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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Pre-Rinse Operations Field Evaluation Report

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Marriott San Ramon, San Ramon Valley Conference Center,
Presidio of Monterey, Tech. Corporate Campus, Stanford University

Food Service Technology Center Background

The information in this report is based on data generated in the field in commercial foodservice facilities 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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Executive Summary

Project Overview

A commercial foodservice pre-rinse operation (PRO) includes the dishroom equipment and procedures used to prepare wares for processing through the dishmachine. PRO types can range from minimalist dry-scrapping-only operations that use practically no water, to dishrooms with large motorized water- and energy-intensive rinsing and scrap processing or pulping equipment, with many types in between, such as operations that employ mostly dry scrapping with some moderate use of pre-rinse spray valves (PRSVs) or spray hoses. Water and energy use of PROs had not been the focus of previous industry studies of dishrooms and dishmachines, thus this project was initiated to develop a more accurate water and energy use estimate for each major type of pre-rinse operation. From this, the researchers could differentiate between the best and worst examples, and then estimate the savings if all the inefficient PROs were replaced with efficient versions.

The project scope included the selection of field testing sites, the installation of instrumentation to monitor and log PRO water and energy usage data, and the documentation of dishroom equipment and operating practices. Data points including water flow, electricity use, hot-water supply temperature, and dishmachine sanitizing rinse time were collected at five-second intervals and stored with a time stamp in the memory of a data acquisition system (DAQ). Nine sites were monitored and included three cafeterias in corporate campuses, four dining halls on a university campus, one cafeteria on a military campus, and a hotel kitchen. The sites were monitored in various stages during the period between May 2017 and May 2018, and each was studied for a period long enough to accumulate at least one month of complete data. The PROs were monitored and characterized as found, irrespective of the condition or state of the equipment. Resultant data sets were compiled to calculate daily water and energy use, and normalized use in terms of usage per hour of dishmachine rinse time. The data from the nine sites from this project were aggregated with data from seven previously monitored sites to compare and draw conclusions from a larger dataset of 16 PROs in total.

The catalyst for this study was funding from the Innovative Conservation Program. All work was performed by Frontier Energy. The project included the development of a 4-page guide covering the design and operation of efficient PROs.

Background

Prior to this project, Frontier Energy had the opportunity to monitor seven PROs in commercial dishrooms. The PRO studies were as a byproduct of several conveyor dishmachine monitoring projects. This exploratory research opened our eyes to the diversity of PRO found in commercial kitchens and the extreme variability in water and energy use between sites, even with the same equipment installed. It was discovered that in some dishrooms the pre-rinse operation consumed more water than the conveyor dishmachine itself, which is often the single most water and energy intensive appliance operating in commercial kitchens; thus, the water and energy intensity of these PROs makes them one of the largest users of water and energy in a commercial kitchen.

Frontier Energy realized that many of the powered PRO units like trough-fed collectors, pulpers or disposers originally installed were not operating any longer and had been substituted with more primitive hand-held substitutes such as utility hoses and high-flow sprayers. Many operating shortcomings associated with the array of PROs surveyed in the field brought to light that this segment demanded further study. This first-of-its-kind research project examined the complexity of PROs in depth while benchmarking water and energy use of powered and manual operations. This research went further to study the factors that lead to inefficient or efficient operation of the diverse range of PRO types.

The segments of the food service sector that often have powered pre-rinse operations are large full-service restaurants, commercial cafeterias, hospitals, hotels with dining and banquet facilities, nursing homes, colleges, universities, K-12 central kitchens, and correctional facilities. It is estimated that there are 30,000 such facilities in California.

Results

The 16 PROs were categorized into 10 distinct types based on equipment combinations as listed in Figure ES-1. PROs in green are considered efficient, and those in red are classified as conventional or inefficient. The quantity in parenthesis after each label accounts for the number of PROs of the same type that have been averaged. The annual water use (x-axis) and energy use (y-axis) values are normalized based on the average PRO operating time of the 16 sites, which was 4.3 average hours per day and 308 days per year. Note that the parabola curve itself mainly is a qualitative representation of efficient PRO system and practice combinations. The conventional-class points are rather spread out because of the limited dataset of the several PRO types with only data point, but most important is the substantial gap between the efficient class and the next closest PRO in the conventional class.

PROs utilizing only PRSVs, dry scrapping, or a combination of both were clear examples of efficient PRO by incurring minimal or zero water and energy costs. In addition, the disposers shown inside the green parabola were classified as efficient PROs based on the limited data gathered thus far. Although these food waste disposers operated with relatively high fresh-water flow rates of 5 gpm, the staff at each site limited the run time by activating the disposer judiciously only as needed. The conventional or inefficient PROs included pulpers and scrap collectors with or without troughs, and high-flow utility hose/sprayer use. In most cases, the high-volume hoses were added so the facility could maintain operations after an originally installed powered PRO unit had failed.

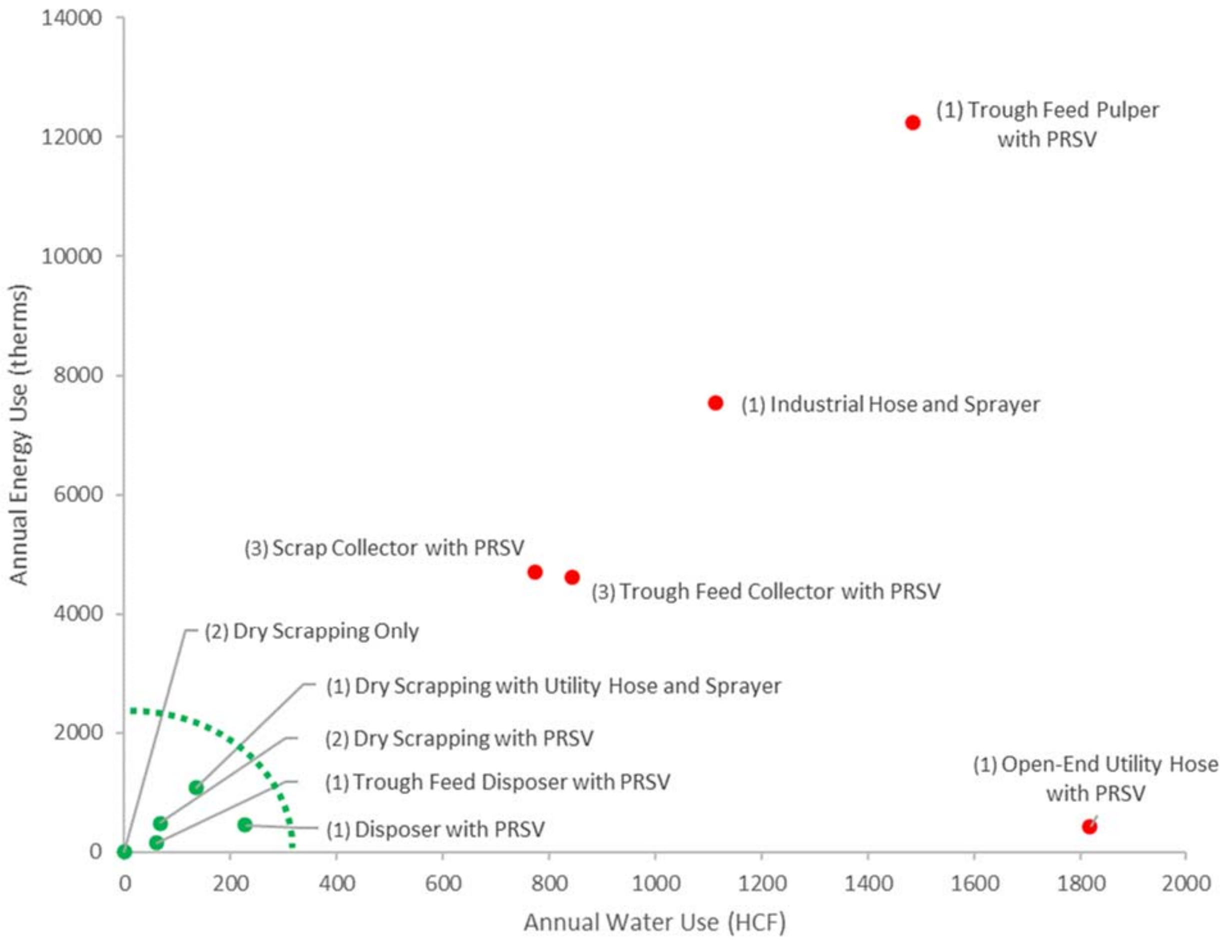

Figure ES-1. Annual energy and water use of various types of pre-rinse operations

The hypothesis of Frontier Energy researchers prior to commencing with this research project was that if the conventional PROs were replaced with efficient PROs and used appropriately by staff, the water and energy use could be reduced by 80% and 30%, respectively in the large dishroom segment. The results showed that greater than 90% water and energy savings is possible. In terms of cost, the average conventional PRO cost $14 in water and energy costs per hour of dishmachine rinse operation versus $1 for efficient PRO.

Using the normalized average operating time, per facility, the total annual savings potential of moving from a conventional PRO to an efficient PRO is 952 HCF of water, 7,605 kWh of electricity and 4,706 therms of gas, which translates to an average facility utility cost savings of roughly $17,000 per year. It is estimated that 75% of the 30,000 large dishrooms in California have conventional PROs, and if all 75% were retrofitted with an efficient PRO, California operators would save annually 21.4 million HCF, 171 MWh and 106 million therms, totaling $390 million.

Recommendations

While the results of this study are promising, the data for each type of PRO is limited to only one to three sites, and because the staff operating practices that can greatly affect the efficiency and performance of each PRO are highly variable, it is recommended that a more thorough segment analysis be conducted before commencing with broad policy or incentive development. The main recommendation would be to conduct a large 40-site study to start drawing statistically sound, quantified conclusions regarding the impact of specific types of equipment and the effects that dishroom staff operating practices have on water and energy use. This large study should include ten sites with pre- and post-monitoring analysis where the existing pre-rinse equipment and practices are changed to more efficient alternatives. Some existing PRO types that have not been previously monitored and will need to be added include undercounter pulping systems, scrap or trough-fed collectors that operate at a lower (1-gpm range) fresh-water flow rate, collectors that operate with proximity sensors to activate or deactivate the unit, and food and organic waste digesters.

In addition, a statistical survey-based research project is recommended to further broaden the characterization by documenting active PRO equipment and usage patterns—including whether the equipment is operated as intended, adjusted, not used or abandoned, and the number of staff members utilized during regular and peak dishroom operation. This feedback would be immensely valuable for kitchen designers so they can adjust future dishroom designs to be better utilized. The additional monitoring, analysis and dialogue with key stakeholders such as manufacturers, designers, operators and dishroom personnel is needed to work toward incorporating comprehensive PRO programs that are beneficial for all stakeholders.

Further research notwithstanding, mandatory submetering of any appliance or equipment that uses over 1,000 gallons per day would be good policy to minimize the impact of future droughts. Among the examples highlighted in this report, the continuously-flowing PRO equipment such as collectors and pulpers on average used 1,380 gallons of water per day based, and the conveyor dishmachines used on average 2,000 gallons per day. Therefore, it would be warranted that all new high-throughput dishrooms and existing dishrooms that go through a major retrofit have water meters installed to submeter separately the continuously flowing PROs and the adjacent conveyor dishmachines. The purpose is to ensure that the dishroom equipment is first commissioned properly, that benchmarks for use are set, and that scheduled readings are taken and reviewed to catch any malfunctions or poor operating practices.

A targeted educational program for groups including large facility operators, maintenance personnel, and dishroom or kitchen designers is needed to make an impact on the existing operations and for new facilities being designed. The program would include seminars, trade magazine articles, webinars, development of a PRO design guide and other information dissemination activities and materials.

Abstract

Pre-rinse operations in large dishrooms can be very water and energy intensive, depending on the equipment utilized and operating practices. It has been documented that in some dishrooms the pre-rinse operation consumes more water than the conveyor dishmachine itself, which is often the single most water- and energy-intensive appliance operating in commercial kitchens. Prior research in this area was limited, thus it was not possible to draw any strong conclusions, especially regarding the savings potential associated with high-efficiency equipment and best practices.

This field research project was devised to record comprehensive water and energy use data and to document the operating characteristics of nine pre-rinse operations in large dishrooms that utilize conveyor dishmachines. Facilities selected for monitoring ranged from those with manual operations involving mostly hand scrapping to those with almost fully automated operations using powered equipment such as scrap collectors and trough-fed pulpers. The monitoring results from these evaluations were normalized based on water and energy use per hour of dishmachine rinse time to provide a level comparison from facility to facility. After analyzing the nine monitored sites and incorporating the results of seven previously monitored sites, some strong patterns emerged relative to water and energy use intensity among the various operations. This highlighted a substantial savings opportunity that could be achieved by replacing older conventional equipment and practices with new energy-efficient equipment and practices. A potential water and energy cost savings of 90% for 75% of the segment is realistic.

For future utility incentive or policy development, the main recommendation would be to conduct a larger study for a more thorough segment analysis to start drawing statistically sound, quantified conclusions regarding the impact of specific types of equipment and the effect that the dishroom staff operating practices have on water and energy use.

Keywords: pre-rinse spray valve, pre-rinse operations, PRO, scrap collector, pulper, disposer, trough, trough-fed disposer, trough-fed collector, trough-fed pulper, utility hose, conveyor dishmachine, rack conveyor, flight conveyor, rackless conveyor, ware washers, dishmachine, dishroom, restaurant, food service, cafeteria, commercial kitchens, energy savings, water savings, kitchen design, designer

Introduction

The role of Frontier Energy as operators of The Food Service Technology Center (FSTC) is to support and educate the foodservice industry to utilize best-available technologies and operating practices to improve performance and productivity while reducing the water and energy intensity. This mission is backed with laboratory and field testing to document and then disseminate the findings. In keeping with those efforts, this research project was selected to characterize pre-rinse operations (PROs) in large dishrooms, benchmark their water and energy use, and to quantify the savings potential if conventional PROs were replaced with best-available technologies and operating practices. This research goes further to study and quantify the factors that lead to inefficient or efficient operation of various PROs. This project was made possible by funds from the Innovative Conservation Program (ICP).

Background

Over the last 15 years, Frontier Energy researchers have made significant efforts through laboratory research to recognize energy and water efficient technologies such as high-pressure low-flow pre-rinse spray valves (PRSVs) and energy efficient dishmachines; and through field monitoring studies, substantial attention has been on hot water system efficiency. Building on this foundation, in the last five years the researchers have extensively focused their hot water systems research on real-world dishrooms. Although the water and energy use of the pre-rinse operations had not been the focus of the previous dishroom studies, the spotlight recently has been placed on this segment as it is one of the last components in the kitchen to be researched that offers a high ceiling for improvement. A pre-rinse operation is defined as the commercial dishroom equipment and procedures used to prepare wares for processing through the dishmachine.

Preliminary PRO field monitoring conducted in five sites during prior dishmachine studies had shown significant variability in PRO water usage. Normalized to gallons per hour of dishmachine rinse time, usage varied from 14 gallons per hour of rinse (gal/h_rinse) when only using a low-flow PRSV to 835 gal/h_rinse when using a combination of more water intensive pre-rinse equipment, including a higher flow PRSV and a scrap collector (Delagah 2015). Further surprising is that these two dishrooms with such disparate usage happened to be in two similar cafeterias on the same campus. In terms of total PRO water consumption, the difference in usage was 100 gallons and 3,200 gallons per day for the low-use and high-use dishrooms respectively, which is also partially representative of the hot-water energy load associated with each PRO. Such disparity documented in two similar dishrooms demonstrated a need to do further research.

Most of the current efficiency and incentive programs are focused on the large segment of commercial foodservice facilities that includes coffee shops and quick- and full-service restaurants where PRSVs are the preferred (and often the only) pre-rinse operation equipment, and where batch-style compact undercounter and door-type dishmachines are commonly used. While a significant impact was made in this segment, the same initiatives were not effective or not incorporated into larger commercial kitchen dishroom operations found in cafeterias, hotels and other large hospitality and institutional foodservice segments characterized by high throughput and larger conveyor rack and flight type dishmachines. Large conveyor and flight type dishmachines have been recognized for efficiency through the ENERGY STAR® program, but there has been no similar activity to drive efficiency in PRO.

Urban areas have increasingly been banning food waste disposers because of their impact downstream at the wastewater treatment plant, which had a perceived secondary benefit of water savings for the pre-rinse operation. In smaller facilities, the operators started transitioning to using a PRSV in combination with a sink strainer to handle the food waste. In larger facilities, it was more commonplace to replace the disposer with other motorized equipment such as scrap collectors and pulpers. While this was effective in reducing the food waste down the drain, the real-world water and energy impact of these operations was not quantified versus preceding operations.

PRO equipment that consume water includes but is not limited to scrap collectors, trough-fed collectors, disposers, trough-fed disposers, pulpers, trough-fed pulpers, disposer-fed pulpers, utility hoses with high-flow sprayers, and PRSVs. PRO practices include wet or dry hand scrapping. It is important to understand that most large dishrooms employ a combination of several PRO equipment and practices to meet their needs. Thus, there are theoretically hundreds of potential PRO combinations to study.

One of the hurdles to comparing various pre-rinse operations was that there was no convention or industry-used metric that was appropriate for gauging the water and energy use intensity of each operation, let alone the performance or overall direct or indirect cost to the operator. Some pre-rinse or scrapping equipment may be used on-demand, while some other equipment may be on for the entire dishroom operating period. It was observed that each process was distinct, with different levels of water and energy use, labor and disposal or composting costs. Also, since these larger pre-rinse operations are found only in a small percentage of facilities and typically have been specified and custom designed by kitchen designers, comparing pre-rinse operations side by side was difficult, and no 3rd-party reviews or comparisons were available. Thus, the industry has continued without any feedback on which pre-rinse operations are effective, reliable, or utilized properly by staff. Once these systems were designed and installed and an initial training took place, they were forgotten about, and any feedback on their performance wouldn't be echoed to the designer—especially after routine staff turnover, which is common in the dishroom. Thus, it is has found that many of these systems either have broken down and have been abandoned, were replaced in a short timespan due to breakdowns, or continue to operate in a wasteful way.

