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Laundry Ozone Generators
San Francisco, CA

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Project Manager:	Wayne Krill Pacific Gas and Electric Company
Prepared By:	Erik Kolderup, John Arent, Asim Tahir Architectural Energy Corporation

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Laundry Ozone Generators Evaluation Report
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This evaluation report is a supplement to Report #0609, *Marketable Technologies for the Hospitality Segment*. The full list of supplements follows:

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Preface

The San Francisco office of Architectural Energy Corporation (AEC), an energy and environmental research, development, and design consulting firm headquartered in Boulder, Colorado, prepared this document for PG&E. The report was contributed to by Asim Tahir, and reviewed for technical quality and responsiveness by Erik Kolderup and Donald Frey. Wayne Krill of PG&E provided guidance and input as project manager.

Please note that product and manufacturer names used in this report are proprietary and may be trademarked and copyrighted.

Acknowledgements

This project would not have been possible without the ongoing assistance of Steve Hutchison, PG&E's Hospitality Segment Program Manager and of Sharon Harris, Account Services Manager for major hotels.

0.0 Executive Summary

In a laundry application, ozone can increase the efficiency of the wash cycle. Ozone works in conjunction with laundry chemicals, thereby reducing the energy requirements and the amount of chemicals used.

Laundry ozone generator systems can save 0.22 gallons of water and 1400 Btu of energy for every pound of laundry processed. Energy savings are primarily achieved through reduced heating requirements for hot water. Ozone generators can be added to existing laundry systems to inject ozone gas into the wash water.

Various vendors offer laundry ozone generator systems which work on the same basic principle, but use different methods of introducing ozone gas to the washing machines.

In addition to the savings to heat water, electrical savings are also generated based on reduced run time for washing machines and domestic water pumps and **lower cooling costs,** if the laundry is mechanically cooled. These savings are highly dependent on the configuration of the existing laundry system and the vendor that installs the ozone system.

Municipal agencies may also benefit from water pumping energy savings, if a significant number of customers in their service area implement this technology.

According to a study by the California Urban Water Conservation Council, a **450 room hotel** which handles 3.5 million pounds of laundry per year **can save 49,255 therms and $43,552 annually**. The implementation cost for an ozone generator system is close to $55,000, yielding a 1.2 year payback. This system can qualify for a maximum of a $27,500 incentive from PG&E under the Standard Performance Contract program, reducing the payback period to 0.6 year.

Similarly, a **150 room motel** which handles 0.6 million pounds of laundry per year **can save 8,374 therms and $7,404 annually**. The implementation cost for an ozone generator system is close to $17,000, leading to a 2.3 year payback. This system can qualify for a $10,300 incentive under the Standard Performance Contract program, reducing the payback to 1.39 years.

Currently the following vendors are known to offer products based on this technology:

- Clearwater Tech, LLC - http://www.cwtozone.com
- EnviroCleanse Inc. - http://www.envirocleanse.com
- Ozone Laundry Systems - http://www.ozonelaundrysystems.com
- IndustrOzone Tech Inc. - http://www.industrozone.com
- WaterEnergy Tech, Inc. - http://www.waterenergy.com
- Green Suites' O-Tech Direct Injection Ozone Laundry System - http://www.greensuites.com
- Wet-Tech - http://www.wet-tech.com

1.0 Evaluation Summary

Estimates by the California Urban Water Conservation Council indicate that each pound of laundry requires approximately three gallons of fresh water, which is eventually discharged into the sewer system and has to be treated at a wastewater plant. Ozone in the laundry increases the efficiency of the wash cycle, leading to water savings of 0.22 gallons and energy savings of approximately 1400 Btu for every pound of laundry processed. Energy savings are primarily achieved through reduced heating requirements for water. Ozone generators can be added to existing laundry systems to inject ozone gas into the wash water. Ozone is an unstable molecule of oxygen which makes it extremely effective in cleaning and sanitizing.

Ozone is 3,000 times faster and 150 percent more effective than chlorine at destroying bacteria and viruses, and leaves no residue.

