DISCLAIMER

This project was conducted with financial assistance from a grant from the Metropolitan Water District of Southern California (Metropolitan), the U.S. Bureau of Reclamation, the Environmental Protection Agency, the Central Arizona Project, the Southern Nevada Water Authority, the Southern California Gas Company, and the Western Resource Advocates through Metropolitan's Innovative Conservation Program (ICP). The ICP provides funding for research to help document water savings and reliability of innovative water savings devices, technologies, and strategies. The findings of this project, summarized in this report, are solely from the project proponent.

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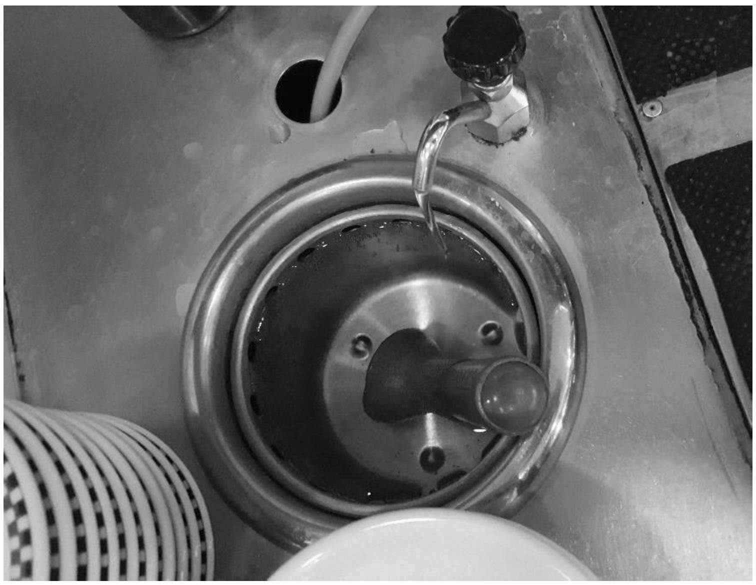
Dipper Well Replacement Field Evaluation Report

Frontier Energy Report # 50115-R0
November 2017



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Test Sites:
Los Banos Black Bear Diner, Madera Black Bear Diner

Food Service Technology Center Background

The information in this report is based on data generated in the field in commercial kitchens by Frontier Energy who operate the Food Service Technology Center. Dedicated to the advancement of the foodservice industry, Frontier Energy is the industry leader in commercial kitchen energy and water efficiency and appliance performance testing for 30 years. They have developed over 35 Standard Test Methods for evaluating commercial kitchen appliance and system performance as well as pioneering lab and field research with cooking appliances, kitchen ventilation systems, hot water systems and dishroom equipment.

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Revision History

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Executive Summary

Dipper wells are a common technology used to clean serving utensils, such as ice cream scoops and mashed potato or butter scoops, with a continuous flow of either hot or cold water. They can also represent a large portion of both water and energy consumption in commercial foodservice operations, as some dipper wells can use up to 500 gallons of water per day of operation and hot water dipper wells can place a load of over two therms per day on the building's gas water heater. The objective of this study was to monitor the energy and water use of two field sites with dipper wells, to replace the dipper wells with sound technologies and then to measure savings through sub-metering. Staff members at each site were interviewed to gain operator feedback. The main anticipated benefits of this project include water and sewer savings, as well as energy savings with hot water wells. All work was done under the auspices of The Metropolitan Water District of Southern California within the scope of the Food Service Technology Center Program by Frontier Energy Inc.

While researchers had conducted limited lab studies and field monitoring of dipper wells and the two replacement technologies, the Lolsberg i.ScoopShower and the Server ConserveWell heated utensil holder, these studies yielded promising results and lent third-party credibility to manufacturers' claims of savings potential. A more robust field monitoring and replacement study was needed to verify water and energy savings in order to make a clear business case for replacement for all foodservice facility types. Part of the reason dipper wells are commonly specified is that the newer replacement technologies are unfamiliar to designers, operators and health departments. Also, restaurants interested in replacing dipper wells are burdened with needing to submit applications and plans to plan-check, and often need to provide documents such as standard operating procedures for operating and cleaning the unit. While getting a buy-in from the relevant county health departments was a challenge, introducing the replacement technologies to officials resulted in creating an easier path for health department approvals for future projects.

The research process had four main phases. The first was to identify suitable sites based on reasonable criteria, the second to monitor existing dipper wells at these sites, the third to replace the dipper wells and continue monitoring, and the forth was to train staff, gain feedback and gauge acceptance. The field study was conducted at two Black Bear Diners, one in Los Banos and one in Madera from May to August of 2017. Water and energy use data was recorded and stored in an electronic data acquisition system.

Each of the dipper well changeouts resulted in significant water savings of over 90%. The dipper well at the Los Banos site consumed an average of 468.5 gallons of cold water per day, and the dipper well at the Madera site consumed an average of 321.4 gallons of hot water per day. Because hot water was consumed for the Madera dipper well, it also caused the building's water heater to consume 2.8 therms of gas per day. The Los Banos dipper well was replaced with a Lolsberg I.ScoopShower, which consumed 4.9 gallons of cold water per day, and the Madera dipper well was replaced with a ConserveWell Heated Utensil Holder, which consumed daily 3.8 gallons of water and 3.2 kWh (0.1 therms equivalent) of electricity. The results for annual water and energy savings are summarized in the tables below. The energy savings differentiates with direct site savings and embedded energy savings from supplying, conveying, treating, and distributing water.

Summary of Annualized Water Savings

	Baseline Water Use	Replacement Water Use	Savings
Los Banos (gal/y)	**178,000**	**1,800**	**176,200**
Madera (gal/y)	**117,300**	**1,400**	**115,900**

Summary of Direct and Embedded Energy Savings

	Baseline Energy Use	Replacement Energy Use	Savings
Los Banos (Embedded, kWh/y)	**657**	**7**	**650**
Madera (Embedded, kWh/y)	**422**	**5**	**417**
Madera (Direct, therms/y)	**1,037**	**1168 kWh or 40 equivalent therms**	**997**

These results show a cold-water dipper well replacement savings of 176,200 gallons and 650 kWh in embedded energy annually. This equates to an average direct annual savings of $3,066 for the Los Banos site. Based on the total purchase cost of $500 for the replacement ScoopShower unit the simple payback without incentives is 0.16 years. Based on average incentive rates for water and energy savings in the first year of $1/therm, $0.08/kWh, and $4/CCF, future sites could qualify for $992 in joint utility incentives, which could easily cover the cost of installation.

These results show a hot water dipper well replacement savings of 115,900 gallons and 997 therms equivalent annually, as well as 417 kWh of embedded energy savings. This equates to an average annual savings of $2,355 for the Madera site. Based on the total purchase cost of the replacement ConserveWell unit of $500, the simple payback without incentives is 0.18 years. Based on average custom incentive rates for water and energy savings in the first year of $1/therm, $0.08/kWh, and $4/CCF, future sites could qualify for $1,557 in joint utility incentives based on this one field site result, which could easily cover the cost of installation, even if an electrician is needed to add a standard outlet.