A long-term hurdle is that many kitchen designers do not have access to the latest technical research on energy and water efficiency that would allow better designs to propagate throughout the industry. Often, dishroom designers typically rely on anecdotal experience, industry trends, trade conferences, manufacturer's marketing information and their network of colleagues and industry professionals in their continuous learning process. Furthermore, the primary function of the dishroom is to clean and sanitize ware, frequently with little regard to the energy and water cost associated with a functional operation. Thus, as many aspects of the commercial kitchen have experienced efficiency and performance improvements in the last three decades—such as commercial kitchen cooking appliances, refrigeration, and kitchen ventilation systems—large-commercial dishroom pre-rinse equipment design, as part of the sanitation segment, has lagged.

Pre-Rinse Operation Options in Small and Large Dishrooms

In smaller dishrooms, batch- or door-type dishmachines are used to wash and rinse a rack of wares in a one- to two-minute period, thus having the capability to handle 30 to 60 racks per hour. The manual pre-rinse operation commonly consists of one dishroom staff member handling a PRSV, who must keep pace with the machine to maximize production. If a second staff member is utilized to speed up dishroom throughput, it is to unload racks of clean wares while the pre-rinse operator loads wares onto racks, sprays them down and loads them into the dishmachine. Two to four staff members are typically assigned in large dishrooms that employ rack and flight conveyor dishmachines that can commonly wash 200 to 400 racks per hour or equivalent in wares. In hotels for example, this typically involves additional staff members to pre-scrap food and other waste prior to dropping off sorted wares on the pre-rinse table to expedite the rest of the manual pre-rinse operation. In a cafeteria setting, a passive drop-off window or active tray accumulator or conveyance system commonly is utilized to transfer the trays and wares from the patrons to pre-rinse staff members. Mechanizing the transfer and pre-rinse of wares is a conventional approach in high-throughput dishrooms to minimize labor and space constraints. Mechanizing the pre-rinse operation (in terms of water flow) typically allows the operator to use both hands to scrap, rinse and load wares onto the conveyor. The idea is that this can speed up productivity significantly as the typical pre-rinse spray valve above a sink only allows the operator to use one hand to manipulate wares while the other hand is operating the spray valve.

Pre-Rinse Operation Technology Descriptions

Common types of powered PRO equipment include scrap collectors, disposers, pulpers—and trough-fed versions of each these three (Figure 1). A description and the rated water use range for each type of powered PRO is shown in Table 1. Table 2 provides a description of common unpowered PROs, which have been found in some large dishrooms to be used as either the sole PRO device or in combination with powered PRO equipment.

Figure 1. Scrap Collector, Disposer, Trough-fed Collector and Trough-fed Pulper (from left to right)

Table 1. Characterization of Powered Pre-Rinse Operations

Type	Description	Rated Water Use (gpm)
Scrap Collector	Continuous waterfall effect rapidly flushes water over wares catching debris in large deep well with perforated basket inside. One hand washes dish under the water plume while other hand loads the previous scrapped dish into a rack.	1-2 gpm fresh tempered water (2 gpm typical), 8-30 gpm recirculated
Disposer	On demand motorized grinding of food waste that is mixed with cold water to create a slurry and sent to drain. Some units cannot handle bones and plastic straws.	3-10 gpm fresh cold water
Waste Pulper	Combination of a macerator and dewatering unit used in series to decrease the volume of food waste.	2-3 gpm fresh tempered water (2 gpm typical)
Trough-Fed Collector	Continuous river effect rapidly moves water over wares placed in basin to carry debris into large strainer basket.	2-3 gpm fresh tempered water (2 gpm typical), 8-30 gpm recirculated
Trough-Fed Disposer	On demand river effect rapidly carries debris left in basin into disposer in a slurry for grinding and disposal down drain.	3-10 gpm fresh cold water
Trough-Fed Pulper	Continuous river effect moves water over wares placed in basin to carry debris into pulper for grinding and dewatering.	2-3 gpm fresh tempered water (2 gpm typical), 8-30 gpm recirculated

Table 2. Characterization of Unpowered Pre-Rinse Operations

Type	Description	Rated Water Use (gpm)
Dry Scrapping	Manually scrap by hand or push food off the plate using a spatula. Viable in combination with flight conveyors dishmachines that can handle the extra food waste and have powerful pumps that have the ability to remove dried on debris.	No water use
Pre-Rinse Spray Valve	Handheld on-demand, focused water spray requires one hand to operate the spray valve. Debris falls typically into a perforated metal basket in a pre rinse sink.	0.5-3 gpm (1.2 gpm typical) fresh tempered water
Utility Hose with Sprayer	Handheld on-demand, wide or focused water spray.	1-8 gpm (3 or 6 gpm typical) fresh tempered water

Market

The segments of the food service sector that often utilize powered pre-rinse operations are found in large full-service restaurants, commercial cafeterias, hospitals, hotels with dining and banquet facilities, nursing homes, colleges, universities, K-12 central kitchens, and correctional facilities. It is estimated that there are 30,000 such facilities in California.

Purpose

The goal of this project was to evaluate and characterize various PROs to develop a more accurate water and energy use estimate for each type of operation. From this, the researchers could differentiate between the best and worst PROs operating in the real world, identify opportunities to reduce waste, and then estimate the savings if all inefficient PROs were replaced with efficient versions.

Objectives and Scope

The objective of this project was to monitor and analyze the water use, energy use, and staff work processes in PROs installed in large commercial foodservice facilities. The project scope included the selection of field testing sites, the installation of instrumentation to monitor and log the PRO water and energy use and the rinse time of the dishmachine, and to document dishroom equipment and operating practices determined by observation or via staff interview. The project includes development of a 4-page guide, to be used for distribution by the utilities, on the design and operation of efficient PROs to educate owners and kitchen designers.

Hypothesis

Frontier Energy estimates that water use can be reduced by 80% and energy use by 30% in the large dishroom segment, if the conventional PROs were replaced with high-efficiency PROs and used appropriately by staff.

Project Limitations and Challenges

PROs are very diverse in many aspects, including the available types and whether one type is ideal or better suited for a given facility based on their throughput needs, staff resources, type of dishmachine and space constraints. One limitation was that this study couldn't cover all the various PROs employed in large dishrooms. Some PROs where hard to find or get access to the site. Identifying sites using some of the targeted PRO types, namely pulpers was also a challenge. The research team came across several abandoned or decommissioned pulpers, before finding a working unit. In addition, the water and energy use of PROs can be even more variable based on the dishroom staff operating practices. There are instances of errant habits, such as leaving pre-rinse faucets on and open hoses flowing for hours at a time, or leaving troughs on even when staff goes on break, that skew the total usage higher than normal. Also, the water and energy use from other related sanitation operations such as using a utility floor and equipment cleaning hose to wash and rinse the entire dishroom was not easily separated from the rest of the data and other times not identified or metered. Thus, the results gained from this study are a work in progress as more field work is needed to generate more comprehensive and accurate results.

Methodology

Data Acquisition and Instrumentation Setup

The FE team installed instrumentation and data logging equipment at the PRO test sites to measure and record the water and energy use of each piece of equipment or fixture. Depending on the PRO configuration, the sites required varying types and levels of instrumentation. At each hose, pre-rinse sink, scrap collector, disposer or pulper, researchers monitored the hot and cold water supplies. Commercial-grade water meters were placed on all water inlets. In most cases, flexible supply hoses (or flexible plastic pipe) were used to connect the meters to the fixture inlet plumbing. Some of the equipment was hard-piped, which required that the pipes be cut and connectors attached to facilitate the meter installation. In some cases, the meters were cut in and hard-piped in-line with the piping.

The instrumentation setup included a rinse solenoid valve sensor to measure the operating time of the fresh-water rinse operation of the conveyor dishmachine, which was used to normalize PRO water use data from site to site. Electrical power metering equipment was temporarily installed to gather spot power measurements on collectors and pulpers. Depending on the facility and the model of data logger used, the loggers were typically installed within water-proof enclosures (with cell modems, as shown in Figure 2) and placed on or near the dishmachine, or they were installed within the dishmachine control panel. At most of the sites, power for the data logger and water meters was tapped from the dishmachine, as dishrooms typically do not have wall receptacles.

Figure 2. Enclosure with data logger and cell modem

The water meters provided pulse outputs (per unit of measure) to the data logger. The dishmachine rinse solenoids were instrumented either with a clamp-on current sensor placed around a wire to the solenoid and connected either to an independent state logger or the main data logger, or with a motor on/off logger (that senses magnetic field) placed directly on the rinse solenoid body. Water meter data was logged at five-second intervals and stored with a corresponding time stamp in logger memory. The water temperature was measured at the PRO hot water supply to gauge the domestic hot water energy contribution. It was either spot-measured with a hand-held thermocouple thermometer, or monitored with a temperature sensor connected to the data logger. Based on the delivered temperature data, a nominal water heater outlet temperature was estimated to account for line losses.

Instrumentation Specifications

Water Meters

Omega Engineering FTB-4607 1/2″ single-jet turbine meter with 151.4 pulses/gal output, accuracy 1% of full scale, flow range of 0.2 to 11 gpm, maximum temperature of 190°F (Figure 3). www.omega.com

Figure 3. Omega FTB-4607

Power Metering

Dent Instruments ELITEpro XC portable power data logger, single- and three-phase capability, accuracy ±1% (Figure 4). www.dentinstruments.com

Figure 4. DENT ELITEpro XC

Dent Instruments mini hinged split-core current transformers, 20A and 50A, low voltage 0.333 Vac out, accuracy ±1%.

Continental Control Systems Acuu-CT split-core current transformers, CTL-0750 Opt C0.6, 20A and 50A, low voltage 0.333 Vac out, accuracy ±0.5%. www.ccontrolsys.com

Dataloggers

DataTaker DT80, ten isolated analog inputs and twelve pulse counter inputs (Figure 5). www.datataker.com

Campbell Scientific CR300, six universal input channels and four pulse counter channels (Figure 6). www.campbellsci.com

Figure 5. DataTaker DT-80

Figure 6. Campbell Scientific CR300

Pace Scientific XR5-SE–M, with 8 analog input channels and three pulse input channels (Figure 7). www.pace-sci.com

Figure 7. Pace Scientific XR5-SE–M

Current Sensor Switch

Veris H300, operating range of 0.15 to 60 A (Figure 8). www.veris.com

Figure 8. Veris H300

State and Motor On/Off Loggers

Onset Corporation HOBO UX90-001M State Logger and HOBO UX90-004M Motor On/Off Logger timestamp log the nearest second. (Figure 9). www.onsetcomp.com

Figure 9. HOBO UX90-001M (left) and UX90-004M (right)

Data Analysis

Data sets were compiled to calculate average daily water and energy use and dishmachine rinse time, which was key for comparing sites on a normalized basis of PRO water use per hour of dishmachine rinse time (the total time in hours per day that the dishmachine called for a fresh water rinse as wares were passed through), which is representative of the volume of wares processed through the PRO. Although this normalizing parameter of hours of dishmachine rinse time is not a perfect means to compare the array of rack- and flight-conveyor dishmachines monitored, it is the second-best parameter available. The best parameter, being meals served, is very difficult to obtain from facilities. Nonetheless, the rinse time normalization provides a reasonable comparison between operations, though it doesn't fully account for the real throughput of wares through a machine that is dependent on staff, conveyor speed, flight conveyor width and loading efficiency (number of wares per rack or per conveyor distance). Also, dishmachine use is affected by varying amounts of back-of house wares that are run through the dishmachine, depending on the facility's separate ware-washing and compartment sink operations.

Further calculation incorporating the hot water supply temperature and water volume were used to estimate the energy use at the water heater to supply hot water for the PRO. The following outlined parameters were tabulated on spreadsheets, but only some were important enough to discuss, analyze and document in this report:

- Operating time (h)
    - Hot/cold water flow time
    - Powered PRO operating time
    - Dishmachine rinse time
- Water flow rate (gpm, gph)
- Hot water supply temperature (°F)
- Water use (gal)
    - Cold/cold PRO component water use
    - Total PRO water use
- Electrical energy use (kWh) (therms$_{eqiov/}$)
- Domestic water heater gas use (therms)
- Misc. parameters
    - Electricity cost ($/kWh)
    - Water and sewer cost ($/HCF)
    - Gas cost ($/therm)
    - Electricity use per hour of dishmachine rinse operation (kWh/h_rinse)
    - Gas use per hour of dishmachine rinse operation (therms/h_rinse)
    - Energy use per hour of dishmachine rinse operation (therms/h_rinse)
    - Water use per hour of dishmachine rinse operation (gal/h_rinse)
    - Cost per hour of dishmachine rinse operation ($/h_rinse)
    - Annual operating cost ($/year)

Monitoring Results

The following section presents the compiled energy and water consumption data and the operating characterizations for the nine PROs monitored in the field. Four operations were in Stanford University dining halls, and two were in cafeterias at a corporate campus that preferred to remain anonymous. The remaining sites were more diverse settings: a dining hall at the Presidio of Monterey Army Base, the San Ramon Marriott Hotel Bishop Grill Restaurant and the PG&E San Ramon Valley Conference Center cafeteria.

All the monitored sites had some level of scrapping performed before wares were conveyed to the PRO. At the corporate campus cafés and at the Stanford dining halls, the patrons/students (or staff members at one dining hall that catered meetings and event) scrapped their own dishes into compost receptacles before the wares proceeded to the dishroom. At the army base dining hall, a pre-scrapping program was initiated but has been only partly successful as much of the food waste, in the range of 50%, was still ending up at the PRO. In the hotel, staff members would pre-scrap into bins located either near the bussing areas or adjacent to the pre-rinse staging dishtable.

Monitoring at each site was conducted for a period long enough to accumulate at least 30 days of complete operating-day data, and the resulting data were compiled to calculate average daily water and energy use for each PRO, and to normalize consumption in terms of usage per hour of dishmachine rinse. Each facility was documented individually and then compared on water and energy usage and cost of operation. In the overall comparison, the data from the nine sites monitored for this project are aggregated with data from seven previously monitored sites to compare and draw conclusions from a larger dataset.

The PROs and dishmachines were monitored and characterized as found, thus any observed variance from the equipment's normal operating parameters was noted if identified but not altered. The following presentation of the individual site results is arranged in the order of lowest to highest normalized PRO total water and energy operating cost per hour of dishmachine rinse. Monitoring data compiled for each work day is shown in the Appendix.

Stanford — Schwab Dining Hall

Site Overview

The Schwab dining hall hosts events and operates with a varying schedule and therefore a varied dishroom usage pattern. The dishroom is equipped with a 64" high-temp rack conveyor dishmachine, a PRSV with a faucet spout, and a fresh-water-flushed trough flowing to a disposer, which was the main reason for this site selection. Figure 10 shows the pre-rinse area with the dishmachine, the pre-rinse sink, faucet and PRSV assembly, and the disposer and trough.

Figure 10. Schwab—Pre-rinse sink, disposer and trough area

Monitoring

Three water meters were installed and wired to the data logger, and an on/off logger was installed on the dishmachine rinse solenoid. Figure 11 shows the water meter connection to the disposer and trough (using cold water only), the hot and cold water meters for the pre-rinse faucet and spray valve, and the data logger placed in the dishmachine control panel. The monitoring period spanned 90 days and yielded 57 days of data used for the analysis.

Figure 11. Schwab—Disposer water meter (left); PRSV water meters (center); data logger (right)

Results

This dishroom staff performed the pre-rinse operations quite efficiently. Total pre-rinse station water use amounted to 19 gallons per day, and based on the flow rate data, the faucet spout fraction was about 20% of the fixture total. The disposer/trough consumed only 31 gallons of cold water per day because it was switched on only occasionally to flush the trough as needed, which prevented excessive water use—similar to typical residential sink disposer use. Table 3 shows a result summary.

Table 3. Schwab data summary

PRSV (and Spout) Hot Water Use (gal/d)	16	PRSV Flow Rate (gpm)	1.0
PRSV (and Spout) Cold Water Use (gal/d)	3	Disposer/Trough Flow Rate (gpm)	5.0
Disposer/Trough Cold Water Use (gal/d)	31	Hot Water Supply Temperature to PRO (°F)	140
Total PRO Water Use (gal/d)	50	Electricity Use (kWh/d)	0.2
Disposer Power (kW)	2.0	Estimated Water Heater Gas Use (therms/d)	0.1
PRSV Operating Time (h/d)	0.3	Operating Days Per Year	231
Disposer Operating Time (h/d)	0.1	Annual Water Use (gal)	11,590
Dishmachine Rinse Time (h/d)	1.5	Annual Electricity Use (kWh)	48
PRO Water Use Per Hour Rinse (gal/h_rinse)	34	Est. Annual Water Heater Gas Use (therms)	37

Presidio of Monterey — Belas Hall

Site Overview

Belas Hall is a dining facility at the U.S. Army Presidio of Monterey. The facility serves three meals per day and opens seven days per week except for one closed weekend per month. The dishroom was reconfigured in June 2017 and updated with an efficient 64″rack conveyor dishmachine. The original PRO utilized a trough-fed pulper system, which had failed and had been abandoned; and in response, an open-ended utility hose was situated at the end of the trough and used heavily for continuous flushing similar to operating a fresh-water trough. This open-hose water usage was in the order of 1500 gal/d, and is further discussed in the summary of results section, ASHRAE paper (Delagah et. al. 2017) and in the upcoming project report (Johnson 2018). For the renovation, the hose was removed and replaced with a reeled hose with a trigger sprayer intended for general floor, trough, and dishmachine cleaning as needed. The trough was adapted for PRSV use by widening it to fit dish racks and by adding a screen basket to collect food scraps at the end of the run where the pulper used to be. The Figure 12 shows the pre-rinse area over the original trough, and the rack conveyor dishmachine and the load and unload area.

