CHAPTER 2
Economic Benefits of Ozone Laundering

Two remarkable properties of ozone stand out in its application to laundry systems:

a. because it leaves no chemical residue and because the amounts of detergent and other chemicals needed with ozone treatment are sometimes much lower than for conventional laundering systems, ozone-sanitized laundry wash needs less rinsing, thus saving water, and

b. because ozone works so efficiently in cold water, sanitizing as well as cleaning can be performed in cold water, saving considerable energy.

Additional cost savings accruing to the ozone user will become apparent from the following discussion of specific items.

Specific Items that Result in Cost Savings from Ozone Laundering

Reduces Energy Use
Ozone enhances the effectiveness of the actions of chemicals, reducing the need for high temperature washing. Estimates of savings potential made by one supplier of ozone laundering systems based on commercially operating ozone laundry systems are as high as 90% in washing and 20% in drying.

Reduces Water Use
Ozone wash systems normally require fewer rinse steps, thus reducing water usage by an estimated 30-45%. Closed-loop laundering systems are more expensive from a capital cost point of view. On the other hand, these systems recover most of the water, so that reductions in water use can reach 70-75%.

Reduces Chemical Use – Ozone allows existing chemicals to work better, and reduces overall chemical demand in several ways:

- **Ozone Helps Supply Oxygen To The Wash Water,** which increases chemical effectiveness and reduces chemical demand.

- **Ozone Oxidizes Linen Soils,** making them easier to remove from the wash water.

- **Ozone Can Reduce The Need For Harsh, High-pH Chemicals.** While virtually all ozone laundry systems use at least some chemicals, savings claims range from 5% to 30%. Actual savings will depend on the type of laundry being washed, the temperature and hardness of supply water and the design of the system.

- **Ozone In Water Solution Performs Some (but not all) The Functions of Chlorine Bleach.**
  Because ozone improves the removal of soils from wash water, it helps prevent redeposition of soil onto the linen (one of the major causes of fabric graying) which, in turn, reduces the need for bleaching. Control of ozone output, concentrations, dilutions, etc., allows ozone to do its soil-removing work without actually bleaching the laundry. However, conventional bleaching may still be required to bleach stains (see Chapter 6).

- **Ozone Assists In Water Softening** by helping to remove water hardness cations (calcium and magnesium ions) from the water. This occurs by the complex mechanism of ozone adding oxygen moieties (or group of atoms) to some of the partially oxidized organic materials present in laundry soils. The oxygenated organic laundry soils then can form insoluble complexes with polyvalent cations (Ca, Mg, Fe, Al, etc.), thereby partially softening the ozone-treated laundry waters (this does not mean that an ozone system will replace the need for or use of a water softening system). Softer water produces a better feel in washed fabrics due to better sudsing and more complete rinsing action.

- **Improves Textile Life and Quality**
  Shorter cycle times and cooler temperature water means less wear and tear on textiles. Also, reduced exposure to chemicals can improve fabric life. A study performed in the United Kingdom on ozone laundering of nurses' uniforms showed that ozone laundering removed significant moisture from laundry in comparison to a conventional wash cycle (both cycles had the same final spin speed and time). Thus, ozone laundering results in less drying time and increased linen life (Hook, 2007a).

- **Improves Effluent Quality**
  In addition to reducing the volume of wastewater to be discharged, effluent surcharges can be reduced because the effluent contains lower levels

of biochemical and chemical oxygen demands (BOD and COD). This is because ozone oxidizes bacteria, other microorganisms, and some dissolved organic compounds that make up biochemical and chemical oxygen demands. Also, because fewer chemicals are used with ozone laundry cycles, chemical oxygen demand (COD) will be reduced as well.

- **Lowers Staff Labor Costs**
  With less rinsing, wash loads can be completed faster, thus utilizing the laundry equipment more efficiently and reducing the total number of staff hours required per load.

Estimated Cost Benefits of Ozone Laundering Obtained in the USA

Some economic benefit data were presented by Cardis et al. (2006) that were based on 2005 national (USA) averages for consumables and labor costs. These extrapolated average economic savings are presented in Table 2-1, and lead to estimated times to Returns-On-Investment of 0.75 to 1.45 years, depending upon the size of ozone equipment required.