The next step will require funding to complete additional field research to measure and demonstrate dipper well replacement technologies in common foodservice segments such as ice cream shops, juice shops, restaurants and cafeterias. Researchers will need to field evaluate all dipper well replacement technologies currently on the market to determine which technologies will maximize savings for each type of foodservice establishment and for any set of operating conditions. From this, a screening tool will be developed to support utility incentive programs and to ensure that all sites are satisfied with the replacement equipment options and rinsing and cleaning process that is in accordance with the health department. The results from two or three dozen field sites will support the design of a comprehensive utility replacement program and ensure that water and energy utilities and health departments understand how the replacement technologies will actually be used in the field and the savings associated. Certain dipper well replacement products that are a mismatch for a specific segment (e.g. hot water dipper well for ice cream shops) would be noted to support the rollout of a robust incentive or direct install program.

California would benefit from a dedicated joint water and energy utility incentive program centered around dipper wells to take full advantage of the significant savings potential and lead to a relatively quick market transformation towards dipper well replacement technologies or practices. Frontier Energy Inc. strongly believes that a market transformation similar to high efficiency low flow pre-rinse spray valves is possible with applicable dipper well replacement products in a rapid time frame if the financial support for additional research and collaboration amongst utilities to build consensus on the market transformation project is fast tracked.

Abstract

Dipper wells are used to hold utensils such as stirring or serving spoons and ice cream scoops, in a sanitary state for up to four hours before being replaced with a fresh, clean utensil. They served a practical purpose in the 20th century, but are incredibly water and energy intensive when operated for long hours in commercial foodservice facilities and are not suited for our drought prone state. They can use water at a rate as high as 500 gallons per day and, with hot water applications, they represent a water heating load approaching 3 therms per day. Because dipper wells are a niche piece of equipment and their use has been the status quo for decades, there has been very little motivation for designers to try alternative technologies or for utilities to fund research projects to highlight alternatives. Historically, health departments have been slow to approve replacement technologies on a case by case basis. Fortunately, research in this area is gaining traction quickly and a healthy number of manufacturers have brought products to the marketplace which will allow for comprehensive programs to replace dipper wells in all applications.

This field research project was devised to determine the actual savings in a real-world application of two of these technologies, the Lolsberg i.ScoopShower and the Server ConserveWell heated utensil holder. The project team monitored the baseline water and energy use and then replaced the existing dipper wells with the alternative products and calculated savings at two full-service restaurants. These savings results were then compared to each building's total water and energy use to determine a cost savings and payback period for each new technology as well as the overall impact of each changeout. The major recommendations from this project are to establish general SOPs for these technologies such that all health departments will allow their use, and to recommend that these technologies be used in the place of a dipper wells for newly constructed full-service restaurants. . This study also acknowledges the value of a utility funded direct install/incentive program to promote the removal of wasteful dipper wells and more research is needed in this area to confirm that these results are repeatable in business models different from full-service restaurants such as ice cream shops, juice shops and cafes. Lastly, Frontier Energy has identified additional dipper well replacement technologies such as the Wells heated utensil holder and the Nemco RinseWell which need to be similarly tested to validate their savings potential in all relevant foodservice market segments.

Introduction

Background

Standard dipper wells work by flowing at a low (between 0.2 and 1 gpm) flow rate of either hot or cold water into a cleaning basin continuously and overflowing to the drain. At first glance, this low flow rate seems innocent. However, these devices are generally left on for the whole operating day and sometimes never turned off. Prior to this study, Frontier Energy conservatively estimated that the average dipper well was flowing at 0.2 gpm for 14 hours per day for a daily consumption of 170 gallons per day. Frontier Energy also estimated that there were 110,000 dipper wells installed in California, primarily in full-service restaurants, coffee shops, juice shops and ice cream shops.

Dipper wells can be quite water and energy intensive, as well as costly. Dipper wells are essentially a leak that has been designed into a system to reduce bacteria buildup on utensils from stagnant soiled water. Three previous unpublished monitoring projects completed by Frontier Energy have shown that for coffee shops and juice shops, the dipper well operation can use approximately 20% and 50% of the facility's total water consumption, respectively. When dipper wells are on a hot water system, they are a sizeable portion of energy consumed at the water heater. Three prior field studies provided justification to conduct further research on market-ready dipper well replacement equipment since each study reduced water use by approximately 95% while receiving approval from facility staff and the health department. The combination of new cold and hot water utensil holding products on the market and water efficiency research funding from the Metropolitan Water District's Innovative Conservation Program allowed Frontier Energy to continue to conduct this valuable research.

Technology Description

Dipper wells have two concentric tanks, as shown in Figure 1. Water flows into and fills the inner tank, which is perforated at the top. The water then overflows out of into the outer tank, which is connected to a drain. Dipper wells can use up to 500 gallons and close to three therms per day if fed with hot water, and are currently the industry-accepted standard for utensil holding and accepted widely by health departments.

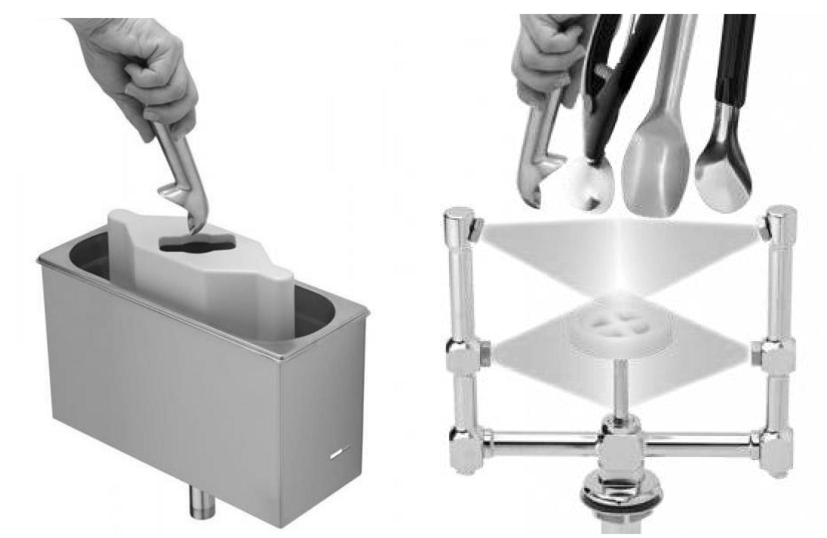
Figure 1. Standard Dipper Well

As more technologies which can provide the same functions as dipper wells with significantly less water use come on the market, there are now many opportunities to save water and energy through the adoption of these new technologies. In particular, two of these utensil holding technologies, the Lolsberg i.ScoopShower (LSS) and the Server ConserveWell Utensil Holder (SUH) have been shown informally to reduce water consumption to below 10 gallons per day and to provide the same level of sanitation, if not better, as a standard cold and hot water dipper well, respectively.

Both these technologies abandon the continuous flow model with the dipper well. The LSS has a pressure-activated switch that allows water to flow to clean a utensil only when the switch is depressed. It is able to flow either hot or water from both below and above the utensil, allowing for a total clean. The LSS is similar to a bar glass or pitcher rinser in that it is just a pressure switch that activates a stream of pressurized water to rinse a utensil between uses, except that it does this from the top and bottom to clean both sides of the scoop. These units cost approximately $500 and typically only use around 10 gallons per day. They are available in multiple configurations for ice cream scoops (Figure 2) and specialized enclosed sprayers for spatulas and scoopers (Figure 3), and can be fed with either hot or cold water. The units are easy to install by the operator without hiring an outside contractor or technician.