Figure 12. Belas Hall—Pre-rinse area (left) and dishmachine with load and unload area (right)

Monitoring

Hot and cold water meters were installed for the PRSV and for the reeled hose. The dishmachine was instrumented with another water meter to monitor rinse flow, thus a separate rinse solenoid sensor was not needed here. A hot water supply pipe thermocouple was installed, and it and the water meters were connected to a central data logger. Figure 13 shows the PRSV, the reeled hose and the corresponding water meters. The monitoring period spanned 151 days and yielded 134 days of data used for the analysis.


Figure 13. Belas Hall—PRSV and water meters installed (left); water meters installed on hose reel (right)

Results

While some dishrooms process dishes smoothly with enough space and staff to meet the workload, other sites such as Belas Hall are quite hectic during peak load at the end of meal periods where the students are all dropping off their trays and starting to head back to class at the same time. Although the daily operating times of the PRSV and hose are minimal for a cafeteria that serves three meals a day, their labor needs for dry scrapping and overall dishroom operation are extensive since dining room tray use is standard practice, wares are not sorted, and all food waste is kept on plates at the drop-off window. Since there is a huge bottleneck where the tray conveyance system delivers trays to the pre-rinse area, a large portion of staff time is spent on removing food waste, sorting wares and trays, and then loading them onto racks and into the dishmachine. Only during non-peak moments during each meal period do the staff have time to operate the spray valve to pre-rinse dishes. The dishmachine must handle most of the residual food load after dry scrapping operation and thus the tanks need to be emptied, cleaned and refilled after every meal period. The combination of eliminating the open hose and not having the time to regularly operate the PRSV reduced water use by 17.5 times down to a total of 92 gallons per day.

Table 4. Belas Hall data summary

PRSV Hot Water Use (gal/d)	41	PRSV Flow Rate (gpm)	0.8
PRSV Cold Water Use (gal/d)	3	Hose Flow Rate (gpm)	2.1
Hose Hot Water Use (gal/d)	47	Hot Water Supply Temperature to PRO (°F)	140
Hose Hot Water Use (gal/d)	0	Estimated Water Heater Gas Use (therms/d)	0.9
Total PRO Water Use (gal/d)	92	Operating Days Per Year	330
PRSV Operating Time (h/d)	1.0	Annual Water Use (gal)	30,260
Hose Operating Time (h/d)	0.4	Est. Annual Water Heater Gas Use (therms)	296
Dishmachine Rinse Time (h/d)	1.6		
PRO Water Use Per Hour Rinse (gal/h_rinse)	58		

Marriott Hotel — San Ramon

Site Overview

The Marriott Hotel kitchen is open every day and prepares food for the hotel restaurant, catered events, and room service. The dishroom is equipped with a flight conveyor dishmachine and a pre-rinse area comprising a reeled hose with a standard residential-style trigger sprayer for pre-rinsing wares (Figure 14). This site was selected for the study as an example best-in-class case because, with its dry-scrapping PRO and a large dishmachine, it was assumed that it would exhibit efficient water and energy use to pre-rinse dishes, with minimal pre-rinse water use overall (or at least on a dishmachine per-hour-rinse basis). An interesting note is that this dishroom had been originally equipped with a trough-fed disposer, but the disposer was removed and its drain opening area covered with a screen. In California, many hotels have instituted waste diversion programs that train staff to separate food waste and organic materials, and many communities offer commercial hauling and off-site composting services.

Figure 14. Marriott—Flight dishmachine and pre-rinse area (left) and pre-rinse hose (right)

Monitoring

The cold-water supply to the entire pre-rinse area was blocked off as it was unneeded. Due to the confined plumbing configuration under the pre-rinse area dishtable, only one hot-water meter was installed upstream on the hot water line, which, in addition to the pre-rinse hose, shared flow to a wash-down utility hose and a utensil soak detergent solution mixer. To better distinguish flows to each of the three fixtures, temperature sensors were placed on each of the branch pipes. Figure 15 shows the data logger enclosure mounted under the dishtable, with the water meter inline on the copper piping to the right. The monitoring period spanned 110 days and yielded 35 days of data used for the analysis. This large differential was due to gaps between logged data segments occurring whenever the logger memory had filled (between site visits to download data and reset the logger), as the logger model used in this installation had a lower memory capacity.

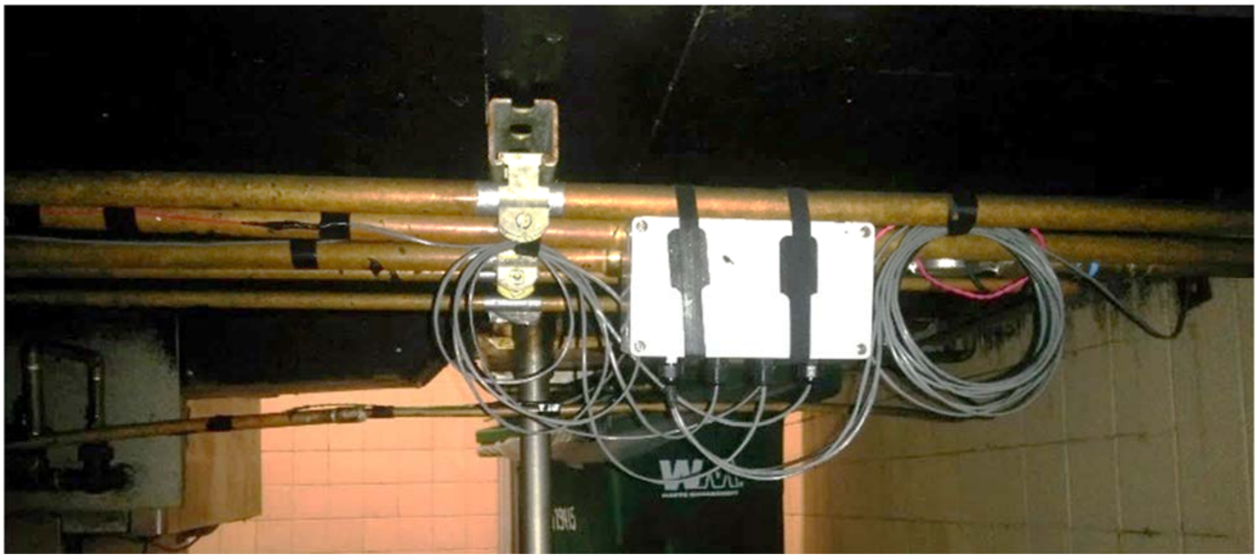

Figure 15. Marriott—Datalogger enclosere and in-line water meter

Results

While this facility used a standard residential-style trigger sprayer to pre-rinse wares, which is typically less efficient than a proper PRSV, the flow rate was typically kept low, and the dishroom crew minimized water use by focusing their efforts on solid dry-scrapping and sorting practices and relying on their flight dishmachine to handle the residual food load. [Note that the pre-rinse hose w/ sprayer water use will be listed under the PRSV category for simplicity throughout other sections in this report, as it was used in a PRSV-like manner and operated with a relatively low flow rate as compared to other more industrial style sprayers observed in other PROs.]

Table 5. Marriott data summary

Pre-Rinse Hose Hot Water Use (gal/d)	446	Pre-Rinse Hose Flow Rate (gpm)	3.5
Hose (and Pre-Soak) Hot Water Use (gal/d)	20	Hot Water Supply Temperature to PRO (°F)	145
Total PRO Water Use (gal/d)	466	Estimated Water Heater Gas Use (therms/d)	5.0
Pre-Rinse Hose Operating Time (h)	2.1	Operating Days Per Year	365
Dishmachine Rinse Time (h/d)	6.2	Annual Water Use (gal)	170,000
PRO Water Use Per Hour Rinse (gal/h_rinse)	75	Est. Annual Water Heater Gas Use (therms)	1,821

Stanford — Lakeside Dining

Site Overview

The Lakeside Dining hall opens for breakfast, lunch, and dinner meal periods, late-night service during the week, and brunch and dinner on weekends. The dishroom is equipped with a 66″ rack conveyor dishmachine, a second-generation (i.e., with timer) trough-fed collector, and a pre-rinse spray valve. Figure 16 is a panoramic view of the dishroom showing the drop-off window, trough, collector, pre-rinse spray valve and conveyor dishmachine. Figure 17 shows the trough while in operation, and a view of the water meter connections.

Figure 16. Lakeside—Panoramic view of dishroom

Figure 17. Lakeside—Trough during operation (left); water meters for collector and PRSV (right)

Monitoring

The instrumentation package comprised hot and cold water meters for the PRSV and collector, a hot water supply pipe thermocouple, a central data logger, and a state logger with a current sensor to monitor the dishmachine rinse solenoid valve. The monitoring period spanned 45 days and yielded 37 days of data used for the analysis.

Results

Table 6 below summarizes the monitoring data. Total PRO water use for this dishroom averaged 421 gallons per day. Upon installation of the metering, it was found that the collector cold-water supply was shut off. It was verified in the data that the staff left it closed during the entire monitoring period. Upon interview, dishroom workers said that the warmer water was preferred for the wet scrapping process. Because this model trough collector incorporates a thermostatic mixing valve that limits overall flow when either supply is off, the operating flow rate was 0.5 gpm as opposed to the 2-gpm range measured at the other sites—effectively a 75% reduction. This chance discovery suggests that a considerably less than standard amount of fresh replenishment water through the trough collector can be satisfactory, especially when at higher water temperatures.

While the lower operating flow rate for the collector was encouraging, the 9.6 hours of operation per day was quite high and problematic with respect to the dishmachine rinse time and PRSV operating time. This demonstrates the continuous operating nature of trough collectors, which naturally is affected by the behavior of staff that might tend to leave the equipment on. As was observed anecdotally with this and other trough collectors in sites visited throughout this project, many times, the trough collector was found running without an operator in the room for an extended amount of time. We found that when there was a timer function was installed on the control systems as a conservation method, the timer mode was typically either not selected or effectively bypassed by setting the timer to shut off in an extended increment of time (as high as 45 minutes), which would completely cover most staff break periods.

Table 6. Lakeside data summary

PRSV Hot Water Use (gal/d)	118	PRSV Flow Rate (gpm)	1.1
PRSV Cold Water Use (gal/d)	3	Collector Flow Rate (gpm)	0.5
Collector Hot Water Use (gal/d)	301	Hot Water Supply Temperature to PRO (°F)	145
Collector Cold Water Use (gal/d)	0	Collector Power Reading (kW)	1.0
Total PRO Water Use (gal/d)	421	Collector Electricity Use (kWh/d)	9.6
PRSV Operating Time (h/d)	1.8	Est. Water Heater Gas Use (therms/d)	4.5
Collector Operating Time (h/d)	9.6	Operating Days Per Year	350
Dishmachine Rinse Time (h/d)	3.5	Annual Water Use (gal)	147,400
PRO Water Use Per Hour Rinse (gal/h_rinse)	121	Annual Electricity Use (kWh)	3,360
		Est. Annual Water Heater Gas Use (therms)	1,568

Stanford — Gerhard Casper Dining Hall

Site Overview

Stanford's Gerhard Casper dining hall serves lunch and dinner on weekdays and is closed on the weekends. The dishroom is equipped with a 44″ rack conveyor dishmachine and a pre-rinse station with a PRSV and a stand-alone modern scrap collector with a timer (Figure 18). This PRO was selected for monitoring specifically because of the stand-alone, timer-equipped scrap collector and the intension of retrofitting it with a newest generation controller that incorporates a proximity sensor to either reduce water flow or shut down the unit if there is no operator presence detected. Completing this pre- and post-monitoring study with the new controller function on the scrap collector system would quantify the savings potential and validate the control technology.

Figure 18. Casper—Dishmachine with Pre-rinse station and scrap collector

Monitoring

Instrumentation for this PRO consisted of hot and cold water meters for the scrap collector and PRSV, a thermocouple for the hot water supply, a dishmachine rinse solenoid current sensor, and the central data logger. Figure 19 shows the water connections and water meters to the scrap collector and PRSV, and the dishroom staff member's standard practice of pre-rinsing wares in batches. Data logging occurred over a 58-day period and covered 41 days of operation that were used in the data analysis.

Figure 19. Casper—PRSV and scrap collector meters (left); efficient PRSV dish rinsing (right)

Results

This scrap collector with a waterfall pattern water flush is intended for pre-rinsing wares while using both hands to scrap and rack, though it was discovered that it was not utilized as intended, and in fact, the operating time and water use data showed that it was barely utilized at all. On a typical day the scrap collector was only operated at the end of the shift or workday to flush and cleanout the strainer basket and cavity. Effectively, the scrap collector was used as a passive oversized strainer, although it provided a large bowl of surface area for staging and pre-rinsing dishes with the PRSV. Unfortunately, because of the negligible usage, the controller retrofit was not viable. Fortunately, it demonstrates opportunities to decommission these units if their utility is minimal, since they otherwise can be and often are misused (by being left on and/or by using supplementary hot water from a faucet). It also reinforces something more recently prominent: that these units get specified and installed, but a good portion of them never get utilized—and cause more work at the end of the shift to clean them out as compared to a regular strainer basket. We can apply these findings to design community and operator training, so they will be covered in the summary of results section in more depth.

Table 7. Casper data summary

PRSV Hot Water Use (gal/d)	119	PRSV Flow Rate (gpm)	1.1
PRSV Cold Water Use (gal/d)	8	Collector Flow Rate (gpm)	2.4
Collector Hot Water Use(gal/d)	5	Hot Water Supply Temperature to PRO (°F)	135
Collector Cold Water Use (gal/d)	5	Collector Power Reading (kW)	1.0
Hose Cold Water Use (gal/d)	5	Collector Electricity Use (kWh/d)	0.04
Total PRO Water Use (gal/d)	142	Estimated Water Heater Gas Use (therms/d)	1.2
PRSV Operating Time (h/d)	2.7	Operating Days Per Year	250
Collector Operating Time (h/d)	0.04	Annual Water Use (gal)	35,430
Dishmachine Rinse Time (h/d)	0.9	Annual Electricity Use (kWh)	10
PRO Water Use Per Hour Rinse (gal/h_rinse)	158	Est. Annual Water Heater Gas Use (therms)	293

PG&E San Ramon Valley Conference Center

Site Overview

The PG&E San Ramon Valley Conference Center (SRVCC) kitchen provides service for the facility restaurant and cafeteria, and for catered events. It operates five days a week and on occasional weekends. The dishroom utilizes a scrap collector and a hot-water supplied utility hose with a sprayer for pre-rinse duties. There is no dedicated pre-rinse station. Figure 20 shows a panoramic view of the dishroom, Figure 21 shows the utility hose and water meter setup and the scrap.

Figure 20. Conference Center—Flight Dishmachine (left) and pre-rinse area (middle in the background)

Figure 21. Conference Center—Utility hose/sprayer water meter (left); collector water metering (right)

Monitoring

Instrumentation included a hot water meter for the utility hose, hot and cold meters to the scrap collector, the main data logger, and a separate on/off logger that was installed directly on the dishmachine rinse solenoid valve. Monitoring period lasted for 107 days of which 29 days were used in the data analysis. The large differential was due to logged data gaps occurring whenever the memory had filled, until the site was revisited to download data and then restart the logger, as the logger model used in this installation had a limited memory capacity.

Results

The results in Table 8 demonstrate more mainstream operation of a scrap collector at roughly twice the operating time of the dishmachine rinse and at a water flow rate of 2.1 gpm, which is close to the specification of 2.0 gpm. This scrap collector system was leaking water internally past its solenoid valve, and staff had to rely on a ball valve to turn water flow off when it was not in operation. Sometimes they forgot to close the valve after a shift, and the water waste associated was included in the daily averages. The pre-rinse hose was used when needed, but staff mainly utilized the scrap collector for most of the pre-rinse operation.

Table 8. Conference Center data summary

Hose Hot Water (gal/d)	132	Hose Flow Rate (gpm)	4.8
Collector Hot Water (gal/d)	591	Collector Flow Rate (gpm)	2.1
Collector Cold Water (gal/d)	367	Hot Water Supply Temperature to PRO (°F)	140
Total PRO Water Use (gal/d)	1,090	Collector Power Reading (kW)	1.0
Hose Operating Time (h/d)	0.6	Collector Electricity Use (kWh/d)	7.4
Collector Operating Time (h/d)	7.4	Estimated Water Heater Gas Use (therms/d)	7.3
Dishmachine Rinse Time (h/d)	3.6	Operating Days Per Year	300
PRO Water Use Per Hour Rinse (gal/h_rinse)	301	Annual Water Use (gal)	326,900
		Annual Electricity Use (kWh)	2,227
		Est. Annual Water Heater Gas Use (therms)	2,194

Stanford — Arrillaga Family Dining Commons

Site Overview

The Arrillaga dining commons offers breakfast, lunch and dinner on weekdays, brunch and dinner on weekends, and late-night service seven days a week. The dishroom employs a 76″ rack conveyor dishmachine, a trough-fed collector, and a pre-rinse station with a spray valve assembly and faucet spout. Figure 22 is a panoramic view of the original dishroom prior to renovation, which occurred during this study (after the initial site visit) and included removal of the tray accumulator, one of the pre-rinse spray assemblies, and redesign of the pre-rinse tabling and equipment for drop off window operation. Figure 23 shows a close-up view of the collector and trough. Figure 24 is a panoramic view of the new configuration with the longer trough, the drop-off window, and the pre-rinse area repositioned to the right near the dishmachine.