In the interest of updating these extrapolations that were based on averages, ClearWater Tech, LLC conducted a two-month comparative evaluation of traditional vs ozone laundering at a California hotel that had retrofit ozone equipment into their laundry. That comparative study is described in detail below (Rice et al., 2009b).

Table 2-1 Total Estimated Cost Savings for Ozone Washing (Cardis et al., 2006)

	Savings		
Item Saved	**per load**	**per day**	**percent**
Water/Sewer	$0.54	$5.40	47%
Water Gas	$1.14	$11.44	90%
Hot Water	165 gal/load		86%
Dryer Gas	$0.34	$3.40	20%
Chemicals	$0.25	$2.50	42%
Labor	$4.93	$49.30	31%

Comparative Evaluation of Traditional vs Ozone Laundering

At the Apple Farm Inn laundry facility (San Luis Obispo, CA), a several month evaluation was conducted during late 2006 and early 2007 to compare the costs of laundering by traditional and by ozone laundering. The Apple Farm Inn is a hospitality hotel with 104 rooms. Laundry processed includes bedding (sheets, blankets, pillow cases) and towels (from rooms and swimming pool area), bath mats and robes. No unusual contamination was present (such as would be found in hospitals or nursing home/health care institutions) at any time during this testing program.

Facilities and Equipment Employed

In the Apple Farm Inn laundry room are two UniMac Commercial Washers (each capable of washing 80 lbs of laundry per load) and two UniMac Commercial Dryers (Alliance Laundry Systems, Ripon, WI), each capable of drying 120 lbs of laundry per load. Twenty (20) loads per day are laundered on the average, equating to 1,600 lbs per day of laundry. Traditional laundering was conducted for one month, followed by ozone laundering for a second month.

The ozone system installed for this study was the EcoTex system (ClearWater Tech, LLC, San Luis Obispo, CA), consisting of an ECO2 ozone generator (maximum ozone output rating of 8 g/h at 3% concentration by weight), a SeQual Technologies Workhorse 8c Oxygen Concentrator, an Aeroqual 100 Ambient Air Ozone Monitor (Aeroqual Ltd., Auckland, NZ), and an ozone diffuser installed in the sump of the clothes washer. Figure 2.1 is the schematic diagram of this ozone laundry system.

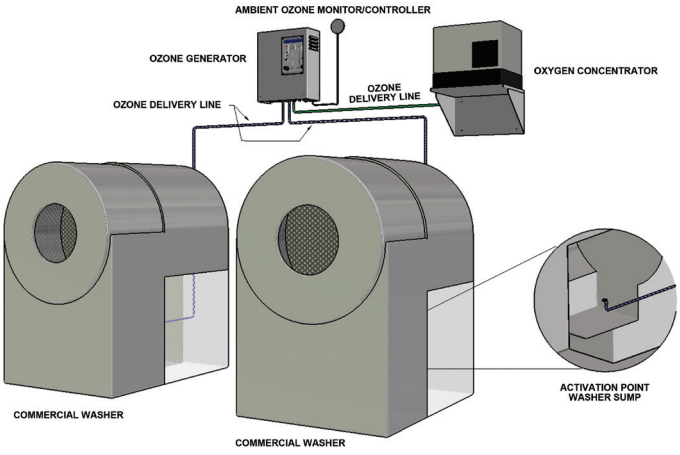

Figure 2.1 Schematic diagram of the ozone system installation at Apple Farm Inn

Traditional vs Ozone Laundering Cycles Used

A key step in the application of ozone in a commercial laundry facility is to determine the appropriate cycle configurations. Among other factors, these wash cycles are designed based on the type of linen being laundered, the soil content of the linen, and the capacity of the washer. Figures 2.2 and 2.3 provide a visual indication of the differences between the traditional wash cycle and ozone wash cycle, respectively, used at the Apple Farm Inn. Chemical signals are as follows; S1 = Break, S2 = Detergent, S3 = Bleach, S4 = Sour/Soft, S9 = Ozone.