Figure 2. Lolsberg I.ScoopShower

Figure 3. Lolsberg I.SpatulaShower



The ConserveWell heated UH has a small heated water tank with a timer and kills bacteria by holding this water at 140°F (Figure 4). The tank holds 28 fluid ounces or 0.22 gallons when filled to the water line. It uses electrical energy to keep the water at this temperature and to dissolve hard-to-clean foods such as mashed potatoes or butter from utensils. The user must dump and refill the tank with fresh water periodically to keep the water clear of solid debris and any undesirable dissolved compounds. The manufacturer recommends refilling at an interval of no less than once every 4 hours, which corresponds with general health department recommendations. The device is fitted with a timer to remind the user that it is time to refill. This timer can be set to any frequency less than once every 4 hours, so operations that clean utensils more frequently can be reminded to dump and refill the water. The water use per day is therefore user-dependent and variable. To make changeouts faster, additional stainless steel containers can be purchased and easily swapped. The heating element is relatively small, so the energy consumption for normal operation is approximately 2 kWh per day. This unit with shipping and taxes costs around $500. It typically lasts until its heating element breaks.

Figure 4. Server ConserveWell Heated Utensil Holder

Purpose

The goal of this project was to measure the savings potential of two dipper well replacement products and to work with the relevant health department and store management to successfully incorporate these technologies in commercial kitchens. The purpose at each site was to measure water and energy use and estimate operating cost associated with both the baseline dipper wells and its replacement technologies.

Objectives and Scope

The objective of this project was to establish real-world baseline energy and water use for dipper wells in foodservice facilities and to measure the savings associated with replacing dipper wells with LSS and SUH, technologies which greatly reduce water and energy use. The original scope of this project included the selection of an ice cream shop for the cold-water study and full-service restaurant for the hot water study. Having already completed cold water dipper well replacement studies in two coffee shops and a juice shop, this plan would allow for expansion into new commercial kitchen segments of interest. The scope was adjusted when an opportunity arose to work with two similar full-service restaurants where hot water dipper wells are often utilized, but in this case, one site was utilizing a cold-water dipper well, which was a unique research opportunity. The scope included training staff at each site on how to properly use the replacement technology upon installation and they would would be interviewed to determine any issues or barriers associated with using the new technologies, as well as to assess the impact of changing technologies on staff behavior. Additionally, a comparison between the baseline and replacement equipment operating costs will be conducted for calculating the payback period on individual retrofits. This is useful to utilities in determining the value of retrofit programs and the expected water and energy incentives associated with the program.

Project Limitations

This project can only address the concerns of a full-service restaurant's hot and cold dipper wells. The hours of operation and other operating characteristics are specific to this business type. A like-for-like replacement would require the operating characteristics of the kitchen around the dipper well to remain mostly the same before and after replacement. More research is needed to expand the understanding of the replacement technology's impacts on other food service facility types.

Methodology

Instrumentation Setup

The Frontier Energy team installed instrumentation and data logging equipment at the test sites to measure and record the energy and water use of each dipper well. Water meters were placed on the water inlet to each dipper well. To estimate the energy use of the hot water dipper well, temperature readings were taken off the hot water supply pipe. There was a very significant temperature difference between the outlet of the water heater and the inlet to the dipper well, so a spot measurement was taken at the outlet of the water heater to confirm its average outlet temperature. A comparison between the spot water heater outlet and the cold water supply temperature to the heater was used for gas use estimations for the hot water dipper well. The researchers used the water heater thermal efficiency rating (TE of 80%) to estimate the average daily operating efficiency of 65% in these energy calculations as a proxy for monitoring the gas use of the water heater (Delagah, et. al 2013). The hot dipper well was replaced with a SUH, which required electrical metering.

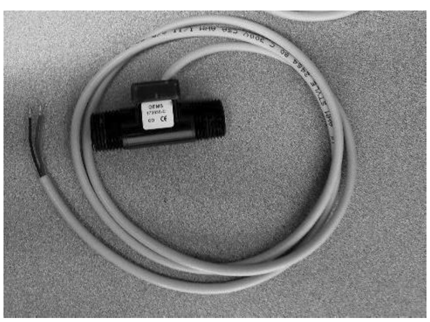
The water meters provide pulse outputs and the temperature sensors provide voltage outputs. These outputs are recorded with an electronic data acquisition system (DAQ). The temperature sensor's voltage output is converted to temperature readings in the DAQ. The baseline unit was logged at one-minute intervals because the flow rate through dipper wells doesn't vary significantly throughout the day, so more resolute sampling was not needed. The replacement unit was logged at five-second intervals because the on/off nature of the technologies monitored required more resolute sampling to capture the actual operating profiles.

For the hot water line, the twisted thermocouple wire junction was affixed to the outer copper pipe walls, and the interface was treated with heat-sink compound, wrapped with electrical tape, and covered with foam pipe insulation to get a reasonably accurate reading. This data was used to understand the heat loss in the pipe between the water heater and dipper well, but it was not directly used to estimate gas use at the water heater associated with dipper well usage.

Instrumentation Specifications

With the hot water dipper well, spot measurements were taken using a Fluke 52 Thermometer handheld device with a Type K thermocouple to estimate the energy use at the building water heater associated with operating the dipper well. To measure temperature of water at the hot water dipper well, Therm-X Class-1 Type-T Teflon extension wire, model number TT(f)-T-24 PFA was used. It has a tolerance of ±1.8°F or 0.75%, and a sensor temperature range of -330 to 650°F. To measure water consumption, researchers used Gems 173993-C turbine water meters as depicted in Figure 5. The water meters had an accuracy of 3% of reading and a flow range of 0.13 to 2 gpm.

Figure 5. Gems Water Meters

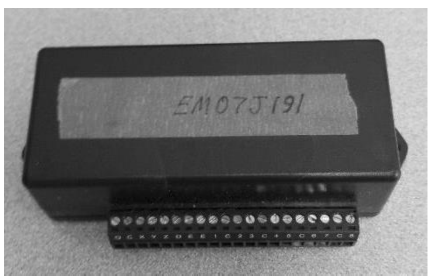


Power metering was accomplished with a Continental Control Systems Wattnode Pulse electricity meter and current transformers. This combination had accuracy ±1% for current between 1 and 50 A (Figure 6).

Figure 6. CCC Wattnode Electricity Meter with Current Transformers and Onset HOBO State Logger

Finally, power metering data was collected with Onset HOBO state logger set to collect data at 5 second sampling intervals (Figure 6) and temperature and water consumption data was collected with a Pace XR5-M data logger set to collect data at the same interval (Figure 7).