Figure 22. Arrillaga #4—Original pre-rinse area with tray accumulator prior to renovation

Figure 23. Arrillaga #4—Collector (left) and trough (right)

Figure 24. Arrillaga—Renovated drop-off window, trough-fed collector and pre-rinse station

Monitoring

Instrumentation for the renovated PRO consisted of hot and cold meters to the PRSV and collector, a hot water supply pipe thermocouple, the central data logger, and a dishmachine rinse time sensor and data logger. Figure 25 shows a close-up of the water meter connections to the PRSV and to the collector. Monitoring occurred over the period of 76 days, which were all included in the final data analysis set.

Figure 25. Arrillaga—Water meters on pre-rinse spray valve (left) and on scrap collector (right)

Results

Although the pre-rinse station had a high-flow faucet spout, the spout portion was used relatively sparingly— about 30% of the already efficient 78-gallon-per-day pre-rinse station total. The trough collector on average operated 13.5 hours per day, and with a water consumption of about 1,600 gallons per day, it was responsible for 95% of the total PRO water consumption. Table 9 shows the data results summary. The trough collector operating time was more than four times the dishmachine rinse time, which means that the collector typically was not shut off between meal periods. With this PRO, they were heavily reliant on the trough collector and less so on the PRSV, which resulted in a high normalized PRO water use per hour rinse time.

Table 9. Arrillaga data summary

PRSV (and Spout) Hot Water Use (gal/d)	51	PRSV Flow Rate (gpm)	0.7
PRSV (and Spout) Cold Water Use (gal/d)	27	Collector Flow Rate (gpm)	2.1
Collector Hot Water Use (gal/d)	770	Hot Water Supply Temperature to PRO (°F)	150
Collector Cold Water Use (gal/d)	824	Collector Power Reading (kW)	1.0
Total PRO Water Use Use (gal/d)	1,673	Collector Operating Time (h/d)	13.5
PRSV Operating Time (h/d)	1.2	Collector Electricity Use (kWh/d)	13.5
Collector Operating Time (h/d)	13.5	Estimated Water Heater Gas Use (therms/d)	9.3
Dishmachine Rinse Time (h/d)	2.9	Operating Days Per Year	350
PRO Water Use Per Hour Rinse (gal/h_rinse)	576	Annual Water Use (gal)	585,400
		Annual Electricity Use (kWh)	4,732
		Est. Annual Water Heater Gas Use (therms)	3,248

Corporate Café 3

Site Overview

Corporate Café 3 opens for breakfast, lunch and dinner on weekdays. The dishroom PRO components include a second-generation (timer equipped) trough-fed collector, a utility hose with sprayer (which is also used partly for pre-rinse duties), and the pre-rinse faucet with spray valve assembly. Figure 26 shows the PRO components in addition to the 64″ rack conveyor dishmachine and the tray accumulator.

Figure 26. Corporate Café 3—Dishroom

Monitoring

Instrumentation included six water meters, a dishmachine rinse time sensor, a hot water supply pipe thermocouple, the central data logger, and the rinse solenoid data logger. Figure 27 shows the water meter connections for each fixture. The monitoring period for this operation spanned 104 days and rendered 55 days of data used for the analysis.

Figure 27. Corporate Café 3—Metering for hose (left), scrap collector (center) and pre-rinse sink (right)

Results

Average PRO water consumption for this facility was nearly 2,000 gallons per day, half of which was used through the trough-fed collector. Researchers witnessed the collector operating during idle dishroom periods on two separate visits. Judging from the extended constant daily operation pattern as viewed in the data, the timer feature was not used. The collector operating time was over three times the dishmachine rinse time. Nonetheless, perhaps the most wasteful PRO water fraction in this site was due to the pre-rinse faucet spout; and the high total PRSV operating time of 5.9 hours was driven by the faucet use. Although the PRSV flow fraction could not be disaggregated from the spout flow, it is estimated from the flow rate data that at least 500 gallons per day (about two-thirds) were used through the faucet spout, which was reportedly done to introduce more fresh, hot water into the trough flow stream. Obviously, the practice of introducing more hot water into the collector to heat the water or increase dilution further increases the PRO water and energy intensity. This practice also occurred at Corporate Café 2 and is described in the case study available in the ICP dishmachine report (Delagah 2015).

Table 10. Corporate Café 3 data summary

PRSV (and Spout) Hot Water (gal/d)	672	PRSV Flow Rate (gpm)	0.8
PRSV (and Spout) Cold Water (gal/d)	75	Pre-Rinse Faucet Flow Rate (gpm)	3.5
Hose Hot Water (gal/d)	77	Collector Flow Rate (gpm)	1.9
Hose Cold Water (gal/d)	143	Hot Water Supply Temperature to PRO (°F)	140
Collector Hot Water (gal/d)	739	Collector Power Reading (kW)	1.0
Collector Cold Water (gal/d)	271	Collector Electricity Use (kWh/d)	8.7
Total PRO Water Use (gal/d)	1,978	Estimated Water Heater Gas Use (therms/d)	15.0
PRSV (and Spout) Operating Time (h/d)	5.9	Operating Days Per Year	250
Collector Operating Time (h/d)	8.7	Annual Water Use (gal)	494,400
Dishmachine Rinse Time (h/d)	2.7	Annual Electricity Use (kWh)	2,174
PRO Water Use Per Hour Rinse (gal/h_rinse)	722	Est. Annual Water Heater Gas Use (therms)	3,761

Corporate Café 4

Site Overview

This facility is a restaurant-style cafeteria that opens for breakfast, lunch and dinner on weekdays. It was the only monitored site with a pulper, which is installed in a separate, isolated room adjacent to the dishroom with a trough that passes through to the pulper drum. Two PRSVs are located at the pre-rinse area, and the right-side pre-rinse spray assembly also connects to a utility hose with a trigger sprayer attached. Figure 28 shows the 64″ rack conveyor dishmachine, the pre-rinse area with trough, the PRSVs and the utility hose connection. Figure 29 shows the pulper in the separate room along with an image of the connected hot and cold water meters.

Figure 28. Corporate Café 4—Dishmachine (left); pre-rinse station with 2 PRSVs, trough and hose (right)

Figure 29. Corporate Café 4—Pulper system (left); hot and cold water meters connected to pulper (right)

Monitoring

The pulper and both PRSVs were instrumented with hot and cold water meters, and together with a hot water supply pipe thermocouple, they were connected to a central data logger. A separate on/off data logger was installed on the dishmachine rinse solenoid. Figure 30 shows the water meter connected to the PRSV faucet assemblies mounted under the trough. Figure 31 shows the data logger and cell modem in the enclosure, and the on/off logger installed on the dishmachine rinse solenoid. The monitoring period spanned 90 days, of which 58 were included in the final data analysis.

Figure 30. Corporate Café 4—Left PRSV_1 water meters (left), and right PRSV_2 water meters (right)

Figure 31. Corporate Café 4—Datalogger in enclosure (left); logger on dishmachine rinse solenoid (right)

Results

Overall PRO water and energy usage for this facility was high. The largest factor was the pulper, with average daily water and energy use of 860 gallons and 55.8 kWh respectively. Combined PRSV and hose water consumption averaged 329 gallons per day. The PRSV_1 (left side) water use occurred more during the work day, and the PRSV_2 (right-side) flow occurred mostly from the hose during dishroom clean-up periods. The data results are summarized in Table 11. This is a prime example of PRO gross over-design. The installed cost and operating cost of this system doesn't justify its need. Operating costs will be presented in the following report section. Whatever the labor resource differences between hauling the dewatered pulp versus the deferred amount wet scrap was not quantified, this facility dry-scraps before the dishroom regardless, so the pulp fraction of overall food waste is likely minimal.

The dishmachine was only rinsing for 1.4 hours per day, but the PRO water, energy and floorspace used to support it were excessive. This is the most water- and energy-intensive commercial PRO monitored even though the technology in the dishroom is otherwise up to date and staff have reasonable operating practices. Although the same idle-time situation is present here as has been the case with the trough-fed collectors. The pulper is left operating throughout the entire meal period and extending onto the shoulder periods at over four times the rinse time of the dishmachine. What was surprising was that not only did the pulper consume a large amount of hot water (thus gas energy at water heater), but it also consumed an extensive amount of electricity, which was the major difference in terms of resource use compared to the collectors.

Table 11. Corporate Café 4 data summary

PRSV_1 Hot Water (gal/d)	160	PRSV_1 Flow Rate (gpm)	1.1
PRSV_1 Cold Water (gal/d)	7	PRSV_2 Flow Rate (gpm)	1.3
PRSV_2 (and Hose) Hot Water (gal/d)	155	Utility Hose Flow Rate (gpm)	3.5
PRSV_2 (and Hose) Cold Water (gal/d)	8	Pulper Flow Rate (gpm)	2.1
Pulper Hot Water (gal/d)	791	Hot Water Supply Temperature to PRO (°F)	140
Pulper Cold Water (gal/d)	69	Pulper Power Reading (kW)	9.0
Total PRO Water Use (gal/d)	1,190	Pulper Electricity Use (kWh/d)	55.8
PRSV_1 Operating Time (h/d)	2.9	Estimated Water Heater Gas Use (therms/d)	11.2
PRSV_2 Operating Time (h/d)	2.1	Operating Days Per Year	250
Pulper Operating Time (h/d)	6.2	Annual Water Use (gal)	297,400
Dishmachine Rinse Time (h/d)	1.4	Annual Electricity Use (kWh)	13,947
PRO Water Use Per Hour Rinse (gal/h_rinse)	831	Est. Annual Water Heater Gas Use (therms)	2,797

Summary of Results and Discussion

Pre-Rinse Operation Field Monitoring Dataset

To enhance the dataset analyzed in this report, data from the nine PROs monitored for this field project were combined with data from seven other PROs previously monitored by Frontier Energy in the last five years. The prior studies covered two high-efficiency dishmachines monitored at a catering operation that are examples of dry-scrapping-only operations without any pre-rinse (Slater et. al. 2017), and three other dishmachine-focused studies that also included monitoring of five PROs between them (Delagah et. al. 2017), (Delagah 2015), (Johnson 2018). The dry scrapping in the catering operation and scrap collector and PRSV operation at Corporate Café 2 are shown in Figure 32.

Figure 32. Dry-scrapping catering operation (left); Corporate Café 2 scrap collector (right)

The 16 sites are listed below in Table 12 with information on the facility type, operating days per year, hot water temperature, PRO type, and dishmachine size and type monitored. The average annual operating days is 308, and the average supply temperature is 140°F; these values will be used in later calculations. The sites are ordered from lowest to highest normalized PRO total water and energy operating cost per hour of dishmachine rinse ($/h_rinse), for which the calculated values will be presented and discussed further down in this section following the overall daily PRO water use analysis. For the cost calculations, Frontier Energy has estimated the average combined rate for water and sewer in California to be $11.25 per hundred cubic feet (HCF) based on weighted (by population) water and sewer rates in the state's eight largest cities. Also, the average electricity rate is $0.19 per kWh and gas rate is $1.10 per therm. The site numbers from this study's nine PROs are shown in **bold**.

Table 12. Complete list of facilities where pre-rinse operations were monitored

Site	Facility	Facility Type	Est. Annual Operating Days	Hot Water Temperature (°F)	Pre-Rinse Operation	Dishmachine Size and Type
1	Gate Gourmet Catering Machine 1	In-Flight Catering	365	NA	Dry Scrapping Only	240" Flight Conveyor
2	Gate Gourmet Catering Machine 2	In-Flight Catering	365	NA	Dry Scrapping Only	240" Flight Conveyor
3	Corporate Café 1	Corporate Cafeteria	350	130	Dry Scrapping and PRSV	86" Rack Conveyor
4	Stanford Schwab	University Cafeteria	231	140	Trough-Fed Disposer and PRSV	64" Rack Conveyor
5	Presidio of Monterey—Belas Hall (Renovated)	Military Cafeteria	330	140	Dry Scrapping and PRSV	64" Rack Conveyor
6	Marriott San Ramon	Restaurant	365	145	Dry Scrapping and Pre-Rinse Hose with Sprayer	152" Flight Conveyor
7	Franklin Elementary School	School Cafeteria	241	115	Disposer and PRSV	44" Rack Conveyor
8	Stanford Lakeside	University Cafeteria	350	145	Trough-Fed Collector and PRSV	66" Rack Conveyor
9	Stanford Gerhard Casper	University Cafeteria	250	135	Scrap Collector and PRSV	44" Rack Conveyor
10	PG&E Conference Center	Corporate Cafeteria	300	140	Scrap Collector and Utility Hose with Sprayer	132" Rack Conveyor
11	Stanford Arrillaga	University Cafeteria	350	150	Trough-Fed Collector with PRSV	76" Rack Conveyor
12	Stanford Wilbur Hall	University Cafeteria	350	150	3 Utility Hoses with Sprayers	108" Rack Conveyor
13	Presidio of Monterey—Belas Hall (Original)	Military Cafeteria	330	140	Dry Scrapping and PRSV and Open-End Utility Hose	94" Carousel Rack Conveyor
14	Corporate Café 3	Corporate Cafeteria	250	140	Trough-Fed Collector and PRSV	64" Rack Conveyor
15	Corporate Café 2	Corporate Cafeteria	250	145	Scrap Collector and PRSV	64" Rack Conveyor
16	Corporate Café 4	Corporate Cafeteria	250	140	Trough-Fed Pulper; 2 PRSVs; Utility Hose with Sprayer	64" Rack Conveyor

Pre-Rinse Operation Daily Water Use Analysis

PRO water use for all 16 sites is summarized in Table 13, separated for hot and cold water use of the PRSV, utility hose, and powered PRO that could be in the form of a disposer, collector, or pulper. Table 13 and each of the following site summary tables will continue to rank each site by the normalized per-hour-rinse operating cost of the PRO. Note the normalized rank order (site number) is reasonably consistent with the total daily PRO water use order as well. What is immediately striking is that the top-five ranked PROs also had the lowest daily water use, and they involve a single or combination of three efficient practices including dry scrapping operations, PRSVs or disposers (used judiciously). The rest of the PRO were significantly more water intensive on a daily water use basis and relied on mostly powered PRO equipment, except for a few sites where hoses were the predominate component.

Table 13. Pre-rinse operation average daily water use summary

Site	Pre-Rinse Operation	PRSV Hot (gal/d)	PRSV Cold (gal/d)	Hose Hot (gal/d)	Hose Cold (gal/d)	Powered PRO Hot (gal/d)	Powered PRO Cold (gal/d)	Total PRO (gal/d)
1	Dry Scrapping Only	—	—	—	—	—	—	0
2	Dry Scrapping Only	—	—	—	—	—	—	0
3	Dry Scrapping and PRSV	90	9	—	—	—	—	99
4	Trough-Fed Disposer and PRSV	16	4	—	—	—	31	50
5	Dry Scrapping and PRSV	41	3	47	0	—	—	92
6	Dry Scrapping and Pre-Rinse Hose w/ Sprayer	446	0	20	0	—	—	466
7	Disposer and PRSV	82	82	—	—	0	65	229
8	Trough-Fed Collector and PRSV	118	3	—	—	301	0	421
9	Scrap Collector and PRSV	119	8	0	5	5	5	142
10	Scrap Collector and Utility Hose with Sprayer	—	—	132	0	591	367	1,090
11	Trough-Fed Collector and PRSV	51	27			770	824	1,673
12	3 Utility Hoses with Sprayers	—	—	1,026	256	—	—	1,282
13	Dry Scrapping; PRSV; Open-End Utility Hose	10	46	39	1513	—	—	1,608
14	Trough-Fed Collector with PRSV	672	75	77	143	739	271	1,978
15	Scrap Collector with PRSV	250	67	—	—	2,251	599	3,167
16	Trough-Fed Pulper; 2 PRSVs; Utility Hose with Sprayer	315	14	—	—	791	69	1,190

For the most part, for each site in which powered PRO equipment was present, the powered equipment dominated the water use, and the other PRO components played a secondary role. The exceptions here were the disposer examples (Sites 4 and 7) because of the efficient staff practices that limited disposer run time. An exception of wasteful non-powered PRO was Site 13 had an open-end hose that consumed over 1,600 gallons of cold water per day.

Pre-Rinse Operation Normalized Water and Energy Use Analysis

As is reflected in the total average daily PRO water use data, there is large level of diversity between the sites, which involves the type of manual and/or powered PRO equipment and the manner in which they were utilized, and the total PRO and dishroom throughput, which is also a function of cafeteria hours of operation and patron count. Normalizing the usage data to the hours of conveyor dishmachine rinse time will allow for a comparison that better accounts for this diversity. In this section, the water and energy use of each PRO are normalized to dishmachine rinse time and ranked by the combined water and energy utility cost per hour rinse.

Upon review of the normalized data, Frontier Energy researchers ascribed a nominal threshold value for which an operation would be classified as efficient to be $3/h_rinse. Shown in Table 14, the top seven PROs have operating costs of less than $3/h_rinse **($ cost in bold)** and together have an average operating cost of $0.99/h_rinse. Succeeding the dry-scrapping-only operations, which use no PRO water and energy, the most efficient of the group used dry scrapping in combination with other manual operations (utility hose or PRSV) and had some of the lowest normalized water and energy use rates. The only powered operations that made the efficient list were both PROs with disposers that used cold water at rates of 34 and 127 gallons per hour of dishmachine rinse time respectively. Normalized water use for the other PRO combinations is quite scattered—from efficient dry scrapping with a utility hose using 75 gal/h_rinse and inefficient similar PRO combination using 1,018 gal/h_rinse.

In contrast, the bottom nine PROs relied on water- and energy-intensive uncontrolled or utility hose use and/or with the use of collectors and pulpers. The scrap collectors and all trough based systems sans disposer systems were classified as inefficient, ranging from 121 to 841 gal/h_rinse. The inefficient PROs consumed an average of 577 gallons, 5.7 kWh, and 3.8 therms per hour of dishmachine rinse. The worst example overall was a PRO that utilized 2 PRSVs, and a trough connected to a large pulper. This setup was both water and energy intensive and cost the facility roughly $29 per hour of dishmachine rinse.