Ozone can achieve viral and bacterial removal rates as high as 99.7% when applied properly.

Chemical suppliers have a high degree of influence on the operation of commercial laundry facilities. Securing their cooperation is crucial to the implementation of an ozone system in an existing laundry.

Table 1-1: Evaluation Summary

Criteria	Score (1 = poor, 10 = excellent)	Notes
Speed of Implementation	5	Cooperation will be required between the product manufacturer, the facility staff, and the laundry chemical supplier to design an optimal system for the type of laundry load at the facility.
Focus on Products	7	Product is well-defined and benefits are readily understood.
Demand Reduction	3	Savings are primarily realized through reduction in water heating requirements. Unless a facility is using an electric boiler to heat the laundry supply water, the demand reduction will be low. Most laundries work on an early schedule and are not in operation during peak times. Ozone systems may also reduce wash time per load; this may allow laundries to avoid operating at peak times.
Cost Effectiveness	6	Significant initial cost. Payback depends on frequency of use and has been reported in various case studies to be between 2 to 4 years, without incentives.
Persistence	7	Savings should persist with good O&M practices over the life of the system. The system life is estimated at 15 years.
Customer Satisfaction	7	Ozone laundry systems are best suited to medium or lightly soiled fabrics such as guestroom linen. Facilities with restaurants where table linen is also laundered may have to continue using chemical reagents for satisfactory performance.
Supply	6	Numerous suppliers exist, offering varying designs and techniques of using ozone in laundry systems.
Market Size	4	Applicable to hotels with on-site laundry systems. A range of system sizes are available to accommodate various laundry installations.

Magnitude of Energy Savings	7	Energy savings will be mostly realized through reduction of natural gas use in water heating requirements. There are secondary electric energy savings realized because less energy is required to pump water. Reduced cycle times for washing machines also save energy.
PG&E Program	6	Can be rebated through SPC programs, so actual savings are verified through performance monitoring
Existing Installations	8	Mature technology with many installations nationwide.

2.0 Technology Overview

Ozone is made up of three oxygen atoms (O_3), instead of the more common molecular structure of two oxygen atoms (O_2). The extra atom makes it an unstable molecule. Chemically, it wants to shed one of the oxygen atoms. A single atom of oxygen is extremely reactive. That is, it wants to combine with something else. Ozone is a powerful oxidizer and germicide that works 3,000 times faster and is 150% more effective than chlorine in removing soil from laundry.

Ozone works in combination with detergents to make the detergents more effective. It removes the soil that is held by the detergents so that the detergent can be released back into the washing cycle to remove additional soil from the fabric. Ozone accomplishes this by:

- replenishing oxygen in the wash water
- decomposing fats, oil, and grease
- preventing re-deposition of soil
- softening the wash water
- purifying the wash water
- working like an oxygen bleach
- removing soil attached to the wash chemicals

This process makes wash water cleaner by reducing soil levels and making chemicals more effective. Cleaner water allows for detergent and bleach formulas that use fewer chemicals. The wash cycle has fewer water operations, shorter wash time, and lower water temperatures (hot water is not needed). Peroxide can be used instead of chlorine for bleaching (this enhanced oxygen technology has synergy with peroxide; ozone and oxygen bleaches provide superior performance compared to chlorine bleach).

Ozone cannot be shipped or stored due to its unstable nature and must be produced at the point of use. Ozone generator systems for laundries use a corona discharge or ultraviolet light to generate ozone from ambient air. The ozone gas is either injected directly into the wash wheel or transferred to a pressurized holding tank which injects it into the wash wheel as needed. The specific method by which ozone is injected into the wash process is different for each manufacturer. The equipment needed to generate ozone is of a moderate size, and many components can easily be mounted on the wall.

2.1 Technology Description

The technology is offered by various suppliers for different capacity systems. Some of these suppliers are mentioned below along with their corporate websites for more information. This list is not comprehensive and many other suppliers may offer this technology.