Figure 7. Pace XR5-M Datalogger



Data Analysis

Data was measured to provide sufficient detail on the following parameters:

- Operating time (h)
    - SS operating profile
    - UH refill schedule
- Water consumption (gal)
    - Dipper well operating flow rate (gpm)
    - SS flow rate and span (gpm)
    - UH refill volume (filled to tank fill line)
- Electricity use (kWh)
    - UH initial tank heatup
    - UH tank heater idling

Data was estimated for the following parameters:

- Gas use (therms)
    - Portion of water heater energy associated with hot water dipper well
        - Based on spot metering of inlet and outlet temperature at water heater
        - Based on water heater operating efficiency estimates

Data was calculated for the following parameters:

- Average daily water use (gal/d) and energy use (btu/d)
- Average annual water use (gal/y)
- Average annual direct energy use (btu/y_direct) and embedded use (btu/y_embedded)
- Operating cost and savings from replacement ($/year) based on average 2018 California rates

    - Water and sewer rate ($11.20/HCF)
    - Electricity rate ($0.20/kWh)
    - Gas rate ($1.00/therm)
- Potential utility incentive ($/year) based on 2018 custom incentive rates based on 1st-year savings
    - Water incentive ($4.00/HCF)
    - Electricity incentive ($0.08/kWh)
    - Gas incentive ($1.00/therm)

Baseline Results

The first phase of this study determined the baseline water and energy use at each site by monitoring each dipper well for a month. This baseline is significant because it represents typical use patterns of dipper wells in the field, and all data comes from real foodservice operations as opposed to lab results. The data is clearly influenced by staff operating behavior. The presentation of these results is divided by each site for clarity. A site description is included so that some of the operating conditions are noted.

Los Banos Site

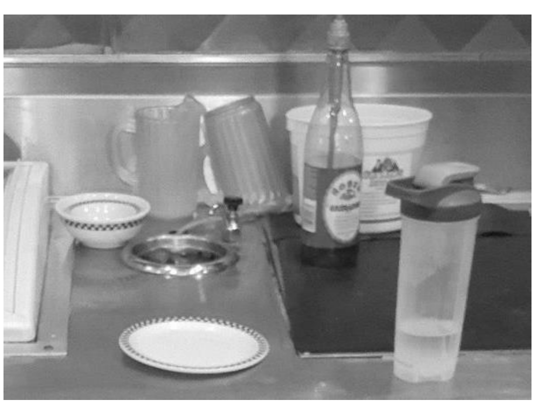
Site Overview

The Black Bear Diner at 955 West Pacheco Boulevard in Los Banos, California is a medium full-service restaurant specializing in American fare (Figure 8). It is open from 6 AM to 10 PM Sunday through Thursday and until 11 PM on Fridays and Saturdays, and serves breakfast, lunch, dinner and confectionry items throughout all hours of operation.

Figure 8. Los Banos Black Bear Diner Storefront

The site uses a cold-water fed dipper well, mostly to clean its ice cream scoops and other small serving utensils (Figure 9). The dipper well is placed on a line in between a salad assembly chef-base station and an ice cream freezer on the West side of the store. As per health department standards, the dipper well drains into a floor sink.

Figure 9. Los Banos Cold Water Dipper Well



Monitoring Period

The dipper well at Los Banos was monitored for water consumption from 5/18/2017 to 6/15/2017 for a total of 29 operating days.

Measurement Points

The baseline period required a single cold water flow measurement, recorded at 1 minute intervals to determine the water use of the dipper well. Because it was a cold water dipper well and didn't consume any gas or electric energy at the site, temperature was not recorded. Total daily water use was recorded, as well as water use per hour of operation.

Results

The dipper well ran for an average of 14 hours per day and used 486.5 gallons of water per day. Factoring in the days when the dipper well was not used, the average daily water use was 405.4 gallons. It had an average flow rate of 0.57 gpm. The staff was in the habit of turning the dipper well on every morning and turning it off before leaving at night. The dipper well basically ran at the same flow rate, but the daily flow rate was highly variable because it depended on control by the operator. The lowest flow rate was 0.18 gpm, the highest was 1.38 gpm and the standard deviation of flow rates was 0.35 gpm. The measured results are shown in Table 1.

Table 1. Los Banos Dipper Well Daily Average Results

Parameter	Result
Water use on flow days (gal/d)	**486.5**
Water use on all days (gal/d)	**405.4**
Operating time (h/d)	**14**
Flow rate (gpm)	**0.57**
Highest flow rate recorded (gpm)	**1.38**
Lowest flow rate recorded (gpm)	**0.18**

The average operating profile for two days is shown in Figure 10 which illustrates the day to day variability in flow rate. The average flow rate on June 13 was approximately 0.3 gpm and 0.8 gpm on June 14th.

Figure 10. Los Banos Dipper Well June 13th and 14th Operating Profile

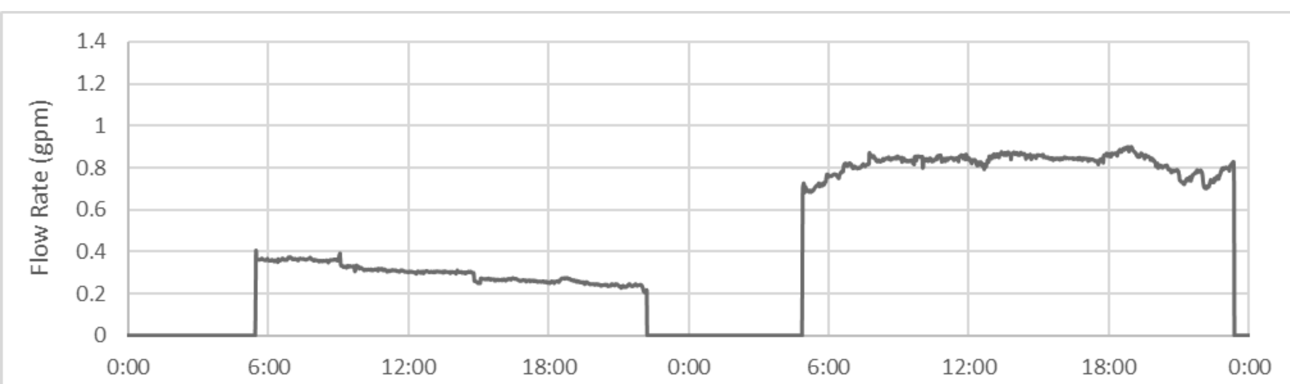
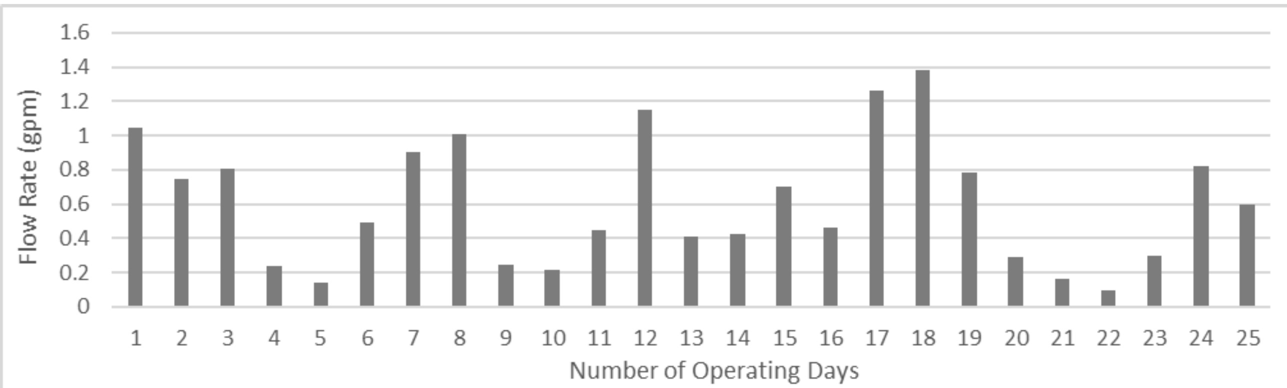


Figure 11 shows average daily flow rates, verifying that its operation was heavily dependent on the operator. On the four days when the dipper well was off completely, the flow rates were omitted. There doesn't appear to be a pattern to days that have the highest flow rates. Staff would essentially turn on the dipper well at the beginning of the work day around 5 AM to a random flow rate, so the operator was likely just eyeballing it. Because dipper wells don't demand constant staff attention, these operating practices are likely common throughout the foodservice industry. It's difficult to imagine restaurant staff rigorously checking the dipper well's flow rate at the beginning of each day.