Table 14. Normalized pre-rinse operation water and energy use and cost summary

	Pre-Rinse Operation	Dishmachine Rinse Time (h/d)	PRO Water Use Per Hour Rinse (gal/h_rinse)	PRO Electricity Use Per Hour Rinse (kWh/h_rinse)	PRO Gas Use Per Hour Rinse (therms/h_rinse)	PRO Total Water and Energy Cost ($/h_rinse)
1	Dry Scrapping Only	15.6	0	0.0	0.0	$0.00
2	Dry Scrapping Only	14.9	0	0.0	0.0	$0.00
3	Dry Scrapping and PRSV	5.4	18	0.0	0.1	$0.44
4	Trough-Fed Disposer and PRSV	1.5	34	0.1	0.1	$0.65
5	Dry Scrapping and PRSV	1.6	58	0.0	0.6	$1.50
6	Dry Scrapping and Pre-Rinse Hose with Sprayer	6.2	75	0.0	0.8	$2.02
7	Disposer and PRSV	1.8	127	0.2	0.3	$2.32
8	Trough-Fed Collector and PRSV	3.5	121	2.8	1.3	$3.77
9	Scrap Collector and PRSV	0.9	158	0.04	1.3	$3.83
10	Scrap Collector and Utility Hose with Sprayer	3.6	301	2.1	2.0	$7.14
11	Trough-Fed Collector and PRSV	2.9	576	4.7	3.2	$13.07
12	3 Utility Hoses with Sprayers	2.1	623	0.0	5.6	$15.57
13	Dry Scrapping and PRSV and Open-End Utility Hose	1.6	1,018	0.0	0.3	$15.66
14	Trough-Fed Collector and PRSV	2.7	722	3.2	5.5	$17.51
15	Scrap Collector and PRSV	3.8	841	0.0	7.1	$20.47
16	Trough-Fed Pulper and 2 PRSVs and Utility Hose with Sprayer	1.4	831	39.0	7.8	$28.51
	Average Overall	4.3	344	3.3	2.3	$8.28
	Average Efficient PRO	6.7	45	0.1	0.3	$0.99
	Average Conventional PRO	2.5	577	5.7	3.8	$13.95

Pre-Rinse Operation Comparison by Type

The 16 monitored PROs were categorized into 10 distinct types as shown in Figure 33. The quantity shown in parenthesis after each label accounts for the number of PROs of the same type that have been averaged. The annual water use (x-axis) and energy use (y-axis) values are based on the normalized average PRO operating time of the 16 sites, which was 4.3 hours per day (of dishmachine rinse) and 308 days per year; and the data points correspond with the normalized water and energy use values shown from Table 14, multiplied by normalized operating time. PROs in green are classified as efficient (less than <$3 per hour rinse to operate), and those in red are classified as conventional or inefficient. Dry scrapping, PRSVs, and Disposers shown inside the green parabola represent efficient PRO based on the limited PRO data gathered thus far. The position of parabola curve itself is mostly a qualitative representation of efficient combined PRO equipment and practices. As we learn more with subsequent studies with a much larger field-monitoring dataset and expansion of the types of PRO monitored, a more accurate quantitative representation of the threshold separating efficient and conventional PRO can be developed.

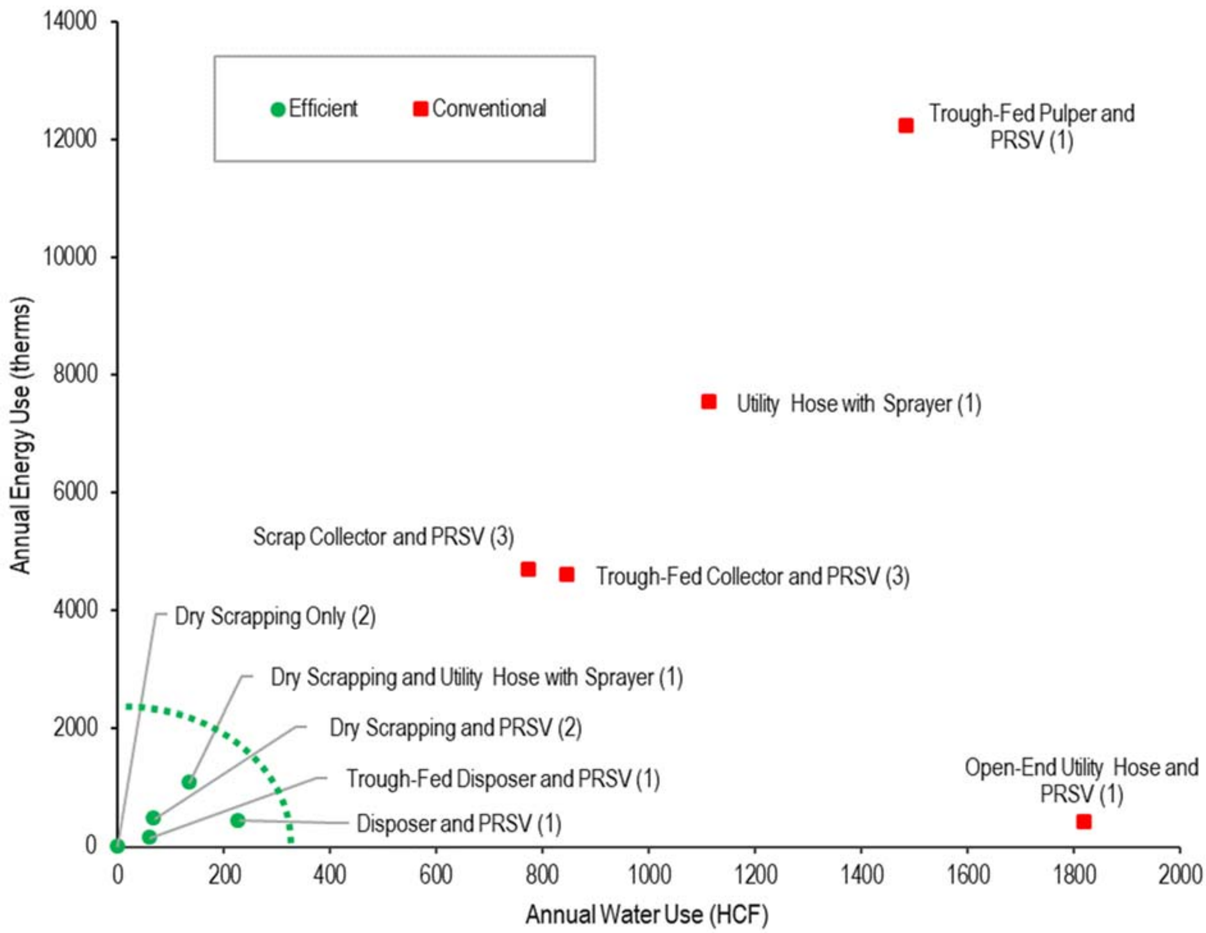

Figure 33. Normalized energy and water usage of pre-rinse operation types

Pre-Rinse Operation Annual Savings Potential Per Normalized Facility

Using the average normalized hourly water and energy use data for the efficient top seven PROs and conventional bottom nine PROs, the annual water and energy use figures are shown in Table 15. The calculations utilize the 16 site collective averages of 4.3 hours of dishmachine rinse time per day and 308 operating days per year. The average efficient PRO cost approximately $1,322 to operate were as the conventional PRO cost 14 times as much at $18,649. The average annual savings per facility is huge at 952 HCF, 7,605 kwh and 4,706 therms, which would save the average large commercial kitchen in California of over $17,000 in operating costs in making the switch. The hypothesis that 80% water and 30% energy savings can be achieved through retro commissioning PROs was exceeded.

Table 15. Normalized savings potential for an efficient pre-rinse operation

	Average Water Use Per Year (HCF)	Average Electricity Use Per Year (kWh)	Average Gas Use Per Year (therms)	Average Cost Per Year
Conventional PRO	1,031	7,678	5,079	$18,649
Efficient PRO	80	72	373	$1,322
Savings	952	7,605	4,706	$17,327
Savings Percentage	92%	99%	93%	93%

Savings Potential from Market Transformation

The normalized average water, electricity and gas use for efficient (top 7 sites) and conventional PROs (bottom 9 sites) was multiplied by the average rinse time and the average days in operation from the 16 sites and then multiplied by the number of facilities in California to yield the total use and cost numbers in Table 16. The number of large dishrooms with efficient PRO is estimated to be 25% of the total large commercial kitchen segment with a total of 30,000 facilities. If all the rest of the 22,500 conventional PROs were switched out for efficient PROs, the savings would be 21 million HCF of water, 171.1 MWh of electricity and 106 million therms of natural gas, and these facilities would save $390 million per year.

Table 16. Normalized market-wide replacement savings potential of efficient pre-rinse operations

Types	Estimated Number of Facilities in California	Average Water Use Per Year (million HCF)	Average Electricity Use Per Year (GWh)	Average Gas Use Per Year (million therms)	Average Cost Per Year (million $)
Total PRO	30,000	23.8	173.3	117	$430
Conventional PRO	22,500	23.2	172.7	114	$420
Efficient PRO	7500	0.6	0.5	3	$10
Savings From 100% Market Transformation		21.4	171.1	106	$390

Normalized Dishroom Water and Energy Use Analysis

Monitoring from nine sites (two from this study and the seven from the prior studies) also included water and energy metering on the conveyor dishmachines in addition to the PROs. These more comprehensive dishroom monitoring projects provided additional insight regarding the combined PRO and dishmachine normalized use and cost (Table 17). As was demonstrated in the first two examples, a PRO may not be necessary with large flight conveyor machines with multiple wash tanks. The normalized water use per hour of rinse of 143 and 223 gallons respectively was significantly lower than the average of the remaining seven sites. Granted, the total daily water use amounts were elevated, but these catering operations worked around the clock and ran the dishmachine for two thirds of the day cumulatively while rinsing practically that whole time; and keep in mind that these units also washed significantly more wares on a per hour of rinse basis due to the wider conveyor width and conveyor speed that flight machines provide. Overall, this approach reduces labor, and water and energy use and overall operating cost while increasing ware throughput in the dishroom and still maintaining quality in the clean wares.

The results show that the most water efficient dishroom operations use dry scrapping and or PRSVs in combination with either electric flight conveyors or gas-fired rack conveyors. The most intensive operations, gauged by operating cost per hour of dishmachine rinse time, utilize uncontrolled or utility hoses or scrap collectors in combination with old steam-heated conveyor dishmachines. Site 13, with the highest dishroom operating cost of $113 per hour of dishmachine rinse time, was ten times costlier than site 7, which was the lowest normalized operating cost site at $11 per hour. Site 13 was also the most water intensive PRO site, due to an open-end cold-water hose that was routinely left on during most of the dishroom operation period, and it was the most water and energy cost intensive dishmachine site where the rinse senor was always triggered when the conveyor belt was running, even without wares passing through the conveyor (Delagah et. al. 2017).

Table 17. Normalized pre-rinse operation and dishmachine water and energy use and cost

	Pre-Rinse Operation	Dishmachine	PRO and Dishmachine Water Use Per Hour Rinse (gal/h_rinse)	Dishmachine Electricity Use (kWh/h_rinse)	Dishmachine Gas Use (therms/h_rinse)	PRO and Dishmachine Water and Energy Cost ($/h_rinse)
1	Dry Scrapping Only	Efficient Electric Flight Conveyor	143	97.6	0.6	$21.36
2	Dry Scrapping Only	Efficient Electric Flight Conveyor	223	138.2	2.1	$31.93
3	Dry Scrapping and PRSV	Efficient Gas 86" Rack Conveyor	262	86.2	1.2	$21.65
5	Dry Scrapping and PRSV	Efficient Gas 64" Rack Conveyor	451	10.6	8.2	$17.82
6	Dry Scrapping and Utility Hose with Sprayer	Conventional Electric Flight Conveyor	343	115.2	4.4	$31.89
7	Disposer and PRSV	Conventional Gas 44" Rack Conveyor	292	2.0	5.3	$10.55
12	3 Utility Hoses with Sprayers	Conventional Gas Steam 108" Rack Conveyor	1289	10.2	20.3	$43.70
13	Dry Scrapping and PRSV and Open-End Hose	Conventional Gas Steam 94" Rack Carousel Conveyor	4693	18.0	35.8	$113.37
15	Scrap Collector and PRSV	Efficient Gas 64" Rack Conveyor	1208	7.4	14.6	$35.60

Water and Energy Efficiency Policy Considerations

Currently, regarding PRO equipment, only PRSVs are regulated on a state and federal level and recognized through the EPA's WaterSense program. Although powered PRO equipment is not regulated from a water and energy efficiency standpoint, disposers are banned in some jurisdictions due to the age and capacity of some waste water treatment plants and their inability to handle all the food waste in the wastewater. In places where they are not banned, sanitary sewer districts may have programs in place to check the Total Suspended Solids in the wastewater stream from a facility and determine a custom surcharge based on the findings. This regulatory action or potential monetary disincentive has had positive and negative results for commercial kitchens. The progressive facilities have moved toward simple PRO methods such as dry scrapping, and using strainer baskets, PRSVs and/or utility hoses in absence of the previous generation reliance on a disposer combination. Other facilities, and most new large facilities, have been designed to incorporate the other types of powered PROs. Many manufacturers have highlighted existing and new product lines that are not banned or do not greatly affect the Total Suspended Solids concentration for the facility. Some were studied in this report, but many have not been studied, which include digesters, compact disposer fed pulping systems or other methods.

Also, there are other regulatory forces at play, including the 2014 California AB 1826 bill that was signed into law requiring businesses with certain amounts of organic waste production per week to recycle the waste—starting in 2016 with the facilities with the most waste, and progressively ratcheting up annually through 2021 to incorporate smaller facilities. More information on this can be found at http://www.calrecycle.ca.gov/recycle/commercial/organics/. This means that composting services will likely become readily available. Thus, an increase in patron and/or staff dry-scrapping directly into waste bins, and the use of strainers, collectors or pulpers in the PRO will be the path for the industry moving forward as it contains the organic material. On a larger scope, one can make the case that, with certain jurisdictions, sending the food waste to the treatment plant and provide it as a feedstock to digesters is a form of organics recycling, which may be more water and energy efficient both directly for the site and indirectly for the community. There is a life cycle assessment that has been funded by one of the disposer manufacturers that states that using the waste to operate a digester to operate a cogeneration plant is more energy efficient than composting residentially (Insinkerator 2011).

The commercial kitchen food waste dilemma of what to do with the waste has been studied, but not to the level it has residentially. More field research and reporting by experts is needed to pave a clear path to sustainable food waste management in commercial kitchens.

Discussion on Design, Sizing, Operations, and Maintenance of Pre-Rinse Operations

Design and Sizing Considerations

PRO staging in hotels typically closely mimics the procedures in full-service restaurants where bussers scrap and drop off mixed wares on a large pre-rinse table for sorting. These operations typically use a PRSV sink setup with food strainer and dry scrapping. They still need to accommodate the increased load during banquet functions, but typically choose to add additional staff to the dishroom as needed. In cafeteria settings, the role of the busser is eliminated, and a passive drop-off window, motorized belt or tray accumulator transports the wares from the drop-off area to the dishroom. The overall design is more focused on meeting the peak drop-off load to avoid a logjam of patrons. In many facilities with this arrangement, mechanization extends to the pre-rinse operation in the form of powered PRO equipment, which operates at full capacity regardless of the load experienced in the dishroom to keep up with the peak rush, but at all other operating times it may have partial or no food load, which translates to excessive water and energy waste.

Overdesigning and oversizing of the dishroom PRO and dishmachine with respect to volume of wares processed is commonly found. As the trend in some areas of the country has been to move away from disposers and troughs with a continuous high-flow fresh-water flush (3-10 gpm), alternative technologies using pumped recirculating water have seen an increase in market share; though they are still dependent on a continuous supply of tempered fresh replenishment water (2-3 gpm) for staff comfort and cleaning performance. While this is a substantial reduction in flow rate, in practice in at least some PROs that still use high-flow fresh-water flush equipment, due to increasing water costs and the resultant need to limit water use, some operations have been cycling the units on intermittently as needed to sparingly flush the trough. Compared to this scenario, the pumped recirculating units can have much longer operating times per day and can result in over a 90% increase in cumulative water and energy—as shown in this study when compared with the two disposer examples that were operated efficiently. Albeit, the sample size is limited, hence more examples/variations of the same PRO type need to be monitored to understand common and outlier operating practices.

Another phenomenon is the variability in trough width: in some cases, it is wide enough to fit trays and dinner plates for immersed scrapping and pre-rinsing below the water line, and in other cases, the trough is narrow with more table surface above (sometimes with perforated flat sections covering sections of the trough), and the trough functions more as a food-waste mover for hand scrapping above the trough or water line, and often designed with PRSVs at the station. The latter scheme is typically the least efficient since substantially more fresh water than necessary is used to simply clear the trough, especially if the operation employs dry scrapping into food waste receptacles. With current technology, the powered equipment makes no distinction of trough contents or activity, nor does it have a means to modulate the fresh-water replenishment rate.

Operations

The research showed that operating practices widely varied with all types of PRO equipment and played a significant role in the amount of water and energy waste related to the specific operation. As was highlighted above, a major differentiator between an efficient and inefficient PRO in a facility was found to be whether the overall operation relied on continuous water flow for the PRO (collector, pulper, running hose) over the entire dishroom operating span or if the PRO was only used as needed (dry scrapping, PRSV, hose with sprayer, disposer). Using an open hose is obviously a poor practice, but so is operating a trough continuously while staff are on break. During various site visits, Frontier Energy researchers routinely observed operations where a scrap collector or trough-fed collector was in operation, but staff was away or on break for extensive periods of time ranging from 10 to 30 minutes. It was found that with the second-generation systems equipped with a timer, the feature was used only sporadically if at all.