To highlight, the ozone cycle uses two fewer steps with the removal of an extract and combining detergent (suds) and bleaching into one step. Removing these two steps plus reducing the amount of water and time in each of the steps, allows for 22 fewer gallons of water to be used per cycle (18% savings) and 11 minutes less in overall time of laundering - time which not only saves labor but also electrical consumption.

Traditional Cycles

PROGRAM: Sheets/Towels

STEP	TEMP	LEVEL	TIME	S1	S2	S3	S4	S9
1 SUDS	H	M	8	20	3			
2 BLEACH	H	M	7			13		
3 RINSE	H	H	2					
4 EXTRACT		E	2					
5 RINSE	W	H	2					
6 FINAL RINSE	W	M	3				3	
7 EXTRACT		E	5					
Total Cold Water Gallons:	0							
Total Warm Water Gallons:	52							
Total Hot Water Gallons:	74							
Total Gallons:		126						
Total Time (min):			29					0
Total Time (sec):				20	3	13	3	
Total Chemical Used/Signal (OZ):				4	0.6	2.6	0.6	
Total Chemical Used/Wash (OZ):								7.8

Figure 2.2 Laundering cycles used for the traditional procedure

These figures also break down the amount of hot, warm and cold water used in the laundering cycles. The ozone cycle is clearly shown to reduce the volume of elevated temperature water by 104 gallons (82%) per wash load. Additional savings in natural gas also result from the use of less hot water. Finally, a portion of the savings shown in the test case cycles comes from chemicals, which have been reduced in the ozone cycle by 1.6 ounces (21% savings).

Ozone Cycles

PROGRAM: Sheets/Towels

STEP	TEMP	LEVEL	TIME	S1	S2	S3	S4	S9
1 SUDS	H	M	5	14	3	10		5
2 RINSE	C	H	2					2
3 RINSE	C	H	2					2
4 FINAL RINSE	C	M	2				3	2
5 EXTRACT		E	6					
Total Cold Water Gallons:	82							
Total Warm Water Gallons:	0							
Total Hot Water Gallons:	22							
Total Gallons:		104						
Total Time (min):			18					11
Total Time (sec):				14	3	10	3	
Total Chemical Used/Signal (OZ):				2.8	0.6	2	0.6	
Total Chemical Used/Wash (OZ):								6.0

Figure 2.3 Laundering cycles used for ozone laundering

Commodity/Consumables Used

Figures 2.4 and 2.5 show the Traditional and Ozone formula totals used in each of the one month test times for each process.

Traditional Cycle	
Water	
Total Avg Per Load - Gallons	141.00
Avg Cost Per Load	$1.69
Cost Per Month	$974.59
Cost Per Year	$11.695.10
Chemical	
Total Avg Per Load - Ounces	7.60
Avg Cost Per Load	$0.99
Cost Per Month	$569.09
Cost Per Year	$6,829.06
Electrical	
Total Avg Per Load - kWH	1.53
Avg Cost Per Load	$0.21
Cost Per Month	$123.70
Cost Per Year	$1,484.42
Natural Gas	
Total Avg Per Load - Therms	0.62
Avg Cost Per Load	$0.77
Cost Per Month	$444.02
Cost Per Year	$5.328.26
Labor	
Total Avg Per Load - Minutes	29.50
Avg Cost Per Load	$4.92
Cost Per Month	$2.712.00
Cost Per Year	$33,984.00

Figure 2.4

Ozone Cycle	
Water	
Total Avg Per Load - Gallons	104.00
Avg Cost Per Load	$1.25
Cost Per Month	$718.85
Cost Per Year	$8,626.18
Chemical	
Total Avg Per Load - Ounces	6.00
Avg Cost Per Load	$0.78
Cost Per Month	$449.28
Cost Per Year	$5,391.36
Electrical	
Total Avg Per Load - kW	1.07
Avg Cost Per Load	$0.15
Cost Per Month	$86.12
Cost Per Year	$1,033.48
Natural Gas	
Total Avg Per Load - Therm	0.12
Avg Cost Per Load	$0.15
Cost Per Month	$84.77
Cost Per Year	$1,017.28
Labor	
Total Avg Per Load - Minutes	18.00
Avg Cost Per Load	$3.00
Cost Per Month	$1,728.00
Cost Per Year	$20,736.00

Figure 2.5

The bottom two lines show the costs per month and projected costs per year, respectively. It is clear that the ozone system resulted in annual cost savings in all categories [water, chemicals, electrical (with ozone considered as electrical), natural gas and labor] of $13,248 (38%).