Figure 11. Los Banos Dipper Well Average Daily Flow Rates



Madera Site

Site Overview

The Black Bear Diner at 1209 East Almond Avenue in Madera, CA serves the same menu and is open for the same hours as the Black Bear Diner in Los Banos. The storefront is depicted in Figure 12.

Figure 12. Madera Black Bear Diner Storefront

This site uses a hot water fed dipper well drained to a floor sink shown in Figure 13. This dipper well is located on the south side of the restaurant between a microwave and milkshake mixer and the ice cream freezer, but is close to other food preparation stations. It is used primarily to clean ice cream and butter scoops. An interview with staff at the site suggested that the site used a hot water dipper well because it heated utensils, which made it easier on staff members to scoop refrigerated or frozen products.

Figure 13. Madera Hot Water Dipper Well

Monitoring Period

The dipper well at Madera was monitored for water consumption from 5/18/2017 to 6/15/2017 for a total of 29 operating days.

Measurement Points

The hot water consumed was measured with a water meter, and the cold water temperature was measured with a thermocouple. The cold water temperature was compared to the outlet temperature of the water heater for an analysis of how much energy the water heater added to the water. The average operating efficiency of a conventional commercial storage water heater is estimated to be 65% based on an earlier mentioned study. This was used to estimate the amount of energy the building water heater consumed to handle the dipper well's hot water load.

Results

The operating pattern at Madera differed from Los Banos in that the Madera dipper well ran at a lower flow rate, but the dipper was left runnning during off hours. The dipper well ran at about 0.23 gpm and consumed an average of 321 gallons per day with extremely little variation. This unit accounted for 2.84 therms of gas energy consumed at the water heater per day. These results are summarized in Table 2.

Table 2. Madera Dipper Well Daily Average Results

Parameter	Result
Water use (gal/d)	**321.4**
Operating time (h/d)	**24**
Flow rate (gpm)	**0.23**
Cold water temperature (°F)	**69.3**
Hot water temperature at water heater (°F)	**138.4**
Energy use (therms/d)	**2.84**

It is important to note that energy use was not directly monitored, but was calculated according to measured parameters with Equation 1.

$$Energy\ use\ per\ day = Q = \frac{V*\rho*C_p*(T_{heater}-T_{cold})}{\eta_{heater}} \text{(Eqn 1)}$$

Where:

$$V = Water\ use = 321.4 \frac{gal}{d}$$

$$\rho = Water\ density = 8.314\ \frac{lb}{gal}$$

$$C_p = heat\ capacity\ of\ water = 1\ \frac{btu}{lb * °F}$$

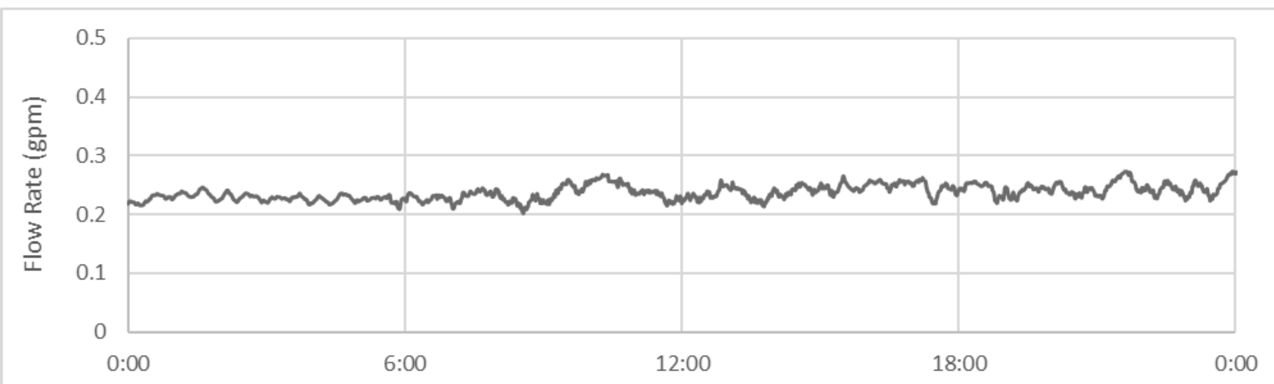
$$T_{heater} = 138.4\ °\mathrm{F}$$

$$T_{cold} = 69.3\ °\mathrm{F}$$

$$\eta_{heater} = Water\ heater\ operating\ efficiency = 65\%$$

Figure 14 shows the daily operating profile of the baseline dipper well at Madera. On this day, the dipper well flow rate closely matches the average daily flow rate of 0.23 gpm. This device had a very consistent use pattern, as this operating profile was essentially repeated on every day the device was monitored. This means that the site operators set this dipper well up with its flow rate before researchers began monitoring the device, then just never made any significant adjustments to the position of the valve which controls the flow rate. It also highlights how forgettable dipper wells are to the staff of a commercial kitchen. The small flow rate trickling looks so innocent that in a mad dash to close down a restaurant, it's easy to forget to turn the dipper well off, which leads to the wasteful situation depicted in Figure 14.

Figure 14. Madera Dipper Well June 1st Daily Operating Profile



Replacement Results

Los Banos Site

The dipper well at the Los Banos Black Bear Diner was replaced with a Lolsberg i.ScoopShower (Figure 15). There was a dramatic reduction in average water used from 486.5 to 4.9 gallons per day. This was due to the large reduction in average operating time. The LSS ran for less than half an hour per day with average flow rates similar to the original dipper well. For this phase of the study, the instrumentation was not changed from the baseline phase as we were just measuring cold water use at much higher sampling rates.

Figure 15. Los Banos Replacement ScoopShower

Figure 16 shows the daily operating profile of the new device. The daily operating profile of the new device is much more representative of the overall operation at the site. On this day, there were 12 LSS operations (including multiple uses close together at 10 AM and 6:30 PM.) There are a few uses before noon to accommodate the breakfast and brunch rush and lull in the middle of the day between about 1 PM and 6 PM, with most of the scoop shower uses clustered for the dinner rush between 6 PM and 9 PM. The large flow at the end of the day is the water used to clean out the scoop shower before the end of the shift. The range of uses per day varied greatly, with a minimum of 9 uses per day and a maximum of 26. The range of total daily water consumption was also highly variable, but essentially scaled with number of uses per day.

