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A feasibility and cost comparison of perchloroethylene dry cleaning to professional wet cleaning: case study of Silver Hanger Cleaners, Bellingham, Massachusetts

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ABSTRACT

The Toxics Use Reduction Institute (TURI) has been working with the dry cleaning sector for over 10 years – focusing on the ultimate goal of eliminating the use of perchloroethylene in this sector due to the availability of less toxic, feasible alternatives. Professional wet cleaning has been identified as one of these alternatives and has been a focus of the Institute in recent years. In 2008, the Institute provided a matching grant to Silver Hanger Cleaners in Bellingham, Massachusetts to convert their operations from perchloroethylene-based to water-based processes. Two years of data have been collected from the facility, reflecting one year of solvent use and one year of dedicated professional wet cleaning. The analysis of that data is presented here, including capital costs, performance data and associated costs, operational costs, and resource use and associated costs.

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1. Introduction

The concept of wet cleaning in the professional garment care industry has been in existence for several decades. However, it is only in the last 10 years or so that advancements have been made to the technology that allows for 100% of garments to be cleaned using the wet cleaning system. In 1998, Koeleian, et al. recommended in the Journal of Cleaner Production that larger cleaners could consider operating mixed mode facilities that use both dry cleaning and wet cleaning equipment (Koeleian et al., 1997). Today over 150 cleaners in California are operating as dedicated wet cleaners, a state where perchloroethylene (commonly known as perc or PCE) is being phased out through regulations (California Air Resources Board amendments will over time phase out the use of PCE dry cleaning machines and related equipment by January 1, 2023). Still, the shift to wet cleaning from solvent based cleaning has been slow, especially where regulations phasing out solvent use do not exist. At the time of writing, there were three dedicated wet cleaners in Massachusetts known to the Institute. Cleaners believe that insurmountable obstacles exist that do not make wet cleaning a feasible alternative – their concerns include increased costs, garments and fabrics that require extra care, and additional time investments. The data has shown that these concerns are now lessened if not eliminated due to the newer technology. Sinsheimer et al. concluded in the Journal of the Air and Waste Management Association in 2007 that cleaners they studied in California who switched to professional wet cleaning were able to maintain their level of service and customer base while lowering operating costs. They also found that the cleaners were able to transition to professional wet cleaning without a great degree of difficulty and were highly satisfied with the new technology (Sinsheimer et al., 2007).

This case study based on a Bellingham, MA cleaners shows that electricity and natural gas usage decreased as much as 20%, and even water use was reduced at a dedicated professional wet cleaner. For this facility, equipment costs were reduced by $500 over 12 months, performance costs (claims) were reduced by $1000 over 12 months, operational costs (mainly due to costs of detergents) increased by $1069 over 12 months, and costs associated with resource use (calculated using normalized rates) were reduced by $2318 over 12 months, totaling $2749 in savings over the 12 months of the study. The facility spent approximately $12,000 (in actual costs, but not factoring in discounts and grant monies received) more than it would have to simply replace their solvent machine. This equates to a return on investment realized in just under 4.5 years.

With appropriate training and practice the personnel at this facility have been able to master difficult garments and even boast

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Table 1
Comparison of performance attributes.

Attribute	PCE	Wet cleaning	Qualitative analysis
Send-outs	5 items/month	Initial: 15–40 items/month After experienced: 5 items/month	Learning curve applies; eventually no difference
Re-dos	0	Initial: 3 items/month After experienced: <3 items/month	Staff learning curve effects rate of re-dos; eventually slight increase
Claims	$1226	Initial: $1125 After experienced: $0	Saved >$100/year initially; saved >$1000/year with experience

that whites come out whiter and colors brighter in wet cleaning. Time spent cleaning is difficult to quantify, however, again with proper training and practice, total cleaning time can be reduced due to less pre-spotting, the ability to simultaneously wash and dry in separate machines (unlike the all-in-one traditional dry cleaning machines), and a mastery of the finishing equipment. Indirect benefits of improved air quality, reduced liability, elimination of regulatory oversight, and environmentally friendly niche marketing should all also factor into the overall analysis of the professional wet cleaning system.

