / gallon used	Overall Assumptions
Annual $ saved	**$ 1.65**	$ / year Saved	Calculated - (Gallons/Year * $/Gallons Used)

Energy Star Rated Clothes Washers

N	Brand	Manufacturer	Model	RF_Volume	Kwhyear	MEF	Energy Factor	CW_WaterFactor	RMC	Max Test Load (lb/cycle)	Dryer kWh/Cycle	Gallons / Cycle
1	Asko	Asko	W600	1.9	182	1.62	4.09	9.00	44.6%	8	0.71	17.1
2	Asko	Asko	W620	1.9	177	1.63	4.21	9.00	44.9%	8	0.71	17.1
3	Asko	Asko	W640	1.9	181	1.88	4.11	9.10	35.4%	8	0.55	17.3
4	Asko	Asko	W660	1.9	176	1.92	4.23	9.00	34.9%	8	0.54	17.1
5	Avanti	Samsung	W1092F	1.6	227	1.48	2.76	10.63	37.8%	6.8	0.50	17.0
6	Avanti	Samsung	W6092F	1.6	227	1.48	2.76	10.63	37.8%	6.8	0.50	17.0
7	Avanti	Samsung	W8092F	1.6	227	1.48	2.76	10.63	37.8%	6.8	0.50	17.0
8	Bosch	Bosch	WFK2401UC	1.62	188	1.399	3.38	8.10	49.7%	6.8	0.68	13.1
9	Equator	Philco	EZ 3600 CEE	1.9	200	1.73	3.72	10.04	37.7%	8	0.59	19.1
10	Fisher & Paykel	Fisher & Paykel Appliances Inc.	GWL10	3	298	2.2	3.95	8.90	26.1%	12.5	0.60	26.7
11	Frigidaire	Frigidaire	39012	2.65	259	1.57	4.01	9.10	47.1%	10.9	1.03	24.1
12	Frigidaire	Frigidaire	39022	2.65	259	1.57	4.01	9.10	47.1%	10.9	1.03	24.1
13	Frigidaire	Frigidaire	FWT425RH	2.65	259	1.68	4.01	9.43	42.5%	10.9	0.92	25.0
14	Frigidaire	Frigidaire	FWT645RH	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
15	Frigidaire	Frigidaire	FWT647GH	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
16	Frigidaire	Frigidaire	FWT648GH	2.65	259	1.68	4.01	9.43	42.5%	10.9	0.92	25.0

N	Brand	Manufacturer	Model	RF_Volume	Kwhyear	MEF	Energy Factor	CW_WaterFactor	RMC	Max Test Load (lb/cycle)	Dryer kWh/Cycle	Gallons / Cycle
17	Frigidaire	Frigidaire	FWT865RH	2.65	351	1.44	2.96	9.44	43.7%	10.9	0.94	25.0
18	Frigidaire	Frigidaire	FWT867GH	2.65	351	1.44	2.96	9.44	43.7%	10.9	0.94	25.0
19	Frigidaire	Frigidaire	FWTB59RG	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
20	Frigidaire	Frigidaire	FWTB69RG	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
21	Frigidaire	Frigidaire	FWTR425RH	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
22	Frigidaire	Frigidaire	FWTR645RH	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
23	Frigidaire	Frigidaire	FWTR647GH	2.65	259	1.68	4.01	9.10	42.5%	10.9	0.92	24.1
24	Frigidaire	Frigidaire	FWTR865RH	2.65	351	1.44	2.96	9.44	43.7%	10.9	0.94	25.0
25	Frigidaire	Frigidaire	FWTR867GH	2.65	351	1.44	2.96	9.44	43.7%	10.9	0.94	25.0
26	Frigidaire	Frigidaire	NGST127A (New England)	2.65	351	1.44	2.96					
27	Frigidaire	Frigidaire	NGSTR127A (New England)	2.65	351	1.44	2.96					
28	General Electric	General Electric	WPXH214A**	2.65	351	1.47	2.96	9.47	42.1%	10.9	0.91	25.1
29	General Electric	Frigidaire	WSXH208A	2.65	259	1.59	4.01	9.10	46.3%	10.9	1.01	24.1
30	Gibson	Frigidaire	GWT645RH	2.65	259	1.68	4.01	9.43	42.5%	10.9	0.92	25.0
31	Gibson	Frigidaire	GWTR645RH	2.65	259	1.68	4.01	9.43	42.5%	10.9	0.92	25.0

N	Brand	Manufacturer	Model	RF_Volume	Kwhyear	MEF	Energy Factor	CW_WaterFactor	RMC	Max Test Load (lb/cycle)	Dryer kWh/Cycle	Gallons / Cycle
32	Imperial	Frigidaire	LFW201E	2.65	259	1.68	4.01	9.43	42.5%	10.9	0.92	25.0
33	Kenmore	Whirlpool	2106*	3.01	337	1.55	3.50	7.40	43.6%	12.5	1.08	22.3
34	Kenmore	Whirlpool	2108*	3.01	337	1.55	3.50	7.40	43.6%	12.5	1.08	22.3
35	Kenmore	Whirlpool	2206*	3.01	337	1.55	3.50	7.40	43.6%	12.5	1.08	22.3
36	Kenmore	Whirlpool	2208*	3.01	337	1.55	3.50	7.40	43.6%	12.5	1.08	22.3
37	Kenmore	Frigidaire	41042	2.65	234	1.86	4.44	9.07	38.8%	10.9	0.83	24.0
38	Kenmore	Frigidaire	41052	2.65	234	1.86	4.44	9.07	38.8%	10.9	0.83	24.0
39	Kenmore	Frigidaire	41142	2.65	234	1.86	4.44	9.07	38.8%	10.9	0.83	24.0
40	Kenmore	Whirlpool	4292*	3.18	286	1.7	4.36	4.43	44.5%	12.9	1.14	14.1
41	Kenmore	Whirlpool	4293*	3.18	286	1.7	4.36	4.43	44.5%	12.9	1.14	14.1
42	Maytag	Maytag	MAH4000	2.9	282	1.72	4.03	8.00	40.6%	12.1	0.97	23.2
43	Maytag	Maytag	MAH5500	2.9	282	1.64	4.03	8.00	43.7%	12.1	1.05	23.2
44	Maytag	Maytag	MAH5500B	2.9	302	1.64	3.76	7.29	41.8%	12.1	1.00	21.1
45	Maytag	Maytag	MAH7500*	2.9	362	1.66	3.14	8.10	35.2%	12.1	0.82	23.5
46	Maytag	Maytag	MAV9600	3.2	418	1.3	3.00	10.38	52.0%	13.3	1.40	33.2
47	Maytag	Maytag	MLE2000 (stack unit)	2.9	314	1.69	3.62	8.00	38.6%	12.1	0.91	23.2
48	Maytag	Maytag	MLG2000 (stack unit)	2.9	314	1.69	3.62	8.00	38.6%	12.1	0.91	23.2