Figure 16. Los Banos ScoopShower August 1st Daily Operating Profile

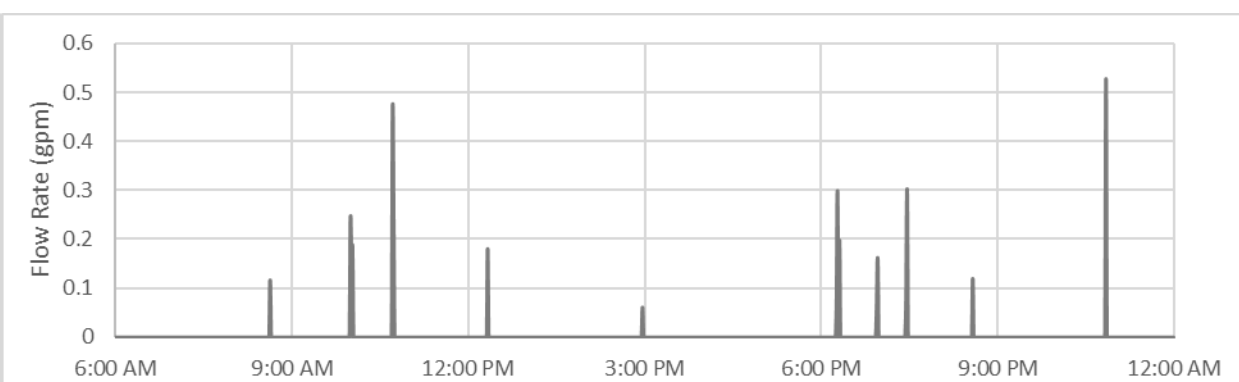


Table 3 summarizes the results. Ultimately, the i.ScoopShower used 0.28 gallons per use. If 17.7 uses per day are applied to the baseline dipper well, the dipper well would be consuming 27 gallons per use and 100 Wh per use in embedded energy. Anecdotal evidence was collected by a brief interview with staff at the site. Staff adapted quickly and easily to using the new device, and no major operating problems or staff frustrations were reported.

Table 3. Los Banos ScoopShower Daily Average Results

Parameter	Value
Water use (gal/d)	**4.9**
Operating time (h/d)	**0.27**
Flow rate (gpm)	**0.3**
Uses per day	**17.7**
Water use per scoop (gal/use)	**0.28**

Madera Site

The Madera ConserveWell UH replacement unit (Figure 17) consumed a trivially small amount of water. The staff replaced the water to the fill line an average of every 2.5 hours during their 16 hours of operation, so their total water use was about 2.5 gallons per day based on between 7 and 8 fills at 0.22 gallons per fill.

Figure 17. Madera Replacement ConserveWell Heated Utensil Holder

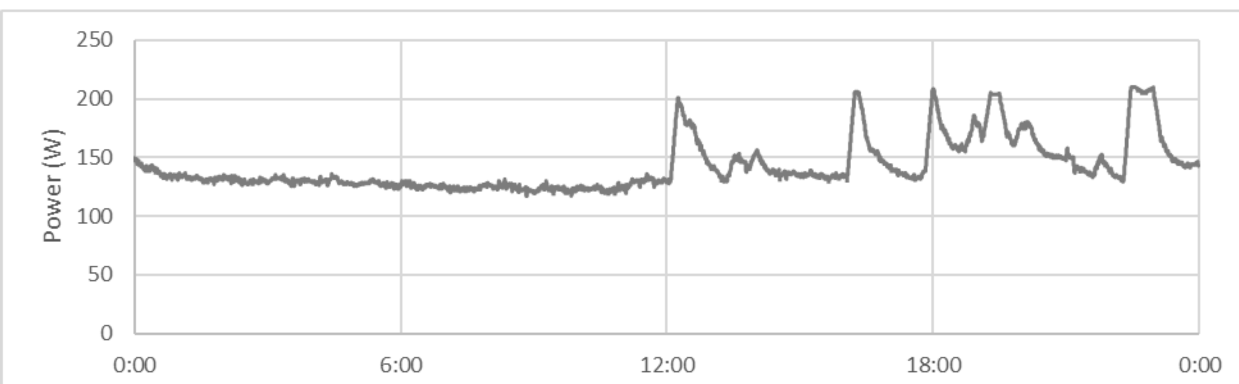
The instrumentation at the site changed from the baseline when only a hot water meter was used. This was removed with the replacement unit because the water consumption of the new device was actually happening at a hand or utility sink, where staff would remove and fill the unit's tank manually. This created a metering challenge because there was no convenient point to directly submeter the water use of the new device. Even submetering the water use at the utility sink adjacent to the dipper well wasn't a good option because there would not be a clean way to differentiate the use at the dipper well from all other uses of the utility sink. It was possible to count the number of SUH basin fills per day by tracking changes in the electricity input rate to the SUH. By assuming that operators filled the basin to its capacity each time, it was possible to calculate the average daily water use. The electricity submetering data showed an average of 7.6 tank fills per day, which resulted in an estimated water use of 2.5 gallons per day. It also showed an average electricity use of 3.2 kWh per day. The site did not change its operating practice of leaving its utensil washer operating throughout the night, so the average operating time for the new unit was still 24 hours per day. Table 4 summarizes these results and also compares the SUH's average input rate to its rated maximum input rate.

Table 4. Madera Utensil Holder Daily Average Results

Parameter	Result
Water use (gal/d)	**2.5**
Operating time (h/d)	**24**
Tank fills (Fills/d)	**7.6**
Electricity use (kWh/d)	**3.2**
Average input rate (W)	**135**
Rated maximum input rate (W)	**400**

The difference between normal operation, during which the heater adds heat to the tank to maintain a constant 140°F temperature and a tank fill, during which the heater warms up insufficiently hot water, was noted by a difference in average input rate per unit time. During normal operation, the unit had a duty cycle of about 33% and an average input rate of - 130W, but during tank fills, the unit was on at a higher input rate until the water reached its setpoint temperature. Additionally, because the scoops that were rinsed with the SUH were much colder than the water, the input rate rose slightly each time a scoop was rinsed to maintain the setpoint temperature. This explains the input rate variability seen after 6 PM; it was the period of the day when the operator needed to clean scoops most frequently. This aligns with the dinner rush. Additionally, the SUH basin was dumped and refilled at roughly 6 PM, which means the operators at the site probably replaced the water in anticipation of the dinner rush. The unit's water consumption was calculated as the number of tank fills by the tank volume. For August 1st, the data in Figure 18 shows that there were five tank fills (one just after noon, one around 4:30 PM, 6 PM, and 7 PM and one at the end of the operating day), therefore the ConserveWell consumed 1.25 gallons of water on August 1st.

Figure 18. Madera Utensil Holder August 1st Daily Operating Profile



After an interview with staff members at the Black Bear Diner in Madera, Frontier Energy was not made aware of any issues with the SUH. After a brief period where staff caught each other up to speed on how to use the new device, operators had a generally easy time adapting. This is largely due to the similar operation of the SUH to a dipper well; the only real difference to an operator is the need to dump and replace the water in the tank every few hours.

Comparison Analysis

Los Banos Site

Table 5 lists the savings from replacing the dipper well at the Los Banos site with the LSS. The LSS saved 99% of the original dipper well's water. This huge savings is largely due to the massive reduction in runtime. The original dipper well ran for all of the hours of operation at the site, but the LSS was only consuming water when staff was actually rinsing scoops. Assuming the number of scoops cleaned per day was not significantly different between the baseline and the replacement periods of the study, the data suggests that the baseline system was using almost 500 gallons to rinse about 18 scoops per day. This is intuitively excessive, and an analysis of the LSS data confirms that most of this water use is simply waste. The dipper well was using 27 gallons of water to rinse a single ice cream scoop. In contrast, the scoop shower used about a quarter of a gallon per scoop, which means that the existing dipper well uses almost 100 times more water than the LSS.