- Clearwater Tech, LLC - http://www.cwtozone.com
- EnviroCleanse Inc. - http://www.envirocleanse.com
- Ozone Laundry Systems - http://www.ozonelaundrysystems.com
- IndustrOzone Tech Inc. - http://www.industrozone.com

- WaterEnergy Tech, Inc. - http://www.waterenergy.com
- Green Suites' O-Tech Direct Injection Ozone Laundry System - http://www.greensuites.com
- Wet-Tech - http://www.wet-tech.com

The concept is essentially the same across all the product offerings. The differences are in the way ozone is generated and whether it is injected directly in the wash water or sent to a pressurized tank. These differences lead to varying system efficiencies and paybacks.

Systems that inject ozone directly into the wash wheel operate only when ozone is needed, while systems that maintain ozonated water in a tank may require the generator to keep cycling to maintain the required ozone level. It is, therefore, difficult to estimate the additional electric energy consumed to power the ozone generators. Wet-Tech is one of the manufacturers with a product that works on the principle of direct injection of ozone into the wash wheel. It estimates that in a standard laundry that has three wash machines with capacities between 35 lbs. and 180 lbs., its system will require about 4 amps at about 1,200 volts to operate. For three phase power, this is roughly equivalent to 8 kW. However, this operation is intermittent; so the energy consumption is not increased significantly, but demand might spike. This increase in energy consumption is overcome by the significant energy savings due to reduction in wash times. Overall, Wet-Tech claims electrical savings between 12–15%.

The EnviroSaver II

Figure 2-1: EnviroSaver II Ozone System from Wet-Tech

A typical ozone system has four main components.

Air delivery: An oil-free compressor with an air dryer delivers clean dry air to the ozone generator.

Ozone generator: The ozone generator passes this low pressure air through a high voltage electric field or ultraviolet exposure to create ozone from the oxygen in the air. The ozone is then passed on to the injection apparatus.

Ozone injection: Ozone can be injected directly into a wash wheel or into a pressurized storage tank.

Controls: Integrated controls are used to program wash formulas for different kinds of loads. The controls determine when ozone will be injected into the system and how the various cycles will be run.

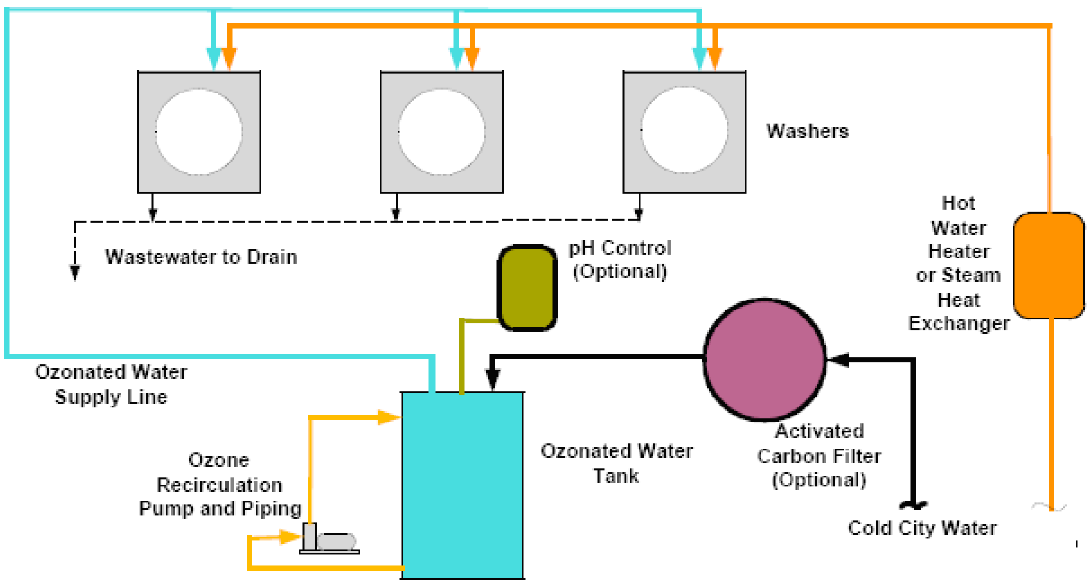

Figure 2-2: Schematic of Typical Ozone System
(Source: California Urban Water Conservation Council)

Figure 2-2 shows a system using a pressurized water tank instead of direct injection into the wash wheel. Due to the wide variety of products and solutions offered by different manufacturers, a more detailed technical analysis of these systems is beyond the scope of this report.