There are occupancy sensor technologies available on some newest generation scrap collectors designed to reduce the idle water and energy use by turning off or reducing the flowrate of the unit if no one is standing in front of the collector/pre-rinse sink. However, none of the 20 sites visited that used scrap collectors had one of these newer models with occupancy sensor technology installed. This basic control system is not available with trough-based systems because of the variability in where the operator might stand during operation, though it may be possible to develop a sensing system that can operate effectively for trough-based systems, provided that staff are trained to use the equipment effectively.

Overall, perhaps the biggest hurdle especially in cafeteria settings is for staff to be motivated to operate equipment properly. In many corporate and university cafeterias along with other segments, the staff are employed by a 3rd-party foodservice management company that typically is not responsible for overseeing the operating costs but is highly motivated to increase productivity of staff to reduce labor costs. Hence, in this work culture, it is easy to adopt operating practices that achieve the highest productivity, even if negligible or small, while being shielded from the increased operating cost.

Furthermore, motivation, training and staff turnover can be a significant challenge in a commercial dishroom. It is difficult to keep dishroom staff trained in hot and humid environment which experiences high turnover compared to other foodservice positions. Staff sometimes end up developing improper practices due to a lack of training or find shortcuts that are significantly more water intensive.

Maintenance

While routine maintenance of all the powered PRO is recommended, anecdotal evidence from hundreds of site surveys in cafeterias over the years has shown that certain technologies such as pulpers require significant preventative maintenance and careful daily cleaning, or the extractor or impellers can jam up. They are susceptible to poor operating practices, and items such as straws can jam or overload the pulper motor, which will cause headaches or breakdowns.

Over the course of this project, the research team had trouble finding potential monitoring sites with pulper systems; and a few pulper systems found at a handful of cafeterias were either abandoned or removed entirely. In one instance, the research team learned of a pulper system that was designed for a new cafeteria that had opened in the past year. Upon visiting the site with the designer to conduct the site assessment, the team learned that the pulper had been removed entirely weeks prior to the visit. The trough was covered and welded over to create a flat surface for dishracks, and the pulper system was supplanted by the maintenance or operating staff with a utility hose and high-flow sprayer to pre-rinse dishes (Figure 34). The issue with designing for a pulper system and then removing it as illustrated in Figure 34 is that an efficient PRO is not an outcome in either case. Similarly, the Belas Hall site had abandoned their pulping system due to maintenance and electrical wiring issues, and operations had compensated with an open hose running into the existing trough essentially creating a high-flow fresh-water trough flush that used an average of 1,600 gallons per day.

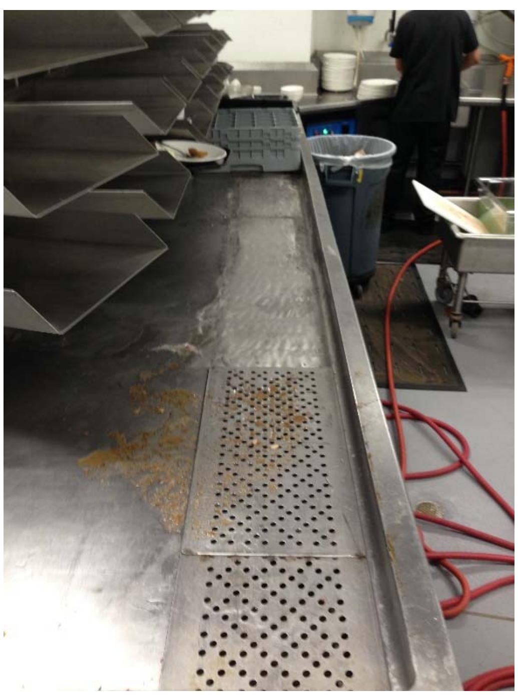

Figure 34: Original pulper system removed and trough covered; replaced with high-flow hose

Conclusions

Prior to this study, characterization of PRO technologies and usage was not readily available, and restaurant owners, designers and other planners have been forced to make ill-informed decisions. Especially with respect to cafeteria build-outs, this lack of information has often lead to over-designed dishrooms, inefficient PROs, higher maintenance costs and an increased potential for system breakdowns. Another challenge faced by owners and facility managers—even after identifying efficient practices vs. wasteful practice—is maintaining consistency with staff practices in the dishroom. This is a continual challenge due to high staff turnover, lack of training, and the lack of incentive or disincentive for dishroom staff to minimize utility costs. There is an additional burden in cafeterias and other large establishments that are run by a contracted service company. In this environment, the dishroom staff is typically many layers removed from the cost of operation and will typically go about completing tasks in the most time effective or least labor-intensive fashion.

A goal of this project was to identify high-efficiency PROs that are effectively used in large, high-throughput dishrooms. The project results have further supported the notion that high-performance operations in large and small dishrooms alike are a product of trained staff and minimalist PRO equipment and methods, such as the use of high- pressure low-flow PRSV and dry scrapping practices. As dishrooms become more mechanized, labor costs may not be significantly impacted, but energy and water operating costs are significantly impacted. The study established a delineation for defining a conventional class and an efficient class of various PRO types based on normalized water and energy cost. The use of PRSVs and dry scrapping practices were clear examples of optimal efficiency that incurred minimal or zero water and energy costs while alleviating maintenance burdens. In the case of the catering operations, dry scrapping also allowed for labor savings as well, since the rackless flight conveyor dishmachines were easy to load and performed the pre-rinsing function. While two of the PRO examples involved the use of food waste disposers with high fresh-water flow rates of 5 gpm, both were operated with limited run times, as they were judiciously used only as needed. Thus, the water and energy consumption was minimal, and these disposers also met the normalized water and energy cost criteria for their inclusion as an efficient PRO type. The conventional and inefficient PROs included other powered PROs such as collectors and pulpers and the use of high-flow utility hoses with sprayers. In some cases, the hoses were added so the facilities could maintain operations after the powered PRO equipment had failed.

The hypothesis prior to commencing this research project was that if the conventional PROs were replaced with efficient PROs and used appropriately by staff, then water use could be reduced by 80% and energy use by 30% in the large dishroom segment. Based on the results of the 16 examples, it was shown that greater than 90% savings for water and for energy is possible. In terms of operating cost, the average conventional PRO costs $14 in water and energy costs per hour of dishmachine rinse versus $1 for the efficient PRO. The $13 in savings could enable the dishroom or kitchen to at least partially offset the cost to hire an additional staff member. Per facility, on a normalized basis, the total annual savings potential of moving from a conventional PRO to an efficient PRO is 952 HCF of water, 7,605 kWh of electricity and 4,706 therms of gas, which translates to an average utility cost savings of approximately $17,000 per year. Segment wide, it is estimated that 75% of large dishrooms in California have conventional PROs, and if each one was retrofitted with an efficient PRO, California operators would save annually an estimated 21 million HCF, 171 MWh and 106 million therms per year, and a total cost savings of $390 million.

Recommendations

The water and energy savings potential per facility for a retro-commissioning program to replace or modify inefficient PROs with efficient operations is significant. Though research on PROs in large dishrooms is at the early stage, and significantly more investigation is required to adequately support a utility incentive or a 3rd-party retro-commissioning program, as it would be too premature to formulate specific equipment incentive programs or enact prescriptive regulations regarding what equipment can or cannot be installed. Additional monitoring, analysis and dialogue with key stakeholders such as manufacturers, designers, operators and dishroom personnel is needed to work toward incorporating comprehensive PRO programs that are a win-win for all stakeholders.

Need for Additional Research

A first step in the characterization performed in the study was to categorize the PRO equipment/combination by type and efficiency class, though there are some custom PRO combinations and some new and existing equipment on the market that have not yet been monitored and normalized, including the following:

- Undercounter pulping systems that use disposers connected to dewatering devices.
- Scrap collectors that operate with a lower fresh-water flow rate (in the 1-gpm range).
- Scrap collectors that operate with proximity sensors to activate or deactivate the unit.
- Food and organic waste digesters.

For policy or incentive development, dependence on data from one to three sites for each PRO type is not statistically strong, and since the highly variable staff operating practices play a huge roll in the performance and efficiency of each PRO, it is recommended that more research be conducted before commencing with broad policy or incentive development. The recommendation is that roughly 10 sites for each PRO type be monitored. Furthermore, survey-based research is recommended to supplement the data set. This would include documenting the PRO type, the equipment involved, whether the equipment is operated as intended or has been adjusted, whether any equipment has been removed or abandoned, an estimate of the total daily operating hours of the equipment, and the number of staff members that are utilized during regular and peak dishroom operating periods. In addition to expanding the data set, this feedback would be immensely valuable for kitchen designers so they can adjust future dishroom designs.

For a more thorough segment analysis, the main recommendation would be to conduct a large 40-site study to start drawing statistically sound, quantified conclusions regarding the impact of specific types of equipment and the effect that the dishroom staff's operating practices have on water and energy use. This large study should include 10 sites with pre- and post-monitoring where the existing pre-rinse equipment and practices are changed to more efficient alternatives. Another enhancement of the study would be to include monitoring of the energy and water use of the conveyor dishmachines in conjunction with the pre-rinse operations to gather the full dishroom energy and water footprint. In addition, the development of a pilot retro-commissioning and replacement program would yield significant water and energy savings per site and support the development of a pre-rinse operation design guide. Lastly, funding to improve existing technologies in the marketplace, such as incorporating occupancy sensors and water flow control on powered PRO equipment, would support future enhancements to products available in the marketplace or currently installed.

Technology

It is acknowledged that the high throughput capacity of powered PRO equipment can offer a labor effort benefit for many facilities. Though as the need for water and energy conservation increases, so might the reluctance of kitchen designers and operators to specify and use water- and energy-intensive equipment. To overcome this reluctance, it would be beneficial for manufacturers to boost R&D efforts for innovative technologies that improve water and energy efficiency.

As was shown in the study, continuous-flow, trough-based equipment was left idle for large fractions of the dishroom shifts. Due to the variable nature of crew member movement in the dishroom, and their side-to-side positioning along a trough, it has been difficult to implement occupancy sensing into the equipment design. It is the opinion of the research team that there is a technical solution, either by using multiple occupancy sensors to cover the entire PRO work area, or a sensor in the trough flow path that distinguishes between the relatively minor fluctuations in flow of an unoccupied trough versus the much more turbulent flow during active use. At the very least, a remote motion sensor tuned to only sense body movement over the pre-rinse area would be able to turn off the unit if staff is on break or extended leave, instead of operating continuously. Furthermore, research should be conducted to determine the least the amount of replenishment water needed for collector systems (and trough-fed pulpers), and to design and implement a control system that modulates the replenishment water accordingly. It was shown in one example with a trough-fed collector that had the cold water supply valve turned off by the staff that a quarter of the normal replenishment water flow rate was still satisfactory.

Policy

Additional research notwithstanding, mandatory submetering of any appliance or equipment that uses 1,000 gallons of water per day would be a good policy for water resource conservation and management. Continuously flowing PRO equipment like collectors and pulpers monitored in this study used an average of 1,380 gallons per day; and the conveyor dishmachines highlighted used an average of 2,000 gallons per day. Therefore, it would be warranted for all new dishrooms and existing dishrooms that go through a major retrofit to have submetering installed—separately for both the continuously flowing PRO equipment and for the adjacent conveyor dishmachines. The objective would be to ensure dishroom equipment is commissioned properly, benchmarks for use are set and monthly readings are taken and reviewed to catch any malfunctions or poor operating practices.

If enacted, perhaps a program between the water district and participating county or city buildings departments could subsidize the cost and oversee these regulations to ensure they are met. If connected to the water district's automatic meter reading or advanced metering infrastructure, the operator can receive automated feedback on their dishroom operation, and the water district can receive valuable data to enact future water conservation programs to minimize the impact of large dishrooms in their territory.

Education

A targeted educational program for large-facility operators, maintenance personnel, and dishroom or kitchen designers is needed to make a significant impact in this segment, both for the existing facilities in operation and for new facilities being designed. The program should include focused seminars, trade magazine articles, webinars, development of a PRO design guide and other information dissemination activities and materials. It would otherwise be a matter of course to continue to design dishrooms and operate them using a business-as-usual approach, and this cannot be sufficiently disrupted without a well-funded educational program.

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Appendix

Stanford: Schwab — Daily Totals					
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Disposer Cold Water (gal)	Disposer Run Time (h)	Dishmachine Rinse Time (h)
12/18/17	13	2	27	0.09	1.5
12/19/17	26	4	52	0.17	2.5
12/20/17	12	2	20	0.07	0.6
12/22/17	11	2	0	0.00	0.0
01/09/18	2	1	9	0.03	0.2
01/11/18	1	0	17	0.06	0.3
01/12/18	1	0	14	0.05	0.2
01/14/18	11	2	27	0.09	1.2
01/15/18	17	4	50	0.17	1.4
01/16/18	13	4	41	0.14	1.4
01/17/18	17	4	28	0.09	1.3
01/18/18	16	3	40	0.13	1.4
01/19/18	16	3	38	0.13	1.2
01/21/18	7	1	10	0.03	0.7
01/22/18	19	5	39	0.13	1.7
01/23/18	15	5	24	0.08	1.5
01/24/18	12	3	21	0.07	1.5
01/25/18	13	3	27	0.09	1.8
01/26/18	21	4	33	0.11	3.0
01/28/18	11	2	21	0.07	1.2
01/29/18	23	4	32	0.11	2.2
01/30/18	22	4	24	0.08	1.8
01/31/18	20	4	22	0.07	2.3
02/01/18	30	6	33	0.11	2.0
02/02/18	11	2	38	0.13	1.0
02/04/18	6	1	11	0.04	0.9
02/05/18	19	3	41	0.14	1.5
02/06/18	6	1	16	0.05	1.0
02/07/18	13	2	24	0.08	1.7
02/08/18	28	5	71	0.24	2.9
02/09/18	6	1	22	0.07	0.8
02/10/18	4	1	6	0.02	0.7
02/11/18	15	3	21	0.07	1.5
02/12/18	14	2	23	0.08	2.2
02/13/18	33	6	33	0.11	2.6
02/14/18	14	3	31	0.10	1.7
02/15/18	15	3	22	0.07	0.8

Stanford: Schwab — Daily Totals					
02/18/18	11	2	0	0.00	0.5
02/25/18	9	2	13	0.04	0.9
02/26/18	22	3	36	0.12	1.4
02/27/18	17	3	46	0.15	1.5
02/28/18	12	3	17	0.06	1.7
03/01/18	26	4	60	0.20	2.3
03/02/18	14	2	42	0.14	0.8
03/04/18	6	1	5	0.02	0.8
03/05/18	27	5	54	0.18	2.1
03/06/18	25	4	46	0.15	1.8
03/07/18	20	3	37	0.12	1.9
03/08/18	21	3	58	0.19	2.5
03/09/18	9	2	23	0.08	0.8
03/10/18	18	3	34	0.11	1.6
03/11/18	6	1	18	0.06	0.9
03/12/18	23	3	45	0.15	1.9
03/13/18	22	4	53	0.18	2.0
03/14/18	43	22	89	0.30	2.9
03/15/18	17	3	54	0.18	2.3
03/16/18	21	21	17	0.06	2.0

Belas Hall — Daily Totals				
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Hose Hot Water (gal)	Dishmachine Rinse Time (h)
11/30/17	68	0	1	1.9
12/01/17	67	0	0	1.5
12/02/17	48	4	1	1.5
12/03/17	25	2	0	1.8
12/04/17	72	4	0	1.7
12/05/17	48	1	0	1.9
12/06/17	68	0	0	2.0
12/07/17	69	4	2	1.8
12/08/17	31	0	2	1.2
12/11/17	61	0	0	1.6
12/12/17	38	1	0	1.8
12/13/17	64	0	0	2.0
12/14/17	18	13	0	1.7
12/15/17	59	2	0	1.3
12/16/17	24	0	0	1.5
12/17/17	32	3	9	1.8
12/18/17	59	0	6	1.5
12/19/17	46	0	0	1.4
12/20/17	53	15	0	1.2
12/21/17	22	6	1	0.8
12/22/17	28	0	0	0.8
12/23/17	10	0	0	0.6
12/24/17	13	0	0	0.4
12/25/17	10	0	0	0.5
12/26/17	23	0	0	0.5
01/03/18	47	0	0	1.1
01/04/18	69	0	0	1.9
01/05/18	39	1	3	1.8
01/06/18	30	2	0	1.8
01/07/18	29	6	0	2.0
01/08/18	55	3	0	1.9
01/09/18	37	4	0	1.8
01/10/18	44	8	0	2.0
01/11/18	61	0	1	1.8
01/12/18	43	0	0	1.5
01/13/18	34	0	0	1.3
01/14/18	50	0	0	1.6
01/15/18	31	0	0	1.7
01/16/18	39	0	0	1.6
01/17/18	64	0	0	2.0
01/18/18	55	0	0	1.5
01/19/18	31	0	0	1.0
01/22/18	25	0	0	1.9
01/23/18	35	0	0	1.4