1.1. Background

Able to dissolve most organic materials, PCE is the most widely used dry cleaning solvent in Massachusetts and nationally. It has been estimated by the Environmental Protection Agency that approximately 85% of cleaners use PCE as their primary solvent. PCE is also a major contributor to contamination at dry cleaning shops, mainly due to past unsafe handling practices. PCE is reported to be the chemical most widely found in groundwater contamination at Superfund sites (Anon., 2007), dry cleaning being one of the main sources. Studies suggest that long-term frequent over-exposure to organic solvents such as PCE may cause lasting and possibly permanent central nervous system effects. Fatigue, lack of muscle coordination, loss of concentration as well as short term memory loss, and personality changes exhibited as nervousness, anxiety or irritability are some of the potential permanent long-term effects of chronic and frequent exposure (Anon., 2007). In addition, PCE inhaled by pregnant women can cross the placenta, causing exposure of the developing fetus. PCE, which has been listed by The International Agency for Research on Cancer as "probably carcinogenic to humans," has also been found in breast milk of mothers exposed to the chemical (Anon., 2007).

Professional wet cleaning has been determined in previous studies to be an energy efficient, nontoxic, zero-emission technology – and can be used to process those garments previously dry cleaned (Sinsheimer et al., 2007). The new wet cleaning technology, consisting of a washer, dryer, and tensioning equipment, allows "dry-clean-only" clothes to be washed with water and detergents in computer controlled machines, dried in moisture controlled machines, and then finished with tensioning and pressing equipment.

1.2. Case study site, Silver Hanger Cleaners

In 2008, the Toxics Use Reduction Institute (TURI) at the University of Massachusetts Lowell awarded Silver Hanger Cleaners of Bellingham, Massachusetts a $17,000 matching grant to switch to 100% wet cleaning technology. Mark Isabelle (hereafter referred to as "the cleaner"), owner of Silver Hanger Cleaners for 14 years, renovated his existing store, removed the PCE machine, and installed wet cleaning equipment. With a few days of down time for the conversion, he opened his facility as a dedicated wet cleaning facility in November of 2008.

Silver Hanger Cleaners was using a third generation PCE machine and now conducts wet cleaning and laundry operations in about 1300 square feet of renovated space. The cleaner hopes to expand soon to accommodate another wet cleaning machine. The facility operates with about 7 full-time equivalent employees (FTEs) and cleans an average of 110 items per day – relatively consistently throughout the study period.

2. Data analysis

A portion of the matching grant money provided to Silver Hanger by TURI was used to fund the collection of data about the performance and costs associated with wet cleaning as compared to PCE dry cleaning. The data was collected from December 2007 through November 2009. Twelve months of PCE use data (December 2007 through November 2008, referred to as "2008 PCE Data" in this report) is compared to 12 months of wet cleaning use data (December 2008 through November 2009, referred to as "2009 Wet Cleaning Data" in this report).

The categories for which data was collected are: capital costs, performance, operation costs, and resource use. Performance data consisted of send-outs, re-dos, and claims. The operational data

Table 2
Summary of costs/savings – operating expenses.

Item	Costs/month (areas where costs are higher with wet cleaning)	Savings/month (areas where costs are lower with wet cleaning)	Costs/savings per year [(−) = savings, (+) = costs]
Maintenance	–	$227	−$2721
Filters	–	$26	−$316
Solvent	–	$130	−$1560
Detergent	$631	–	+$7572
Spotting agents	$41	–	+$492
Hazardous waste disposal	–	$179	−$2148
Regulatory fees	–	$21	−$250
Totals	$672	$583	
Total costs	+$89		+$1069

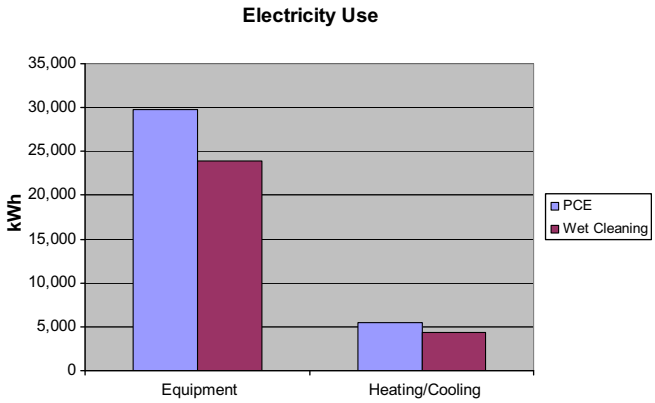

Fig. 1. Equipment and heating/cooling electricity use comparison.

included costs for machine maintenance, solvent filters, solvent product, detergent, spotting agents, hazardous waste disposal, regulatory fees, and a discussion of labor time. Resource use data included electricity for equipment (kilowatt hours or kWh), electricity for the facility heating and cooling (kWh), natural gas for the boiler to produce steam and hot water (therms), water, and sewage (both in gallons). Resource use data was also converted to dollar amounts using average unit costs for each year.