2.2 Where Laundry Ozone Generators are Applicable

Ozone generators can be used in any type of laundry. Manufacturers offer the products in different sizes and with varying capacities to accommodate varying sizes of laundry. This technology has been successfully used in hotels, hospitals, and commercial and industrial laundries. Ozone is not recommended in facilities where a large proportion of the laundry load is heavily soiled. It is most effective with light or medium soil classification loads. Most hotels with on-premise laundries will find it suitable for bedding and most table linens. If the table linens are heavily soiled, the laundry may still have to wash table linens with the traditional wash cycles and chemicals.

2.3 Market Readiness (Current Status)

The technology has been in the market for over 20 years with many suppliers offering varying products. A literature review indicated that ozone systems were the subject of significant debate within the industry over the last 15 years. Some unsatisfactory operation resulted due to neglecting the role of wash chemicals in the process and problems with generator equipment. Ozone systems are thus no longer viewed as a catch-all solution but a complement to existing wash technology and practices. More recent articles from trade magazines and hotel customers all present a favorable picture of the effectiveness of ozone in laundry applications.

2.4 Comparison to Related Technologies

Ozone is the only substance for enhancing laundry operations that provides energy savings, water savings, reduced wash times, reduced chemical usage, and improved fabric life.

Some of the systems inject the ozone on the fabric to remove the soil through oxidation. At least one supplier of laundry chemicals (detergents, fabric softeners, etc.) claims that this process essentially oxidizes the fabric, reducing the tensile strength of the fabric. No independent sources were found to verify this claim.

Systems have to be designed and operated to make sure that the concentration of ozone injected in the water is adequate for it to be effective. The half-life of ozone in water is only about 15 to 20 minutes under normal conditions (75°F with no contaminants). In other words, 15 minutes after generation, the ozone level will normally be reduced to half its original concentration. Ozone depletes much faster in warm water than in cold water. Systems that use a high concentration of ozone to oxidize the soil on the fabric typically require cold water to prolong the life of ozone molecules in the water.

Systems that inject ozone directly into the wash wheel work with low ozone concentration, primarily treating the wash water, which oxidizes the soil and enables the detergent to work more effectively on the fabric. Since ozone is generated on demand, this system allows flexibility in water temperatures and wash formulas.

3.0 Market Opportunity, Benefits, and Cost Effectiveness

3.1 Market Opportunity

According to the California Hotel and Lodging Association (CHLA), there are 6,500 hotels and motels in California with some form of on-premise laundry. Some of these may be limited to coin-operated laundries for guest use, while others will have a high-capacity laundry to process the hotel linen in house. Ozone laundry systems are applicable to hotels, plus many other types of large-scale laundry operations, such as hospitals, nursing homes, and commercial and industrial laundries.

3.2 Average System Energy and Demand Savings

Energy savings are primarily realized through reducing or eliminating the energy required for heating water. This will result in natural gas savings for PG&E's hotel / motel customers that heat water with natural gas. There may be additional electric energy savings due to shorter wash times and reduced energy needed for water pumping. These electric savings depend entirely on existing equipment at a particular site and are difficult to quantify over the whole market segment. This report only estimates gas savings for the customer and electric savings for the municipal water utilities.

Since ozone works best in ambient water temperatures, the water is either not heated at all, or heated to lower temperatures than required in conventional wash cycles. The water heating energy savings over conventional laundry systems is approximately 80 percent in most applications. Actual energy savings realized will depend on the proportion of loads that must be washed with standard chemistry in high temperature, such as food and beverage linen, mop heads, and bar rags.

If the laundry room is mechanically cooled, the reduced use of hot water will also reduce cooling load and lead to electric savings. For laundry rooms not cooled mechanically, the reduced use of hot water will keep the room more comfortable for staff.