Belas Hall — Daily Totals				
01/24/18	18	0	0	1.5
01/25/18	37	0	0	1.5
01/26/18	32	0	1	1.3
01/27/18	23	0	0	1.6
01/28/18	10	0	0	1.3
01/29/18	51	4	0	1.4
01/30/18	24	13	0	1.4
01/31/18	28	40	0	1.9
02/01/18	12	17	0	1.9
02/02/18	43	18	0	1.5
02/03/18	22	0	0	1.5
02/04/18	24	0	1	1.6
02/05/18	5	20	0	1.9
02/06/18	36	7	0	1.8
02/07/18	27	6	0	1.9
02/08/18	48	20	0	2.0
02/09/18	15	40	0	1.0
02/12/18	20	12	0	1.9
02/13/18	22	24	0	1.9
02/14/18	57	0	0	1.8
02/15/18	76	0	0	1.7
02/16/18	19	14	2	2.1
02/17/18	45	1	0	2.9
02/18/18	34	4	0	1.4
02/19/18	69	2	0	1.7
02/20/18	31	7	0	1.4
02/21/18	67	0	0	1.8
02/22/18	92	0	0	2.1
02/23/18	52	4	0	2.0
02/24/18	31	1	0	1.5
02/25/18	42	4	0	1.7
02/26/18	66	2	0	1.7
02/27/18	67	1	0	1.8
02/28/18	62	4	0	1.9
03/01/18	47	2	0	1.3
03/02/18	42	6	0	1.4
03/03/18	30	9	25	1.4
03/04/18	34	0	0	1.2
03/05/18	65	0	0	1.5
03/06/18	39	0	0	1.9
03/07/18	60	0	71	1.6
03/08/18	64	0	16	1.8
03/09/18	34	0	0	1.4
03/12/18	60	1	59	1.6
03/13/18	50	0	10	1.5
03/14/18	57	0	65	2.0

Belas Hall — Daily Totals				
03/15/18	41	8	0	1.8
03/16/18	35	4	61	1.8
03/17/18	35	0	17	1.4
03/18/18	25	0	0	1.7
03/19/18	49	0	83	1.5
03/20/18	37	5	9	1.5
03/21/18	58	0	56	1.5
03/22/18	51	0	32	1.5
03/23/18	26	0	27	1.3
03/24/18	30	0	0	1.4
03/25/18	26	0	0	1.7
03/26/18	55	0	0	1.4
03/27/18	33	0	81	1.1
03/28/18	59	0	53	1.6
03/29/18	50	0	99	1.7
03/30/18	39	0	23	1.5
03/31/18	20	0	60	0.7
04/01/18	38	0	129	1.6
04/02/18	50	0	152	1.6
04/03/18	36	1	91	1.9
04/04/18	55	0	40	1.7
04/05/18	63	0	9	1.5
04/06/18	22	0	184	0.8
04/09/18	31	0	90	1.4
04/10/18	47	0	302	1.5
04/11/18	64	1	93	1.8
04/12/18	43	0	0	1.6
04/13/18	43	0	178	1.5
04/14/18	35	0	0	1.7
04/15/18	15	4	541	1.6
04/16/18	48	3	68	1.5
04/17/18	51	0	230	1.4
04/18/18	55	0	31	1.7
04/19/18	43	0	206	1.7
04/20/18	51	0	59	1.5
04/21/18	26	0	625	1.5
04/22/18	12	0	803	1.1
04/23/18	58	9	42	2.5
04/24/18	34	1	133	1.5
04/25/18	52	1	177	2.1
04/26/18	28	2	87	1.8
04/27/18	21	6	466	1.3
04/28/18	29	0	180	1.3
04/29/18	61	1	544	2.0

Marriott Hotel — Daily Totals		
	PRO Hot Water (gal)	Dishmachine Rinse Time (h)
05/17/17	543	8.6
05/18/17	518	6.9
05/19/17	524	7.6
05/31/17	425	5.5
06/01/17	546	8.6
06/02/17	531	8.0
06/03/17	450	7.2
06/04/17	508	6.1
06/05/17	218	2.4
06/06/17	521	4.4
06/07/17	633	7.0
06/08/17	381	4.4
06/09/17	316	5.3
06/10/17	280	4.4
06/11/17	316	4.0
06/24/17	508	7.2
06/25/17	381	6.0
06/26/17	396	5.0
06/27/17	705	7.6
06/28/17	520	5.0
06/29/17	620	7.1
06/30/17	574	7.3
07/01/17	334	4.9
07/02/17	397	4.9
07/03/17	302	3.0
08/25/17	399	6.8
08/26/17	437	7.3
08/27/17	435	6.7
08/28/17	453	4.7
08/29/17	511	6.4
08/30/17	450	4.2
08/31/17	459	4.4
09/01/17	404	6.6
09/02/17	561	9.3
09/03/17	749	11.7

Stanford: Lakeside — Daily Totals						
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Collector Hot Water (gal)	Collector Cold Water (gal)	Collector Run Time (h)	Dishmachine Rinse Time (h)
03/19/18	149	1	315	0	10.0	3.3
03/20/18	99	0	299	0	9.5	3.6
03/21/18	93	8	278	0	8.9	2.9
03/22/18	93	0	361	0	11.5	3.1
03/23/18	106	6	306	0	9.8	3.2
04/01/18	80	0	207	0	6.6	2.1
04/02/18	141	0	406	0	13.0	3.9
04/03/18	189	0	305	0	9.8	4.0
04/04/18	115	0	277	0	8.8	4.2
04/05/18	118	13	428	0	13.6	3.6
04/06/18	112	0	315	0	10.0	3.4
04/07/18	100	16	245	0	7.8	2.4
04/08/18	92	8	280	0	8.9	3.0
04/09/18	156	0	390	0	12.5	2.7
04/10/18	152	0	281	0	9.0	3.9
04/11/18	104	0	396	0	12.6	4.5
04/12/18	128	0	292	0	9.3	4.3
04/13/18	117	0	311	0	9.9	2.4
04/14/18	48	0	217	0	6.9	2.4
04/15/18	59	6	199	0	6.3	2.4
04/16/18	139	0	378	0	12.0	4.1
04/17/18	161	0	283	0	9.0	4.1
04/18/18	165	6	353	0	11.3	4.1
04/19/18	184	0	390	0	12.4	4.0
04/20/18	116	6	317	0	10.2	3.6
04/21/18	66	7	241	0	7.7	2.6
04/22/18	95	0	262	0	8.4	2.6
04/23/18	119	0	309	0	9.9	3.9
04/24/18	109	0	275	0	8.8	4.1
04/25/18	116	0	282	0	9.0	3.6
04/26/18	109	7	308	0	9.9	4.1
04/27/18	123	13	320	0	10.3	3.9
04/28/18	95	0	213	0	6.9	2.6
04/29/18	71	7	208	0	6.7	2.7
04/30/18	165	0	318	0	10.3	4.4
05/01/18	130	0	270	0	8.7	4.6
05/02/18	138	6	288	0	9.3	4.1

Stanford: Gerhard Casper — Daily Totals						
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Collector Hot Water (gal)	Collector Cold Water (gal)	Collector Run Time (h)	Dishmachine Rinse Time (h)
04/04/18	114	9	1	1	0.01	1.0
04/05/18	119	0	2	5	0.02	0.9
04/06/18	104	2	2	5	0.02	0.9
04/09/18	103	24	15	26	0.12	0.9
04/10/18	122	3	10	15	0.08	0.9
04/11/18	132	0	2	4	0.02	0.9
04/12/18	131	1	3	6	0.02	0.9
04/13/18	95	5	1	2	0.01	0.9
04/16/18	108	31	2	4	0.02	0.8
04/17/18	94	41	4	8	0.03	0.9
04/18/18	125	9	1	3	0.01	0.9
04/19/18	101	20	2	4	0.02	0.8
04/20/18	117	12	1	3	0.01	0.9
04/23/18	116	22	2	3	0.01	1.0
04/24/18	83	22	98	40	0.81	0.9
04/25/18	136	5	1	3	0.01	0.9
04/26/18	120	25	10	11	0.08	0.9
04/27/18	122	2	2	4	0.02	0.7
04/30/18	141	1	2	4	0.02	0.9
05/01/18	141	0	2	4	0.02	0.9
05/02/18	148	5	2	5	0.02	1.0
05/03/18	126	1	2	5	0.02	0.8
05/04/18	90	34	2	3	0.02	0.8
05/07/18	95	49	4	7	0.03	0.9
05/08/18	130	22	3	7	0.03	0.9
05/09/18	138	0	2	3	0.02	0.9
05/10/18	148	0	2	3	0.01	0.9
05/11/18	91	0	0	0	0.00	0.8
05/14/18	146	0	2	4	0.02	0.9
05/15/18	124	0	1	1	0.01	0.8
05/16/18	133	0	0	0	0.00	0.8
05/17/18	116	0	1	1	0.01	1.1
05/18/18	110	0	2	4	0.02	0.8
05/21/18	126	0	1	2	0.01	1.0
05/22/18	136	0	1	3	0.01	0.9
05/23/18	130	0	0	1	0.00	0.9
05/24/18	125	0	1	2	0.01	0.8
05/25/18	66	0	1	3	0.01	0.9
05/29/18	106	0	1	2	0.01	0.9
05/30/18	116	0	0	0	0.00	1.3
05/31/18	137	0	1	2	0.01	0.9

San Ramon Valley Conference Center — Daily Totals					
	Collector Hot Water (gal)	Collector Cold Water (gal)	Hose Hot Water (gal)	Collector Run Time (h)	Dishmachine Rinse Time (h)
05/17/17	457	239	165	9.5	3.5
05/18/17	869	651	215	10.0	3.4
05/19/17	248	24	71	6.5	1.9
05/20/17	171	1	76	2.1	0.5
05/22/17	850	551	171	7.7	4.1
05/23/17	928	858	132	8.1	3.6
06/01/17	420	41	119	9.6	3.5
06/02/17	354	147	54	5.9	2.9
06/03/17	239	0	73	1.6	0.4
06/05/17	414	32	150	10.5	3.6
06/06/17	704	214	202	8.4	3.1
06/07/17	790	642	128	9.4	3.5
06/08/17	1047	472	143	8.7	3.0
06/09/17	539	472	84	4.9	2.9
06/10/17	189	0	49	2.9	0.5
06/12/17	508	84	140	8.6	4.1
06/13/17	401	0	132	9.1	4.2
06/14/17	752	729	137	8.3	5.0
06/15/17	891	1020	108	8.9	5.5
06/27/17	797	752	219	8.2	5.8
06/28/17	622	558	139	7.5	5.2
06/29/17	784	218	168	7.0	5.5
06/30/17	539	599	173	4.2	4.5
08/26/17	197	0	169	3.9	1.0
08/28/17	677	546	122	10.3	4.9
08/29/17	734	430	126	10.5	5.4
08/30/17	1189	854	119	10.8	5.4
08/31/17	530	358	150	6.7	4.1

Stanford: Arrillaga — Daily Totals						
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Collector Hot Water (gal)	Collector Cold Water (gal)	Collector Run Time (h)	Dishmachine Rinse Time (h)
01/18/18	38	2	853	954	14.2	3.7
01/19/18	24	28	857	959	14.3	3.6
01/20/18	18	20	693	788	11.6	2.8
01/21/18	35	40	754	862	12.7	2.4
01/22/18	70	34	785	887	13.2	2.2
01/23/18	35	14	862	976	14.5	2.8
01/24/18	64	9	728	826	12.3	3.2
01/25/18	25	23	863	982	14.5	2.9
01/26/18	56	36	767	887	13.0	3.1
01/27/18	43	2	755	878	12.8	2.8
01/28/18	41	15	686	810	11.8	3.3
01/29/18	58	17	772	907	13.3	3.8
01/30/18	31	24	828	975	14.3	3.7
01/31/18	23	20	828	981	14.4	3.3
02/01/18	26	27	824	984	14.4	2.9
02/02/18	29	21	771	935	13.6	2.9
02/03/18	37	1	627	775	11.1	2.7
02/04/18	53	24	742	934	13.4	2.6
02/05/18	26	22	764	952	13.8	2.8
02/06/18	27	25	783	981	14.2	2.5
02/07/18	52	51	771	966	14.0	1.8
02/08/18	52	62	817	935	14.2	2.2
02/09/18	62	72	940	692	13.5	2.4
02/10/18	33	69	747	577	10.9	2.3
02/11/18	39	100	858	703	13.0	1.8
02/12/18	35	35	908	768	14.1	1.8
02/13/18	47	56	872	754	13.7	1.8
02/14/18	84	57	897	786	14.3	1.6
02/15/18	92	34	887	790	14.2	2.0
02/16/18	89	53	838	771	13.7	2.0
02/17/18	30	48	865	801	14.1	1.9
02/18/18	79	34	751	701	12.3	2.3
02/19/18	104	60	819	757	13.4	1.9
02/20/18	61	54	871	796	14.2	2.0
02/21/18	65	46	858	797	14.2	1.9
02/22/18	104	34	806	756	13.4	1.5
02/23/18	168	126	875	820	14.5	2.4
02/24/18	97	29	797	755	13.2	1.4
02/25/18	53	28	742	704	12.4	1.8
02/26/18	70	41	824	775	13.8	2.0

Stanford: Arrillaga — Daily Totals						
02/27/18	65	33	830	787	13.9	1.9
02/28/18	59	19	803	772	13.6	1.8
03/01/18	64	21	800	817	14.1	1.9
03/02/18	75	54	821	844	14.5	1.3
03/03/18	48	28	657	690	11.8	1.3
03/04/18	71	41	733	770	13.1	1.5
03/05/18	40	23	778	818	14.0	2.9
03/06/18	51	3	811	848	14.5	4.6
03/07/18	40	17	806	849	14.5	3.1
03/08/18	45	7	759	793	13.7	4.0
03/09/18	63	2	792	823	14.2	4.4
03/10/18	38	18	702	739	12.6	3.7
03/11/18	53	14	692	735	12.6	3.1
03/12/18	56	17	749	789	13.6	4.1
03/13/18	65	12	768	828	14.2	4.1
03/14/18	41	13	722	777	13.3	4.1
03/15/18	52	6	821	885	15.2	4.6
03/16/18	62	5	764	828	14.2	3.9
03/17/18	67	2	784	845	14.5	4.1
03/18/18	59	16	667	727	12.4	4.2
03/19/18	52	0	674	812	13.2	4.1
03/20/18	39	10	724	884	14.3	4.3
03/21/18	37	7	767	933	15.2	4.6
03/22/18	53	20	692	854	13.9	3.6
03/23/18	32	24	712	870	14.1	3.7
03/24/18	17	11	696	835	13.6	3.7
03/25/18	31	19	596	720	11.7	2.9
03/26/18	54	40	627	757	12.3	3.5
03/27/18	27	14	615	727	12.1	3.2
03/28/18	21	10	666	797	13.0	3.6
03/29/18	35	3	687	820	13.4	3.4
03/30/18	19	12	711	802	13.6	3.6
03/31/18	20	13	786	875	14.8	3.9
04/01/18	48	14	623	689	11.7	3.1
04/02/18	38	3	685	820	13.6	2.2
04/03/18	34	36	744	859	14.6	3.9

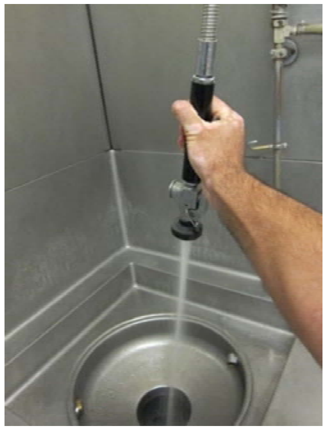
Corporate Café 3 — Daily Totals								
	PRSV Hot Water (gal)	PRSV Cold Water (gal)	Collector Hot Water (gal)	Collector Cold Water (gal)	Hose Hot Water (gal)	Hose Cold Water (gal)	Collector Run Time (h)	Dishmachine Rinse Time (h)
01/16/18	1036	2	929	297	116	223	10.7	3.1
01/17/18	1367	21	705	256	5	107	8.3	3.1
01/18/18	777	24	796	299	16	126	9.3	4.1
01/19/18	659	30	752	257	18	99	8.8	2.6
01/22/18	638	31	592	232	9	57	7.1	3.0
01/23/18	804	3	546	206	10	95	6.5	3.5
01/24/18	844	84	618	218	28	258	7.3	2.2
01/25/18	824	52	581	198	30	126	7.0	3.0
01/26/18	574	77	579	207	30	139	6.8	1.5
01/29/18	698	44	786	280	26	190	9.1	2.8
01/30/18	920	67	861	321	13	254	10.0	3.2
01/31/18	818	1	638	223	29	138	7.6	2.9
02/01/18	694	1	822	292	25	110	9.6	3.0
02/02/18	370	3	655	236	0	115	7.7	2.3
02/09/18	940	69	595	185	41	117	7.0	-
02/12/18	839	82	806	258	16	70	9.3	-
02/13/18	757	221	782	258	63	117	9.0	-
02/14/18	890	86	854	290	15	183	9.9	-
02/15/18	1152	39	800	283	15	74	9.5	-
02/16/18	846	266	553	192	22	105	6.6	-
02/20/18	701	25	907	327	19	100	10.7	-
02/21/18	619	5	891	346	39	128	10.4	-
02/22/18	638	139	815	292	15	95	9.7	-
02/23/18	716	5	673	217	17	126	7.8	-
02/26/18	761	227	678	248	18	136	8.0	-
02/27/18	755	41	631	210	8	78	7.4	-
03/19/18	908	58	760	251	187	201	8.8	2.9
03/20/18	1040	175	793	292	148	217	9.4	2.4
03/21/18	878	122	677	237	168	190	8.1	2.5
03/22/18	488	44	702	263	149	201	8.4	2.6
03/23/18	1046	75	639	199	104	177	7.5	2.0
03/26/18	776	21	862	332	178	211	10.2	2.4
03/27/18	923	42	876	332	134	99	10.4	2.5
03/28/18	600	64	871	343	156	182	10.2	2.4
03/29/18	499	18	878	318	114	198	10.0	2.2
03/30/18	81	35	420	166	192	318	4.8	2.4
04/02/18	261	100	852	298	77	57	9.2	2.5
04/03/18	408	3	939	348	123	115	10.1	3.1
04/04/18	375	307	941	361	38	69	10.7	2.4