2.1. Capital costs

The cleaner was in the market for a new PCE machine when he decided to purchase the wet cleaning system. A new PCE machine would have cost him $44,000 (according to his equipment supplier). Instead, he invested $12,120 in a washer, $4515 in a dryer, $11,008 in a tensioning pants topper, and $19,540 in a shirt finisher (it should be noted that the cleaner purchased a shirt finisher providing more flexibility than generally required for a professional wet cleaner and he could have spent closer to $12,000 on an adequate machine), totaling $47,183. The costs the cleaner incurred for this wet cleaning equipment reflect discounts the vendors offered so that their equipment would be featured in demonstration events coordinated by TURI. The discounts provided to him totaled almost $8800. The cleaner also received $17,000 from TURI and $2500 from National Grid (the facilities electricity and gas provider) – a total of $19,500 – to help offset his capital investment, and therefore spent $27,700 out of pocket. This amount is about $16,300 less than he would have spent on a new solvent machine. However, without discounts and grant assistance, he would have spent $12,000 more than if he had purchased a new PCE machine.

To compare equipment costs for a year of PCE cleaning to a year of wet cleaning, the useful life of each type of equipment was considered and an annualized cost of equipment determined. The capital cost of a new PCE machine being $44,000, assuming a 15-year life for the equipment, based on industry standards, and a cost of capital of 5%, the annualized cost of using a PCE machine is $3054. To determine an appropriate capital cost to use in an annualized cost equation for the wet cleaning equipment, the vendor discounts were added back on to the cost of equipment, however, a lower price for the shirt finisher was used as the additional features of the more expensive shirt finisher the cleaner purchased are not part of a standard wet cleaning system. This leads to a capital cost of $48,443 for the cleaner's wet cleaning equipment, assuming a 20-year life for the equipment, based on industry standards, and a cost of capital of 5%, the annualized cost of using wet cleaning equipment is $2553. This equates to an annual cost savings of approximately $500 by using the wet cleaning system.

2.2. Performance

Send-outs. Send-outs are items that a cleaner chooses to send to another shop to be cleaned, typically because the other cleaner has capabilities that augment the facilities' capabilities. This is a common practice in dry cleaning. When using PCE at his facility, the cleaner sent out only fur, leather, and suede items to a leather processor. The cleaner sent out an average of about five items each month. Immediately after his initial conversion to wet cleaning the cleaner sent out between 15 and 40 items each month to be cleaned elsewhere. His send-outs included fur, leather, and suede items, as well as hard to clean items like ties, pleated skirts, and draperies. Once the cleaner and his staff became more confident in the abilities of the new equipment, he reduced the amount of send-outs significantly and is now back to only sending out fur, leather, and suede items at the same rates he experienced when using PCE.

Re-dos. Re-dos are those items which did not meet visual cleaning or finishing standards as evaluated by the cleaner and are re-processed to fix the issue. The cleaner reports that he did not have any re-dos at his facility over the 12 months prior to converting his facility to wet cleaning. However, starting in December of 2008, his wet cleaning operations required 32 re-dos over 12 months for a monthly average of about 2.7 items. This rate of re-dos can be attributed to the learning process, and decreased as the cleaner and his staff became more comfortable with the use of the new equipment.

Claims. Claims are the items for which customers requested compensation if they felt the items were not properly cared for. The cleaner tracked the dollar amount of his claims to compare PCE use to wet cleaning. In 2008, the cleaner compensated his customers for a total of $1226, or an average of about $102 per month in claims associated with his PCE operation. In the first five months of 2009, the cleaner compensated his customers for a total of $1125 on claims, or about $94 per month on average. However, the claims dropped off to zero between April and October of 2009. The difference between 2008 and 2009 was a saving of $101 in claims or about $8/month. If the cleaner can maintain a $0 claim rate then he would see an average savings of about $1200 annually due to conversion to wet cleaning. A more conservative estimate of savings associated with reduced claims, however, is $1000 annually (Table 1).

Table 3
Electricity use and associated savings.