The Electric Power Research Institute (EPRI) conducted a study of ozone laundry system installations in hospitals and provided a summary of savings claimed by manufacturers and measured at actual installations. This did not include baseline information, so it is not possible to convert the percentage savings to energy units. This summary is useful, however, and is provided in Table 3-1.

Table 3-1: Summary of Measurable Benefits of Ozone (Source: EPRI)

Benefit	Cost Decrease	Source of Values (number of samples)
Reduced Energy Cost[1]	20–100%	Manufacturers claims (n=4)
	75–95%	Actual installations (n=3)
Increased Linen Life	15–50%	Manufacturers claims
	60–66%	Actual installations (n=2)
Reduced Drying Time	10–30%	Manufacturers claims
	13–22%	Actual installations (n=2)
Reduced Chemical / Detergent Costs[2]	35–70%	Manufacturers claims
	36–92%	Actual installations (n=4)
Reduced Water / Sewer Costs	15–75%	Manufacturers claims
	25–35%	Actual installations (n=3)
Reduced Wash Cycle Time (reduced labor costs)	10–45%	Manufacturers claims
	20–46%	Actual installations (n=2)

[1] It is not clear whether these estimates are for gas savings only or for both gas and electricity savings.

[2] A report by the California Urban Water Conservation Council concludes that ozone system installations are cost-neutral in terms of wash chemicals since chemicals optimized for use with ozone systems are more expensive than standard chemicals.

Savings estimates were generated for this evaluation report from data presented in a report prepared for the California Urban Water Conservation Council (CUWCC). Their report calculated a 0.22 gallon reduction in water use and around 1,400 Btu of energy reduction per pound of laundry processed with an ozone system. These values are used here to show savings estimates separately for hotel and motels, since their laundry requirements are different.

Table 3-2: Estimated Energy Savings from Existing Case Studies

	Hotels	Motels	Source
Number of guestrooms per site	450	125	CUWCC
Daily laundry load per guestroom (lbs)	36	23	CUWCC
Average occupancy rate (%)	70%	60%	CHLA & CUWCC
Percent of laundry load washed with ozone system	85%	95%	CUWCC - Heavily soiled laundry will need to be washed with traditional wash cycles and is excluded here.
Annual laundry load per site (lbs)	3,518,235	598,144	CUWCC
Water savings (gal/lb)	0.223	0.223	CUWCC
Site gas energy savings (Btu/lb)	1,400	1,400	CUWCC - Averaged values, assuming 35% medium soiled and 65% lightly soiled laundry load.
Total water savings (gallons)	784,566	133,386	Calculation
Total site gas savings (therms)	49,255	8,374	Calculation
Water cost ($/1000 gal)	$12	$12	Estimated from San Francisco PUC water & wastewater rates.
Gas cost ($/therm)	$0.70	$0.70	Estimated from PG&E GNR-1 rates.
Annual cost savings ($/yr)	$43,552	$7,404	Calculation
Estimated system installation cost ($)	$55,000	$17,000	CUWCC
Simple payback period without incentive (yrs)	1.26	2.30	Calculation
PG&E incentive rate ($/therm)	$0.80	$0.80	SPC program rates
Estimated PG&E incentive ($)	$27,500	$6,700	Incentive limited to 50% of total cost
Estimated system installation cost with incentive ($)	$27,500	$10,300	Calculation
Simple payback period after incentive (yrs)	0.63	1.39	Calculation

A reduction in water use will also lead to reduced pumping energy. These energy savings will not be realized at the facility unless they have additional pumping equipment for domestic hot water.

The California Energy Commission (CEC) estimates that 3,950 kWh is used for every million gallons of water that is pumped and treated as municipal water and wastewater. This value is for northern California. For southern California this value increases to 12,700 kWh per million gallons of water.