Figure 2.6 is a graph showing the annual costs of the traditional vs ozone laundering systems at Apple Farm Inn. Figure 2.7 is a graph showing the annual percent savings resulting from use of the ozone laundering system. Total Annual Savings by ozone laundering were 38%.

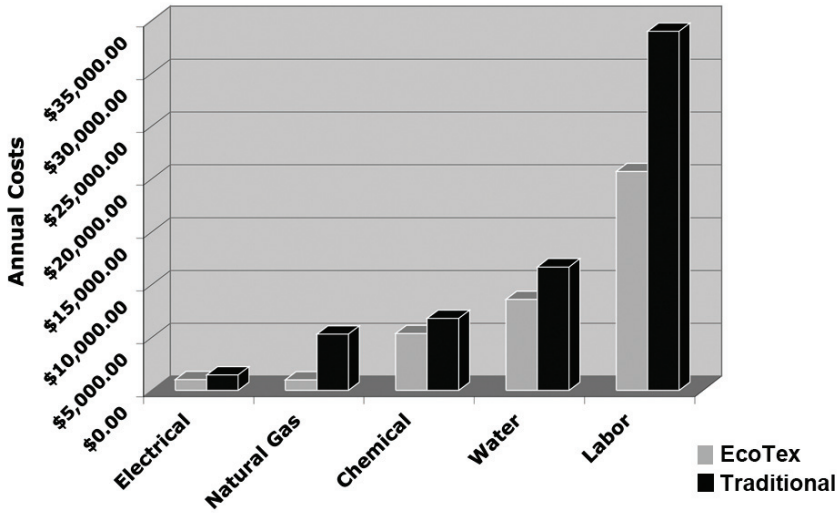

Figure 2.6 Annual costs of traditional vs ozone laundering at Apple Farm Inn.

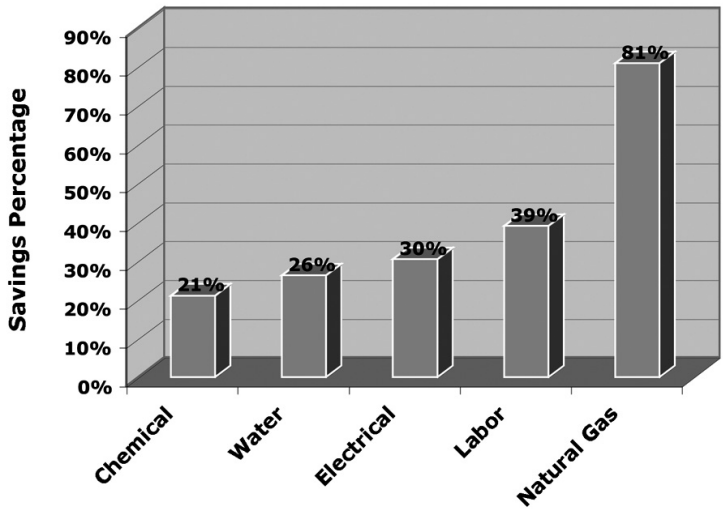

Figure 2.7 Percent of annual savings with ozone laundering at Apple Farm Inn.

Labor and Production Savings

One of the most interesting benefits found in this case study (Apple Farm Inn) is that of labor and/or production savings, which also can be quantified as facility efficiency. This efficiency was equated to the overall reduction of cycle time saved by the ozone laundry system. This does not necessarily mean that the facility paid less in staff labor, but rather that the staff was available to perform other housekeeping duties and charged their time to different projects.