Table 5. Los Banos Daily Consumption Comparison Analysis

	Dipper Well	Scoop Shower	Savings	Savings Percentage
Operating time (h/d)	**14.0**	**0.27**	**13.73**	**98%**
Water use (gal/d)	**486.5**	**4.9**	**481.6**	**99%**
Utility cost ($/d)	**$8.47**	**$0.09**	**$8.38**	**99%**
Embedded energy (kWh/d)	**1.8**	**0.02**	**1.78**	**99%**
Water use per scoop (gal/use)	**27.03**	**0.28**	**26.75**	**99%**

It is evident from the data that the LSS was used for about 15 minutes per day, which encompasses the time during which the pressure switch was depressed and water was flowing. This more closely follows the actual demand for water to clean scoops at the site. This effectively eliminated the high variability in daily water consumption and flow rate from the original dipper well. Staff had less control over the operating conditions of the LSS, which meant that operating practices varied less from staff member to staff member. The most efficient operating practice was followed because it was the only one available. Table 6 lists the annual water consumption and annual utility savings associated with the replacement. The LSS saved 176,200 gallons, which translated to over $3,000 in savings for the customer. The embedded energy savings for the state would be 650 kWh per year.

Table 6. Los Banos Annual Utility Cost Comparison Analysis

	Baseline	Replacement	Savings
Water use (gal/y)	**178,000**	**1,800**	**176,200**
Utility cost ($/y)	**$3,097**	**$31**	**$3,066**
Embedded energy (kWh/y)	**657**	**7**	**650**

Madera Site

Table 7 lists the savings from replacing the dipper well at Madera with the SUH. The SUH saved 99% of the water and 95% of the energy used by the original dipper well. The original dipper well was run for 24 hours per day, which meant that it was always placing a load on the water heater. The SUH was able to maintain its temperature by adding idle energy to the small volume of water in its basin. The heat loss of a small volume of water to the ambient environment around it is a much smaller amount of energy than that required to heat 321 gallons of water from a groundwater temperature to 140°F. The energy savings were possible because the SUH consumed much less water than the original dipper well.

Table 7. Madera Daily Consumption Comparison Analysis

	Original	Replacement	Savings	Savings Percentage
Operating time (h/d)	**24**	**24**	**0**	**0%**
Water use (gal/d)	**321.4**	**3.8**	**317.6**	**99%**
Energy use (therms/d)	**2.84**	**3.2 kWh or 0.11 equivalent therms**	**2.73 equiv. therms**	**96%**
Direct Utility cost ($/d)	**$8.72**	**$0.70**	**$8.02**	**91%**
Embedded Energy (kWh/d)	**1.24**	**0.01**	**1.23**	**99%**

The water savings were substantial because the SUH used the temperature of the water to clean the scoops as opposed to using the water itself to clean the scoops. Table 8 lists the annual water and energy savings data as well as the annual utility cost savings. The SUH saved almost 116,000 gallons of water and 1,000 equivalent therms per year. Additionally, because the water savings were so substantial, there was an embedded energy savings of 417 kWh per year, which partially offsets the increase in direct electricity use with the new unit.

Table 8. Madera Annual Utility Cost Comparison Analysis

	Original	Replacement	Savings
Water use (gal/y)	**117,300**	**1,400**	**115,900**
Energy use (therms/y)	**1,037**	**1,168 kWh or 40 equivalent therms**	**997 equivalent therms**
Direct Utility cost ($/y)	**$3,183**	**$255**	**$2,927**
Embedded energy (kWh/y)	**422**	**5**	**417**

Most of the utility cost savings are from the dramatic reduction in water use. The reduction in energy costs is undercut somewhat by fuel switching. Because electricity is about six times as expensive as gas in California, the 96% reduction in energy use only yielded a 71% energy cost savings. Demand surge prices are of minimal concern because the maximum input rate of the SUH is so small.

Utility Incentive Potential

Table 9 breaks out the value of potential incentives using an estimate of the average incentive provided by California water and energy utilities, and assumes a lifetime of 10 years for each of the replacement technologies. All incentive values have been normalized in terms of an amount based on the first year's savings. Based on one field site, the LSS demonstrated a potential water incentive of $940, which is higher than the purchase cost of the unit and it could potentially support a 3rd-party replacement program in its entirety. With the addition of the embedded energy savings, the - incentive value approaches a total of $1000 for a cold-water dipper well replacement. With regard to replacement of the hot water dipper well, the SUH potential water incentive is $620, while the energy and embedded energy incentive estimates add up to $940, for a total incentive of $1,560.

Table 9. Dipper Well Replacement Incentive Program

	Estimated Average State Rebate Value	Scoop Shower Savings	Scoop Shower Incentive Potential	Utensil Holder Savings	Utensil Holder Incentive Potential
Water (HCF/y)	**$4/HCF**	**235**	**$940**	**155**	**$620**
Gas (therms/y)	**$1/therm**	**0**	**0**	**997**	**$997**
Electricity (kWh/y)	**$0.08/kWh**	**0**	**0**	**-1168**	**-$93**
Embedded Energy (kWh/y)	**$0.08/kWh**	**650**	**$52**	**417**	**$33**
Total			**$992**		**$1557**

Custom joint-utility rebates are much higher than the actual cost of either of these replacement technologies, which should make rebate programs around dipper wells attractive to utilities, particularly water utilities. It is recommended that both water and energy utilities work together to offer a uniform incentive on cold and hot water dipper wells to maximize their market transformation efforts. A joint water and energy utility 3rd-party direct replacement program could potentially be viable when done at scale regionally or across the state.

Conclusions

The most dramatic savings from this study were the water consumption savings at both sites. The Los Banos site saved 176,000 gallons per year, and the Madera site saved 116,000 gallons. At Madera, this resulted in a 997 therms per year direct energy savings. Each site saved over $2,500 per year in direct utility costs, and because each replacement technology costs approximately $500, the simple payback time for both the LSS and the SUH was on the order of a few months. Because of the significant water savings, the Los Banos site saved 650 kWh per year in embedded energy and the Madera site saved 417 kWh/year. At Los Banos, it was possible to normalize to the number of scoops rinsed per day because of the operating characteristics of the LSS. This led to the understanding that the baseline dipper well was effectively consuming 27 gallons per utensil rinsed, and that the LSS was consuming approximately a quarter of a gallon per utensil.

The results of this study exemplify how wasteful dipper wells are and the significant savings potential of their replacement technologies, but more research is needed to determine which replacement technologies will optimize savings under different operating conditions and which technology will best satisfy operator needs. From interviews with the general managers at the sites - in this study, we know that both the LSS and the SUH are reasonable options for full service restaurants, but we can't apply the same option to different operating situations or different technologies.

Recommendations

It's clear that it makes financial sense for utilities to capitalize on the savings potential of dipper well replacement technologies, and that a comprehensive incentive program is a viable way to make this happen. California's water and energy utilities would mutually benefit from working jointly to design a program around replacing dipper wells. The direct and embedded savings are high enough, at approximately $1,000 for cold-water dipper well replacement and $1,200 for hot water dipper well replacement, such that utilities can justify a 3rd-party direct replacement program or at a minimum a replacement product offered at no or little cost to the facility. The biggest roadblock to designing an impactful replacement program is that while these results are promising, they fail to accurately represent all possible combinations of dipper well replacement technologies, site types, and proper applications of each technology.