N	Brand	Manufacturer	Model	RF_Volume	Kwhyear	MEF	Energy Factor	CW_WaterFactor	RMC	Max Test Load (lb/cycle)	Dryer kWh/Cycle	Gallons / Cycle
49	Miele	Miele, Inc.	W1903	1.69	249	1.41	2.66	9.12	41.9%	6.8	0.56	15.4
50	Miele	Miele, Inc.	W1918	1.69	267	1.64	2.48	8.34	27.5%	6.8	0.35	14.1
51	Miele	Miele, Inc.	W1926	2.01	279	1.64	2.82	7.57	32.0%	8.4	0.51	15.2
52	Miele	Miele, Inc.	W1930	1.69	267	1.64	2.48	8.34	27.5%	6.8	0.35	14.1
53	Quietline	Appliances International	WD9900	1.57	237	1.43	2.60	8.80	39.3%	6.4	0.49	13.8
54	Splendide	Philco	WDC1025MCEE	1.9	200	1.73	3.72	10.04	37.7%	8	0.59	19.1
55	Staber	Staber	HXW2304	2	265	1.48	2.96	7.11	40.8%	8.4	0.68	14.2
56	Staber	Staber	HXW2404	2	265	1.48	2.96	7.11	40.8%	8.4	0.68	14.2
57	Staber	Staber	HXW2504	2	265	1.48	2.96	7.11	40.8%	8.4	0.68	14.2
58	Staber	Staber	HXW2901	2	239	1.43	3.28	5.82	47.0%	8.4	0.79	11.6
59	Staber	Staber	HXW2921	2	239	1.43	3.28	5.82	47.0%	8.4	0.79	11.6
60	Thor	Thor	WD9900	1.57	237	1.43	2.60	8.79	39.3%	6.4	0.49	13.8
61	Whirlpool	Whirlpool	GSW9545JQ	3.02	466	1.28	2.54	7.87	46.9%	12.5	1.17	23.8
62	Whirlpool	Whirlpool	GVW9959K	2.99	337	1.53	3.48	7.35	45.4%	12.1	1.10	22.0
								Average	0.41	10.14	0.83	20.78
		Removed from analysis since machines only for New England						Stan. Dev.	0.05	2.06	0.22	4.79

The maximum test load per cycle is from the Federal Rules and Regulations, Table 5.1. The RMC and kWh Dryer/Cycle values are calculated based on the test procedures. The algorithms used are taken from the procedures and are shown below.

$$RMC = \frac{\left(\frac{RF\_Vol}{MEF} - \frac{RF\_Vol}{Energy\ Factor}\right)}{LAF * DEF * DUF * Max\ Test\ Load} + 0.04$$

$$kWh\ Dryer / Cycle = LAF * Max\ Test\ Load * (RMC - 0.04) * DEF * DUF$$

Where: LAF = 0.52

DEF = 0.5

DUF = 0.84

Average water and sewer rates

County	Annual Water and Sewer per Gallon Cost - Average Weighted by Population
Alameda	$ 0.0025
Amador	$ 0.0014
Butte	$ 0.0009
Calaveras	$ 0.0010
Colusa	$ 0.0008
Contra Costa	$ 0.0024
Del Norte	$ 0.0008
El Dorado	$ 0.0023
Fresno	$ 0.0012
Humboldt	$ 0.0023
Kern	$ 0.0009
Kings	$ 0.0009
Lake	$ 0.0016
Lassen	$ 0.0020
Madera	$ 0.0016
Marin	$ 0.0026
Mariposa	$ 0.0011
Mendocino	$ 0.0022
Merced	$ 0.0015
Modoc	$ 0.0027
Mono	$ 0.0013
Monterey	$ 0.0018
Napa	$ 0.0028
Nevada	$ 0.0014
Placer	$ 0.0011
Plumas	$ 0.0009
Sacramento	$ 0.0023
San Benito	$ 0.0008
San Francisco	$ 0.0068
San Joaquin	$ 0.0010
San Luis Obispo	$ 0.0028
San Mateo	$ 0.0046
Santa Barbara	$ 0.0042
Santa Clara	$ 0.0020
Santa Cruz	$ 0.0020
Shasta	$ 0.0005
Solano	$ 0.0026
Sonoma	$ 0.0039
Stansilaus	$ 0.0017
Sutter	$ 0.0011
Tehama	$ 0.0014
Tulare	$ 0.0011
Tuolomne	$ 0.0008
Yolo	$ 0.0007
Yuba	$ 0.0019
All Counties	$ 0.0025