The efficiencies of less water and fewer rinsing cycles resulting from ozone laundering allowed the Apple Farm Inn to launder nearly sixty (60) more loads per month than when laundering using their traditional washing procedure.

Return-On-Investment

In addition to providing environmental and microbiological benefits, ozone laundry systems also provide reduced cycle times, water, energy, and chemicals. They also can pay for themselves and typically within short time periods. As shown in Figures 2.4 - 2.7, the ozone laundry system has saved the Apple Farm Inn nearly 40% of the annual overall costs related to the washing of linens in their laundry facility. This savings paid for the ozone laundering system in less than eight months.

The rate of return on a system such as this may increase dramatically through state and local energy providers and water companies, who provide grants, rebates and other incentives to facilities that install energy- and water-saving technologies and equipment.

Figure 2.8 shows an estimated payback time of 7.7 months resulting from the ozone laundering system, including the labor savings, of $1,756 per month or $22,517 (annually).

Payback With Labor Savings	
Cost Per Pound - Traditional Cycles	$0.11
Cost Per Pound - EcoTex Cycles	$0.07
Savings Per Pound	$0.04
Cost Per Load - Traditional Cycles	$8.60
Cost Per Load - EcoTex Cycles	$5.40
Savings Per Load	$3.20
Monthly EcoTex Facility Savings	$1,757
Annual EcoTex Facility Savings	$22,517
Annual EcoTex Facility Savings Percentage	38%
Retail Cost of EcoTex System	$14,370
Payback (months)	7.7

Figure 2.8 Estimated payback time, considering labor savings

Figure 2.9 shows an estimated payback time (R-O-I)of 18.6 months when labor savings are not taken into consideration.

Payback Without Labor Savings	
Cost Per Pound - Traditional Cycles	$0.05
Cost Per Pound - EcoTex Cycles	$0.03
Savings Per Pound	$0.02
Cost Per Load - Traditional Cycles	$3.70
Cost Per Load - EcoTex Cycles	$3.00
Savings Per Load	$0.70
Monthly EcoTex Facility Savings	$773
Annual EcoTex Facility Savings	$9,269
Annual EcoTex Facility Savings Percentage	37%
Retail Cost of EcoTex System	$14,370
Payback (months)	18.6

Figure 2.9 Estimated payback time without considering labor savings

Corroborating Ozone Performance Data

Information provided by the Daniels Equipment Company, Inc., Auburn NH (a laundry firm with many hundreds of ozone laundry facilities operating throughout the United States) confirms the types of results obtained from the Apple Farm Inn case study. Table 2-2 is a metered savings analysis of the Arapahoe County Detention Facility laundry system (Lakewood, CO) showing total annual utility savings (water, hot water, and dryer) of $35,559; Daniels Equipment Company, 2009a). Table 2-3 is a metered savings analysis of a hotel at which annual utility savings total $80,639 (Daniels Equipment Company, 2009b).

Table 2-4 shows metered actual annual water savings measured at 15 State of Missouri Correctional Facilities at which Aquawing ozone laundry systems were installed during 2007. Also shown in Table 2-4 is the return-on-investment for each Aquawing ozone laundry system calculated from the local utility rates for each facility based on the water savings alone.

Table 2-2 Metered Savings Analysis at Arapahoe County (CO, USA) Detention (Daniels Equipment Company, 2009a)		
	Before Ozone	**After Ozone**
Daily Total Water - gal	6,565	4,989
Daily Total Hot Water - gal	4,267	640
Temperature Rise (ºF)	120	
Cost per Therm, $	$1.10	
Hot Water Heater Efficiency	65%	
Water Cost per 1,000 gal	$4.32	
Sewer Cost per 1,000 gal	$3.45	
Total BTUs	11,811,581	1,771,599
Hot Water Therms	65.62	9.84
Dryer Therms	52.50	42.00
Water Cost - Annual	$18,618.67	$14,149.05
Hot Water Cost, Annual	$36,346.39	$3,951.65
Dryer Cost, Annual	$21,077.11	$16,861.69
ANNUAL UTILITY SAVINGS		
Water		$4,469.61
Hot Water		$26,873.69
Dryer		$4,215.42
TOTAL ANNUAL UTILITY SAVINGS		**$35,558.72**