To do this, all dipper well replacement technologies need to be field evaluated at all applicable site types. Frontier Energy has already identified a dipper well replacement technology that is inappropriate since the water saving aspects of the product can easily be defeated. Others that are application specific, such as using a hot water bath to maintain ice cream scoops, should not be installed at ice-cream shops. The research team has identified several other technologies that have yet to be studied, including the Nemco Rinsewell, Wells Heated Utensil Holder, Lolsberg UtensilShower and Stockel Scoop Shower. There probably are a handful of other technologies that have similar designs we are not yet aware of and others that will bring product to market quickly after they become aware of the savings potential and the potential for incentives. It is highly recommended that all existing dipper well replacement technologies be field evaluated at each of these foodservice site types in multiple replacement studies in order to confirm the savings potential and identify which replacement technologies are most appropriate at each site type prior to rolling out an incentive program.

The utility replacement program will also need to be set up to recognize future technologies that come to market. This means it may require future technologies to be field evaluated by third party researchers to investigate water and energy savings claims and in the process gain the confidence and approval by local, regional and statewide health departments. This is to prevent equipment manufacturers from being able to have equipment qualify for the replacement program with overly-optimistic savings claims and bringing it to market without verification or approval by health departments, which in the past has caused over reactions, and ultimately creates confusion and a slower path to achieving resource savings. It is recommended that the replacement program have an agreed upon minimum level of water and energy savings that a technology must display before being incentivized. This will all together minimize misapplication and maximize facility and regulatory acceptance and deter manufacturers from bringing products to market that fail to yield the same level of savings.

The path going forward should involve being methodical with a roadmapping meeting to seek collaboration between water and energy utilities, CPUC, CEC, DWR, and health departments. This is a good opportunity to show once again that California is a leader in market transformation of water and energy saving technologies as - demonstrated - a decade ago with the introduction of high-efficiency pre-rinse spray valves.

References

1. Delagah, Amin, et. al. *Condensing Hybrid Water Heater Performance Field Evaluation Report*. Fisher-Nickel, Inc. October 2013.

Appendix

Los Banos Baseline			Los Banos Replacement		
Date	**Water use (gal)**	**Runtime (h)**	**Date**	**Water Use (gal)**	**Runtime (h)**
5/18/2017	116.10	1.85	**7/16/2017**	2.31	0.23
5/19/2017	748.42	16.67	**7/17/2017**	5.97	0.59
5/20/2017	204.84	4.25	**7/18/2017**	3.07	0.30
5/21/2017	190.59	13.47	**7/19/2017**	6.99	0.69
5/22/2017	173.48	20.83	**7/20/2017**	4.78	0.47
5/23/2017	437.65	14.92	**7/21/2017**	4.61	0.46
5/24/2017	916.81	16.87	**7/22/2017**	3.11	0.31
5/25/2017	293.93	4.87	**7/23/2017**	9.89	0.98
5/26/2017	180.13	12.10	**7/24/2017**	3.08	0.31
5/27/2017	214.93	16.37	**7/25/2017**	7.00	0.69
5/29/2017	342.92	12.82	**7/26/2017**	5.30	0.53
5/30/2017	1135.96	16.45	**7/27/2017**	2.47	0.24
5/31/2017	398.17	16.30	**7/28/2017**	6.84	0.68
6/2/2017	469.14	18.40	**7/29/2017**	9.54	0.95
6/3/2017	256.37	6.12	**7/30/2017**	2.95	0.29
6/4/2017	251.49	9.00	**7/31/2017**	4.25	0.25
6/6/2017	1279.40	16.92	**8/1/2017**	3.47	0.32
6/7/2017	1325.04	15.98	**8/2/2017**	5.57	0.35
6/8/2017	525.59	11.15	**8/3/2017**	2.43	0.23
6/10/2017	321.05	18.65	**8/4/2017**	5.91	0.53
6/11/2017	3.94	0.40	**8/5/2017**	6.69	0.67
6/12/2017	79.96	13.57	**8/6/2017**	7.00	0.72
6/13/2017	298.23	16.77	**8/7/2017**	6.18	0.58
6/14/2017	911.58	18.50	**8/8/2017**	6.84	0.47
6/15/2017	232.79	6.53	**8/9/2017**	3.27	0.42
			8/10/2017	2.77	0.23
			8/11/2017	1.32	0.28

Madera Baseline		Madera Replacement		
Date	**Daily Water Use (gal)**	**Date**	**Energy Use (Wh)**	**Number of Fills**
5/16/2017	335.48	**6/15/2017**	1154	4
5/17/2017	317.24	**6/16/2017**	3197	7
5/18/2017	302.91	**6/17/2017**	3272	7
5/19/2017	332.58	**6/18/2017**	3574	10
5/20/2017	312.739	**6/19/2017**	3501	8
5/21/2017	307.711	**6/20/2017**	3343	7
5/22/2017	325.608	**6/21/2017**	3039	8
5/23/2017	323.782	**6/22/2017**	2871	6
5/24/2017	326.552	**6/23/2017**	3353	7
5/25/2017	335.798	**6/24/2017**	3463	5
5/26/2017	293.2561	**6/25/2017**	3219	5
5/27/2017	295.1924	**6/26/2017**	2885	3
5/28/2017	314.6355	**6/27/2017**	3119	8
5/29/2017	319.5791	**6/28/2017**	3171	8
5/30/2017	307.6433	**6/29/2017**	3157	9
5/31/2017	341.587	**6/30/2017**	3061	7
6/1/2017	347.3609	**7/1/2017**	1686	3
6/2/2017	334.1918	**7/2/2017**	3527	11
6/3/2017	317.2824	**7/3/2017**	3039	8
6/4/2017	319.317	**7/4/2017**	3053	7
6/5/2017	336.4748	**7/5/2017**	2980	7
6/6/2017	325.7112	**7/6/2017**	3233	8
6/7/2017	353.5745	**7/7/2017**	3078	7
6/8/2017	357.1648	**7/8/2017**	3345	8
6/9/2017	351.0288	**7/9/2017**	3867	8
6/10/2017	342.3042	**7/10/2017**	3360	7
6/11/2017	346.7148	**7/11/2017**	3340	6
6/12/2017	347.4958	**7/12/2017**	3382	6
6/13/2017	317.5845	**7/13/2017**	3163	9
6/14/2017	328.7815	**7/14/2017**	3417	7
6/15/2017	153.0052	**7/15/2017**	3451	7
		7/16/2017	3581	11
		7/17/2017	3466	11
		7/18/2017	3409	11
		7/19/2017	3501	12
		7/20/2017	3242	9
		7/21/2017	3509	9
		7/22/2017	3574	9
		7/23/2017	3540	8
		7/24/2017	3322	7
		7/25/2017	3197	5

Madera Replacement (Cont.)		
Date	**Electricity Use (Wh)**	**Number of Fills**
7/26/2017	3066	5
7/27/2017	3209	6
7/28/2017	3269	7
7/29/2017	3586	8
7/30/2017	3077	8
7/31/2017	3219	9
8/1/2017	3425	5
8/2/2017	3155	7
8/3/2017	3275	9