Corporate Café 3 — Daily Totals								
04/05/18	553	76	832	344	39	32	9.9	3.3
04/06/18	313	21	563	222	74	131	6.9	2.1
04/09/18	725	192	968	344	65	46	11.3	3.4
04/10/18	493	0	720	291	201	229	8.8	3.6
04/11/18	434	257	748	281	63	50	8.9	3.1
04/12/18	434	97	584	232	145	207	7.1	3.3
04/13/18	349	20	468	197	49	148	5.7	2.1
04/16/18	298	32	708	275	90	202	8.5	2.4
04/17/18	459	66	790	306	91	112	9.6	3.1
04/18/18	1170	194	695	276	185	274	8.5	3.0
04/19/18	684	158	780	292	81	104	9.4	3.1
04/20/18	613	32	476	183	166	167	5.8	2.3
04/24/18	538	97	795	305	135	160	9.5	2.9
04/25/18	330	118	813	313	123	125	9.8	2.9
04/26/18	509	102	828	348	76	96	10.1	2.9
04/27/18	352	11	586	238	108	82	7.1	2.1

Corporate Café 4 — Daily Totals								
	PRSV_1 Hot Water (gal)	PRSV_1 Cold Water (gal)	PRSV_2 Hot Water (gal)	PRSV_2 Cold Water (gal)	Pulper Hot Water (gal)	Pulper Cold Water (gal)	Pulper Run Time (h)	Dishmachine Rinse Time (h)
01/29/18	137.8	0.0	228.1	0.0	902.1	33.0	7.0	1.64
01/30/18	137.9	0.0	214.4	0.0	968.7	72.8	7.5	1.62
01/31/18	148.7	0.0	253.9	0.0	782.9	73.4	6.1	1.52
02/01/18	157.6	0.0	282.4	0.0	909.8	32.4	7.0	1.45
02/02/18	144.6	0.0	207.5	0.0	914.2	81.6	7.0	1.10
02/05/18	139.8	0.0	179.3	0.0	841.5	92.4	6.3	1.34
02/06/18	161.5	0.0	205.0	0.0	769.3	65.1	5.8	1.47
02/07/18	166.5	0.0	231.2	0.0	579.5	41.2	4.3	1.34
02/08/18	127.9	0.0	258.5	0.0	661.0	50.4	5.0	1.27
02/09/18	146.9	0.0	158.6	104.5	767.9	32.6	5.9	1.45
02/12/18	213.1	97.6	206.0	0.0	782.1	32.5	5.9	1.47
02/13/18	175.7	26.4	155.5	0.0	693.5	80.5	5.2	1.41
02/14/18	127.8	0.0	122.1	0.0	725.0	81.7	5.6	1.42
02/15/18	145.2	0.0	135.3	0.0	843.8	48.2	6.5	1.64
02/16/18	156.7	0.0	115.4	0.0	799.5	80.4	6.1	1.47
02/20/18	153.7	0.0	86.8	0.0	598.7	63.5	4.6	1.28
02/21/18	144.5	0.0	122.9	0.0	584.5	20.3	4.6	1.35
02/22/18	143.7	0.0	97.2	0.0	732.0	78.5	5.7	2.23
02/23/18	135.4	0.0	102.6	0.0	650.6	64.2	5.0	1.94
02/26/18	140.9	0.0	134.1	0.0	787.0	80.4	6.0	1.39
02/27/18	148.8	0.0	121.0	0.0	754.2	48.2	5.9	2.29
02/28/18	174.5	0.0	133.8	0.0	904.0	64.4	7.0	1.82
03/01/18	147.8	0.0	121.4	0.0	889.1	61.2	6.9	2.19
03/02/18	120.2	0.0	194.5	0.0	948.4	64.4	7.3	2.36
03/05/18	-	-	134.8	0.0	786.5	48.1	6.1	2.36
03/06/18	-	-	154.5	0.0	778.4	64.5	6.1	1.78
03/07/18	173.1	42.6	179.7	0.0	769.5	64.6	5.9	2.21
03/08/18	126.3	0.0	129.5	0.0	612.5	95.4	4.6	2.71
03/19/18	212.2	29.4	80.9	0.0	762.1	49.1	6.1	1.21
03/20/18	153.1	0.0	147.9	0.3	588.2	80.5	4.7	1.20
03/21/18	-	-	-	-	545.1	76.7	4.4	1.47
03/22/18	-	-	-	-	586.0	78.7	4.7	1.02
03/23/18	-	-	-	-	591.7	71.7	4.7	1.12
03/26/18	-	-	-	-	795.5	97.8	6.4	1.21
03/27/18	188.1	19.2	-	-	831.4	95.0	6.6	1.06
03/28/18	168.9	0.0	-	-	804.6	64.6	6.4	1.04
03/29/18	180.8	0.0	137.6	0.0	825.0	64.4	6.6	1.20
03/30/18	214.4	0.0	154.3	0.0	868.6	67.8	6.9	1.00
04/02/18	198.0	0.0	202.0	0.0	821.0	96.9	6.6	1.30

Corporate Café 4 — Daily Totals								
04/03/18	203.3	0.0	151.0	0.0	874.2	64.6	7.0	1.35
04/04/18	179.2	0.0	191.6	0.0	866.2	64.9	6.9	1.16
04/05/18	155.9	0.0	159.5	0.0	757.0	95.3	6.1	0.91
04/06/18	156.7	3.2	138.5	0.0	833.5	98.1	6.7	0.92
04/09/18	157.7	0.0	178.7	0.0	714.9	49.2	5.7	0.90
04/10/18	-	-	-	-	754.3	97.1	6.0	0.98
04/11/18	-	-	-	-	916.2	65.1	7.3	1.21
04/12/18	170.5	39.2	-	-	792.9	64.7	6.3	0.84
04/13/18	-	-	-	-	897.9	97.1	7.2	1.07
04/16/18	-	-	-	-	775.8	81.5	6.2	1.11
04/17/18	-	-	-	-	752.4	97.5	6.0	1.59
04/18/18	-	-	-	-	662.9	81.9	5.3	0.89
04/19/18	-	-	136.1	0.0	861.2	81.0	6.9	1.27
04/20/18	-	-	169.8	8.6	1003.1	64.1	8.0	1.24
04/23/18	-	-	19.9	113.1	888.0	97.4	7.1	1.25
04/24/18	-	-	138.5	0.0	915.6	65.2	7.3	1.47
04/25/18	-	-			935.4	65.2	7.5	2.06
04/26/18	-	-	0.0	110.2	904.1	88.2	7.2	1.22
04/27/18	-	-			1025.1	32.6	8.2	1.27

Design & Operation of Efficient Pre-Rinse Operations

Background

A commercial foodservice pre-rinse operation (PRO) includes the dishroom equipment and procedures used to prepare wares for processing through the dishmachine. PRO types can range from minimalist dry-scrapping-only operations that use practically no water, to dishrooms with large motorized water- and energy-intensive rinsing and scrap processing or pulping equipment, with many types in between. These include operations that employ mostly dry scrapping with some moderate use of pre-rinse spray valves (PRSVs) or spray hoses.

PROs are one of the largest users of water and energy in a large commercial kitchen. In some dishrooms, the PRO consumes more water than the conveyor dishmachine itself, which is often the single most water and energy intensive appliance in commercial kitchens.

This project was partially funded by an Innovative Conservation Program grant initiated to develop a more accurate water and energy use estimate for each major type of pre-rinse operation. From this, the researchers could differentiate between the best and worst examples.

This first-of-its-kind research project examined the complexity of PROs in depth while benchmarking water and energy use of powered and manual operations. The research went further to study the factors that lead to inefficient or efficient operation of ten PRO types. The segments of the foodservice sector that often have powered PROs are large full-service restaurants, commercial cafeterias, hospitals, hotels with dining and banquet facilities, nursing homes, colleges, universities, K-12 central kitchens, and correctional facilities.

FRONTIER energy

ICP INNOVATIVE CONSERVATION PROGRAM

PRO Design Options

PRO staging in hotels mimics the setup in full-service restaurants where bussers scrap and drop off mixed wares on a large table for sorting. These operations typically use a PRSV over a sink with food strainer and dry scrapping practices. During banquets or other large events, hotels typically add staff to handle the peak load.

In cafeterias however, the role of the busser is replaced by the patron who leaves wares at a drop-off window that could be a simple pass through counter, motorized belt or tray accumulator that moves the wares into the dishroom. The overall design is more focused on meeting the peak drop-off load to avoid a logjam of wares. In many facilities with this arrangement, mechanization extends to the pre-rinse operation in the form of motorized PRO equipment. This equipment operates at full capacity regardless of the load experienced to keep up with the peak rush. During slower periods, it may continue to operate with partial or no food load, which results in excessive water and energy waste. Overdesigning and oversizing of the dishroom PRO with respect to volume of wares processed is common practice and creates a disparity in operating costs between the conventional and efficient PRO.

Quick Glance: Operating Costs

Based on utility rates of $11.25/HCF, $0.19/kWh, $1.10/therm
Annual costs based on 308 days per year operation

For More Info

Download report: http://mwdh2o.com/ICP

Guide to Various Types of Pre-Rinse Operations

A description and the rated water use of each type of motorized and manual PROs are shown in Table 1 and 2.

Manual PROs are used in some dishrooms either soley or in combination with motorized equipment.

Table 1. Motorized Pre-Rinse Operations

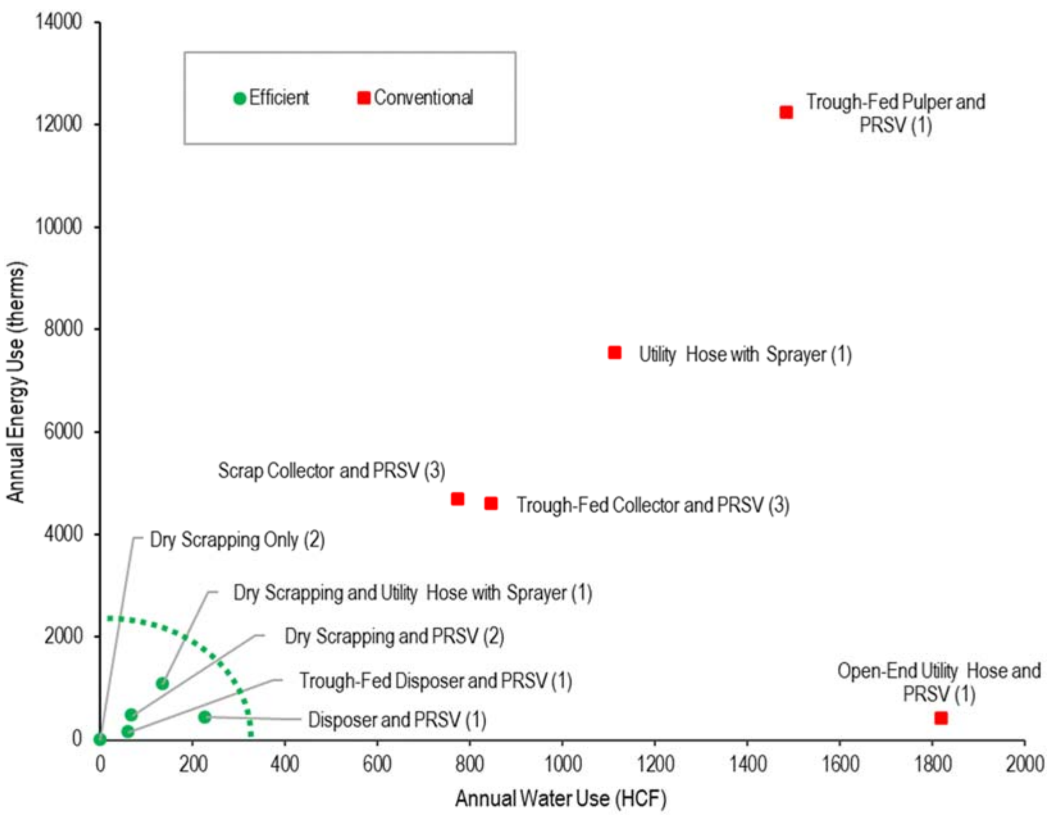
Type	Description	Rated Water Use (gpm)
Scrap Collector	Waterfall effect rapidly flushes water over wares catching debris in large deep well with perforated basket inside. One hand washes dish under the water plume while other hand loads the previous scrapped dish into a rack.	1-2 gpm fresh continuous tempered water (2 gpm typical) and 8-30 gpm recirculated
Disposer	Motorized grinding of food waste that is mixed with cold water to create a slurry and sent to drain. Some units cannot handle bones and plastic straws.	3-10 gpm fresh on-demand cold water
Waste Pulper	Combination of a macerator and dewatering unit used in series to decrease the volume of food waste.	2-3 gpm fresh continuous tempered water (2 gpm typical)
Trough-Fed Collector	River effect rapidly moves water over wares placed in basin to carry debris into large strainer basket.	2-3 gpm fresh continuous tempered water (2 gpm typical) and 8-30 gpm recirculated
Trough-Fed Disposer	River effect rapidly carries debris left in basin into disposer in a slurry for grinding and disposal down drain.	3-10 gpm fresh on-demand cold water
Trough-Fed Pulper	River effect moves water over wares placed in basin to carry debris into pulper for grinding and dewatering.	2-3 gpm fresh continuous tempered water (2 gpm typical) and 8-30 gpm recirculated

Table 2. Manual Pre-Rinse Operations

Type	Description	Rated Water Use (gpm)
Dry-Hand Scrapping	Manually scrap by hand or push food off the plate using a spatula. Viable in combination with flight conveyors that can handle the extra food waste and have powerful pumps that can remove dried on debris.	No water use
Pre-Rinse Spray Valve	Handheld on-demand, focused water spray requires one hand to operate the valve. Typically installed over a pre rinse sink.	0.5-3 gpm (1.2 gpm typical) fresh tempered water
Utility Hose with Sprayer	Handheld, wide or focused water spray.	1-8 gpm (3 or 6 gpm typical) fresh on-demand tempered water

Study Results

16 monitored PROs were categorized into 10 distinct types as shown in Figure 1. The quantity shown in parenthesis after each label accounts for the number of PROs of the same type that have been averaged. The annual water use (x-axis) and energy use (y-axis) values are based on the normalized average dishmachine fresh water rinse operating time at the 16 sites, which was 4.3 hours per day and 308 days per year. PROs in green are classified as efficient and those in red are classified as conventional or inefficient. Dry scrapping, PRSVs, and disposers shown inside the green parabola represent efficient PRO based on the limited data gathered thus far. The position of parabola curve itself is mostly a qualitative representation of a combination of efficient PRO equipment and practices. As we learn more with subsequent studies, which will increase the field-monitoring dataset for each PRO and expand the types of PROs monitored, a more accurate quantitative representation of the threshold separating efficient and conventional PRO can be developed.



The Good

- Dry Scrapping
- PRSV's
- Limited-Use Disposers

The Bad

- High-Flow Utility Hose
- Scrap Collectors
- Trough-Fed Collectors
- Trough-Fed Pulpers

Figure 1. Normalized Energy and Water Usage of Pre-Rinse Operations by Type

The average efficient PRO, which included the top seven PROs monitored, cost $1,320 in water and energy to operate whereas the bottom nine conventional PRO cost 14 times as much at $18,650. The average annual savings potential per facility is huge at 950 HCF, 4,705 therms and 7,605 kWh, which may save the average large commercial kitchen in California over $17,000 in operating costs by making the switch.

Table 3. Comparision of the Average Conventional to Efficient Pre-Rinse Operation

	Conventional PRO	Efficient PRO	Savings	Savings Percentage
Water (HCF/y)	1,030	80	950	92%
Gas (therms/y)	5,080	375	4,705	93%
Electricity (kWh/y)	7,680	75	7,605	99%
Annual Cost	$18,650	$1,320	$17,330	93%

Figure 2. Patron Scrapping (above) and Sorting at Drop-Off Window (below)

Figure 3. Best Practices in Dishroom Design (Batch Rack Loading) and Operation (Hand Scrapping)

Do's and Don'ts?

Design

Trayless dining. A trayless front of house promotes a 30% reduction in food waste and dish use. Combined with having patrons scrap food waste, separate recyclables and trash, and sort wares into specified bins in the transfer window, this collective practice minimizes dishroom labor, water and energy use with manual PROs (Figure 2).

Keep it simple. Provide only manual PROs when possible into the dishroom design to minimize water waste and equipment breakdowns (Figure 3).

Upsize dishmachine and downsize PRO. Dry-hand scrapping in combination with flight conveyors are an effective strategy to minimize labor and resource use.

Add redundancy. If selecting powered pre-rinse equipment, add a PRSV over pre-rinse sink to ensure an efficient secondary method of pre-rinsing wares in case the primary method (i.e. collector or pulper) is not working. This ensures that the high flow utility or floor hose is not the backup.

Extend dirty and clean dish tables. This promotes dry scrapping practices and efficient batch loading of racks into conveyor dishmachine (Figure 3).

PRO throughput is overkill. Don't incorporate powered PRO with door type dishwashers since they have long rack cycle times of 45 to 90 seconds.

Control It. Always incorporate advanced controls namely proximity sensors with powered PRO to minimize operating time when PRO is not required.

Secure It. The dishmachine and floor wash down hose has to be installed in an area that is not in close proximity of the PRO area and locked to dissuade use so it is not misused to pre-wash wares.

Install high-performance accessories. Use high pressure low flow PRSV and hose nozzles.

Operation

Benchmark operations. After commissioning equipment and training staff, submeter PRO and dishmachine and benchmark water and energy use.

Incentivize staff if they meet benchmarks. Many cafeterias and some hotels have 3rd party operators in kitchens that manage staff, hence they are detached from the operating costs, but motivated to reduce labor costs. This places pressure on the operator to work as fast as possible using any means necessary, which results in a resource intensive dishroom operation.

Retrain staff. Continuously train staff to operate and maintain equipment especially if the dishroom is not meeting benchmarks or there are breakdowns.