Table 2-3 Metered Savings Analysis at Equinox Hotel (Daniels Equipment Company, 2009b)		
	Before Ozone	**After Ozone**
Daily Total Water - gal	13,409	6,831
Daily Total Hot Water - gal	9,329	1,505
Temperature Rise (ºF)	110	
Cost per Therm, $	$1.35	
Hot Water Heater Efficiency	65%	
Water Cost per 1,000 gal	$3.00	
Sewer Cost per 1,000 gal	$3.00	
Total BTUs	23,671,835	3,818,856
Hot Water Therms	131.51	21.22
Dryer Therms	105.21	84.17
Water Cost - Annual	$2, 494.07	$1,270.57
Hot Water Cost, Annual	$5,503.70	$887.88
Dryer Cost, Annual	$4,402.96	$3,522.38
ANNUAL UTILITY SAVINGS		
Water		$14,682.10
Hot Water		$55,389.81
Dryer		$10,567.11
TOTAL ANNUAL UTILITY SAVINGS		**$80,639.01**

Table 2-4 Missouri Correctional Facilities, Metered Water Savings and ROI		
Facility	Annual Water Savings	Return-On-Investment – mos (a)
Farmington Correctional Center	$282,963.02	10
Moberly Correctional Center	151,244.65	17
Tipton Correctional Center	81,422.32	12
Northeast Correctional Center	40,299.52	21
Algoa Correctional Center	35,279.42	32
Ozark Correctional Center	25,274.31	21
S. Central Correctional Center	46,687.29	21
Women's Eastern Reception	37,911.44	26
Western MO Correctional Center	43,716.88	30
WRDCC	54,234.48	21
ERDCC	10,568.29	33
JCCC	21,207,43	59
MO Eastern Correctional Center	23,912.76	18
Maryville Treatment Center	8,450.28	53
Southeast Correctional Center	29,420.52	24
a. Costs for laundry installations at correctional facilities typically are 35% higher than normal because of special enclosures, etc., required		
Source: AWOIS, LLC, Bulletin AF-41 (Daniels Equipment Co., 2009c)		

Cost Savings at Installed United Kingdom Ozone Laundering Systems

In contrast to the USA, where most ozone systems purveyors market ozone laundering equipment outright, JLA Ltd. leases ozone laundering equipment (OTEX) in the UK, then provides service contracts to their many clients. As of January 2010, JLA Ltd had installed over 2,000 ozone laundry systems in over 1,000 health care establishments including 72 hospitals, all in the UK. Consequently, some specifics in estimated ozone benefits will vary as a result. Additionally, the amounts of estimated savings in the United Kingdom are expressed in pounds Sterling. Nevertheless, the estimated percentage savings as a result of ozone laundering are strikingly similar on either side of the Atlantic Ocean. Tables 2-5, 2-6 and 2-7 show weekly and annual savings in three different establishments using OTEX ozone laundering equipment installed: a 50-bed care home (70% incontinence) (Table 2-5), a 90-bed care home (85% incontinence) (Table 2-6), and an 800-bed hotel (Table 2-7) (Cardis et al., 2006).

At the North Hertsfordshire Hospital (U.K.), JLA Ltd. was able to prove electricity savings of 85% with an ozone-microfibre mop laundering program (Hook, 2007a).

Table 2-5 Weekly Savings with OTEX - 50-Bed Care Home - 70% incontinence (Cardis et al., 2006)							
Period	**Pre-OTEX**	**1-week**	**Post-OTEX**	**1 week**	**% Saving**	**Weekly Savings**	**Notes**
Electric kw	360	£21.60	119	£7.14	67%	£14.46	
Gas kw	1150	£13.80	691	£8.29	40%	£5.50	Incl. 369 kWh
Hot Water L	8026		992		88%		to heat water
Total Water L	44015	£66.02	26633	£39.95	39%	£26.07	
Chemicals, mL	36280	£90.70	11682	£29.21	68%	£61.50	
SubTotal		£192.12		£84.59	28%	£107.53	
Linen Saving	72					£10	Based on 20%
Labor		£360.00	52	£260		£100	extra linen life
Weekly Cost		£552.12		£344.59			
Total Weekly Saving						£217.53	
Total Annual Saving						£11,311.46	
COSTS							
electric kw	0.06						
gas kw	0.012						
water/effl'nt L	0.0015						
chemicals mL	0.0025						
labor £/hr	5						