Table 3-3: Electricity Use in Typical Urban Water Systems

	Northern California (kWh/MG)	Southern California (kWh/MG)
Water supply and conveyance	150	8,900
Water treatment	100	100
Water distribution	1,200	1,200
Wastewater treatment	2,500	2,500
Total	3,950	12,700

Source: CEC report: California's Water – Energy Relationship

3.3 Other System Benefits

One of the biggest benefits of ozone systems is the reduction in water consumption. Facilities have to pay their water utility for both the water supplied to them and the wastewater removed from their facility for treatment. By reducing the water requirements, owners can save substantially on water costs. Ozone also results in reduced volume of chemical reagents used in the wash cycles. In addition to wider environmental benefits, these two elements can form part of a strategy to certify a facility under the U.S. Green Building Council's LEED rating system.

Water districts benefit because they use less energy to treat the water and pump it to their customers. The current estimate of energy used to transport and treat municipal water and wastewater is about 3,950 kWh per million gallons of water. This is a wider benefit to the state; facility owners won't see this reduction on their electric bills, but should see a reduction in water and wastewater costs.

Due to the reduced chemical usage, the wear and tear on linens is reduced, potentially increasing their service life. (As noted previously, one chemical manufacturer claims that high concentration ozone applied directly to fabric can reduce the life of the fabric.)

A reduction in time for each wash cycle can potentially lead to labor savings, since one person can process more laundry per shift.

An added benefit is that ozone improves the quality of the wastewater going to the sewer, both because it helps reduce the concentration of wash chemicals and because it acts as a pre-treatment for the wastewater.

Chemicals developed to work optimally with ozone systems are typically more expensive than conventional chemicals. This indicates that even though there will be a reduction in the volume of chemicals used per pound of laundry, the cost of chemicals per pound will increase so that there is no net cost savings. The cost of laundry chemicals can be assumed to be about the same with or without ozone treatment.

Customers have reported that linen washed in ozone systems is whiter, fluffier, and smells fresher, compared to linen washed in traditional wash cycles.

3.4 Demand Response Capability

Laundry systems work on a preset sequence of cycles which depends on the type of load being washed. This would indicate that interrupting a wash in progress is not advisable. Therefore demand response is not a realistic capability either in traditional laundries or ones equipped with an ozone generator. If a hotel uses electricity to heat water, some permanent reduction in demand may be achieved, but only if they are washing during the peak hours.

3.5 Cost Effectiveness

System cost ranges from $15,000 to $55,000, depending on size of the laundry facilities. An average-sized ozone system will be able to process around 5,200 lbs of laundry per 8 hour shift and cost about $33,800 or $6.50 per pound of capacity.

The cost effectiveness will depend on the fraction of the laundry load which is classified as having heavy, medium or light soil. Various case studies from existing installations have indicated that the laundry ozone generator pays back in two to three years, based on energy and water cost savings.

Payback and cost effectiveness will be significantly impacted by the amount of laundry at a facility which needs to be washed without ozonation. Ozone systems reportedly don't work well with heavy soiled items like table linen and fabric used in kitchens. Some hotels also choose not to use linen with high thread count in ozone systems. These may still need to be washed with high temperature water and conventional chemicals.

4.0 Design Considerations

4.1 Implementation Issues

Various solutions are available for owners considering implementation of a laundry ozone generation system at their facility. A single ozone generator with a pressurized storage tank can be used to serve multiple machines, or each can be equipped with a dedicated generator. The decision on which solution to use will depend on the size range of laundry loads and the nature of the washing machines present on site. A single generator may be more efficient overall, but modular systems offer redundancy, so in the event one generator is down for service, the other generators can still be used;

Ozone generators require some routine maintenance, such as cleaning of diffusion filters. Case studies indicate that owners have been generally satisfied with the investment and have not reported any problems with their generators.

4.2 System Persistence Risks

A literature review indicated that ozone systems were the subject of significant debate within the industry over the last 15 years. Some unsatisfactory operations resulted due to neglecting the role of wash chemicals in the process and problems with generator equipment. Ozone systems are thus no longer viewed as a catch-all solution but as a complement to existing wash technology and practices. Advances in technology seem to have overcome most of these issues, since more recent articles in trade magazines and hotel customers all present a favorable picture.

Some customers have indicated that high thread count linens, typically found in luxury hotels, are not washed effectively with ozone systems. As a result, these are usually washed with traditional chemical additives and not ozone.

Ozone has a slight odor, which means that laundry rooms need to be well ventilated.

Due to its high oxidizing potential, ozone is a very toxic and highly reactive gas. To prevent the release of gas into workplace air, ozone should be produced, utilized, and consumed within a totally enclosed system. It is extremely important that all controls on the ozone generator system and the workplace ventilation systems are operating properly.

People working with ozone should be properly trained regarding its hazards and its safe use. Only authorized personnel should have access to the work area. All guidelines regarding operating procedures, maintenance, and safety precautions (e.g. lock-out) should be followed closely.

The half-life of ozone in air in the absence of contaminants is 4–12 hours depending on temperature and humidity. Ozone' half life in water varies from seconds to hours depending on temperature, pH, and water contaminants. The concentrations used in laundry systems are usually not high enough to cause serious safety concerns for workers.

4.3 Codes and Standards

Local environmental codes may require pretreatment of wastewater before it leaves the site. The ozone generator improves the quality of the wastewater going to the sewer, both because it helps reduce the concentration of wash chemicals and because it acts as a pre-treatment for the wastewater.

4.3.1 Permissible Exposure Limit

The current long-term maximum exposure level to ozone allowed by the U.S. Occupational, Safety and Health Administration (OSHA) is 0.1 ppm averaged over an eight-hour work shift, five days per week. The ASHRAE maximum allowable concentration in an air-conditioned space is 0.05 ppm. The OSHA short-term exposure limit (STEL) is 0.3 ppm over a 15-minute period, not to be repeated more than two times in an eight-hour period. Prolonged exposure by humans to ozone has produced no apparent ill effects at 0.2 ppm. However, a 60-minute exposure at 50 ppm would generally be considered as fatal. No criteria is set for the permissible concentration of ozone in water, which is not considered a hazard.

5.0 Energy Savings Opportunity in PG&E's Territory

The opportunity for energy savings estimates are based on average water and energy savings estimates. A wider environmental benefit will be the avoided energy use for pumping and treating the water and wastewater

A potential market impact is shown in Table 5-1, for an assumed 10% market penetration in hotels and 25% market penetration in motels.

Table 5-1: Potential Market Impact

	Hotels	Motels	Source
Number of sites	500	6,000	CHLA
Annual laundry load per site (lbs)	3,518,235	598,144	CUWCC
Water savings (gal/lb)	0.223	0.223	CUWCC
Site gas energy savings (Btu/lb)	1,400	1,400	CUWCC - averaged values assuming 35% medium soiled and 65% lightly soiled laundry load.
Total water savings (gallons)	784,566	133,386	Calculation
Total site gas savings (therm)	49,255	8,374	Calculation
Market penetration	10%	25%	CUWCC
Municipal energy savings (kWh/ million gal)	3,950	3,950	CEC
Total water savings (gallons)	39,228,320	200,079,084	CUWCC
Annual PG&E gas savings (therms)	2,462,765	12,561,019	CUWCC
Annual PG&E municipal energy savings (MWh)	155	790	Calculation

Some facilities in built-up areas may use steam from a district heating system to provide hot water to the facility. The heating energy reduction from these facilities will not appear on their PG&E bills.

6.0 References

Derrick, J., “Understanding the Science Behind Ozone Laundering”, American Laundry News. December, 2002

Klein, G.,“California's Water – Energy Relationship”, California Energy Commission. November 2005

Koeller et al., “A report on Potential Best Management Practices” prepared for The California Urban Water Conservation Council January 2006

“Ozone company cleans up in the laundry” case study published by the Department of Environment and Conservation, New South Wales, Australia. March 2005

“Ozone Laundry at Magnolia Manor”. EPRI Case study.

“Pressurized Ozone Hospital Laundry system.” EPRI fact sheet. February 2005

Reiff, J., “Ozone—Science & Technology—Minus the Myths”, Textile Rental magazine,

Riesenberger, J. “Ozone Laundry Technology for Water and Energy Savings”, Strategic Planning for Energy and the Environment. Volume 20, Number 4 / Spring 2001

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