Table 2-6 Weekly Savings with OTEX - 90-Bed Care Home - 85% Incontinence (Cardis et al., 2006)							
Period	**Pre- OTEX**		**Post-OTEX**		**% Saving**	**Weekly Savings**	**Notes**
Electric kw	529	£28.57	319	£17.23	40%	£11.34	
Gas kw 1764	1764	£19.04	1166	£12.59	34%	£6.45	Incl. 436 kWh to heat water
Hot Water L	13,580		1,670		88%		
Cold Water L	63980		34,250		46%		
Total Water L	77560	£116.34	35920	£53.88	54%	£62.46	
Chemicals, mL	58215	£145.54	27488	£68.72	53%	£76.82	
Sub-Total		£309.48		£152.42		£157.07	
Linen Costs		£50.00		£40.00		£10	Based on 20% extra linen life
Labor Saving	112	£560.00	84	£420.00	25%	£1	
Weekly Cost		£919.48		£612.42			
Ttl Weekly Saving						£307.07	
Ttl Annual Saving						£15,967.51	
COSTS							
electric kw	0.054						
gas kw	0.0108						
water/effl'nt L	0.0015						
detergent mL	0.0025						
labor £/hr	5						

Table 2-7 Weekly Savings with OTEX - 800-Bed Hotel (Cardis et al., 2006)							
Period	**Before OTEX**		**After OTEX**		**% Saving**	**Savings £**	**Notes**
	W/C 30 March 2004		W/C 18 May 2004				
Electric kw	1127	£67.62	585	£35.10	48%	£32.52	
Gas kw	3337	£40.04	1739	£20.87	48%	£21.26	Incl. 173 kWh to heat water
Hot Water L	22700		3322		85%		
Total Water L	65100	£97.65	31465	£78.66	52	£18.99	
Chemicals, mL	180810	£452.03	54256	£135.64	70%	£316.39	
Total		£657.34		£270.27	59%	£389.15	
Avg cost/cycle		£2.96		£1.40		£1.56	
Estd Linen Saving						£20.00	
Total Weekly Saving						£409.15	
Total Annual Saving						£21,275.72	
Machine Operating Hours			136	114		16%	
Type of Laundry Equipment			Industry Based Costs				
Washers	2x HF304		IPSO65 & 50		Electric kW	0.6	
Dryers (Gas)	4x ADC 75				Gas kW	0.012	
					Water/Effluent	0.0015	
					Chems, mL	0.0025	
					Labor, £/hr	5	

SUMMARY AND CONCLUSIONS

Economic (Cost) Savings Resulting from Ozone Laundering

1. Ozone laundering brings cost savings in reduced energy use by using cold water (ambient temperature, from the municipal tap), which lowers the energy necessary to heat water. In the USA, these reduced energy savings alone are in the range of 70-90%.
2. Ozone laundering reduces or eliminates the need for the amounts of many chemicals currently used in conventional laundering systems. These chemical savings amount to about 30%, but can be lower or higher depending on the specific factors involved at each specific installation.
3. Because ozone laundering systems lower chemical usage, the number of rinses required is lowered, with resulting savings in water and labor. Labor savings alone amount to about 30%.
4. Fabric life is extended by ozone laundering, due to the lower temperatures required, less agitation time, and lowered amounts of chemicals employed.
5. Confirmation of these cost savings in the UK shows total weekly cost savings of ozone laundry systems ranging from £11,310 to £16,000 in two health care homes. In an 800-bed hotel, these cost savings are as high as £21,275 per week.
6. Annual cost savings found for ozone laundering in the USA allow a return-on-investment between 8 and 18 months for ozone systems, depending on the size of equipment required.

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