	2008 PCE data	2009 Wet cleaning data	Decrease in use (from PCE to wet cleaning)	Savings (in dollars at rate of 16.961 ¢/kWh)
Total annual electricity use for equipment (kWh)	29,736	23,892	5844	$991
Monthly average electricity use for equipment (kWh)	2478 (29,736/12)	1991 (23,892/12)	487 (5844/12)	$83 ($991/12)
Total annual electricity use for heating/cooling (kWh)	5489	4377	1112	$189
Monthly average electricity use for heating/cooling (kWh)	457 (5489/12)	365 (4377/12)	93 (1112/12)	$16 ($189/12)

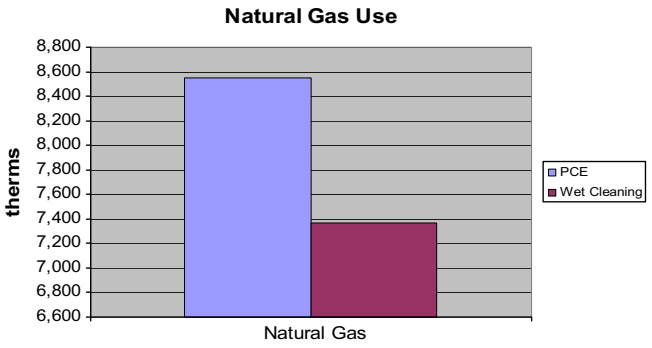

Fig. 2. Natural gas use comparison.

2.3. Operational costs

Labor. Though no labor costs were collected or reported during this study, some anecdotal information was collected based on the cleaners and pressers experience with both the PCE and wet cleaning equipment. After using the tensioning equipment purchased with the wet cleaning system, the cleaner's presser stated that he was able to leave earlier each day as he was able to process the garments more quickly than he had previously. With the wet cleaning washer and dryer, the cleaner is able to run wash and dry loads simultaneously, saving time there. He does hang some hard to dry items in the boiler room overnight for even more gentle drying and this processes adds time; this is only an issue if same day service is requested.

Maintenance. No expenditures on maintaining equipment at Silver Hanger Cleaners were reported by the cleaner. However, when operating PCE equipment, the cleaner would spend time cleaning and changing out filters and otherwise keeping the equipment in working order. With the wet cleaning equipment, there are no solvent filters to be cleaned, however parts do need to be kept in working order. A comparison is made here using industry standards for regular maintenance costs for PCE versus wet cleaning equipment. Sinsheimer et al. estimate that the total expense of maintaining wet cleaning equipment (including parts and labor) comes to $379 per year based on a 15-year life span. The maintenance of a traditional solvent dry cleaning machine was estimated at 1.02% of a facility's annual revenue (Sinsheimer et al., 1997). Based on 2009 revenue of $304,000 at Silver Hanger, the maintenance costs for a PCE machine would have been $3100 for the cleaner. This totals an annual savings of $2721 ($3100 – $379) or $227 monthly.

Filters. When using PCE in 2008, a total of $316 was spent on filters for the PCE machine or about $26/month on average. No filters are necessary for wet cleaning equipment.

Solvent. The purchase of product solvent is, of course, a cost for a PCE facility. In 2008 the cleaner purchased 120 gallons of PCE. In 2009, using all wet cleaning, the cleaner did not purchase any PCE. Although the cost of PCE has gone up slightly over the past few years, the average cost over the study period was about $13/gallon. The total amount spent on solvent in 2008 was $1560 or $130 per month – a total savings as no solvent is necessary for wet cleaning.

Detergent. Because there are several detergents and other products (e.g. softeners and conditioners) that are an important part of the wet cleaning process, the costs for detergent are greater for a facility using wet cleaning, than they are for dry cleaning. The cleaner made an initial purchase of detergent for the wet cleaning of about $2000 that was used to stock his facility. Based on a comparison of 2008 and 2009 data, it can be estimated that for each $10 spent on wet cleaning detergents, about $1 is spent on detergents for laundry (i.e. not wet cleaning loads) done at the facility. A total of $9394 was spent on detergents in 2009, of which approximately 90% can be attributed to the wet cleaning processes at the facility or $8455 or $704/month.

The current average cost of $704/month for detergents minus the previous costs of $73/month is a difference of $631/month that the cost of detergents has increased or $7572 annually.

Spotting agents. The cost for spotting agents went up in the first year of operation as a wet cleaning facility. However, the experience of wet cleaners in California is that the need to apply spotting agents decreases as the technology becomes better understood. This has been the cleaner's experience as well. The cleaner also notes that it is more difficult to remove grease stains with spotting agents appropriate for wet cleaning – as these are spotting agents that do no rely on solvents.

With an average of $48 a month spent in 2009 on spotting agents, this is an increase of $41/month or $492 annually from 2008.

Hazardous waste disposal. Because hazardous waste is generated by the use of PCE, the cleaner spent an average of about $179/month on hazardous waste disposal in 2008, or a total of $2148. When the switch to wet cleaning was made these costs were eliminated because wet cleaning does not generate any hazardous waste.

Regulatory costs. Any dry cleaning facility that uses PCE in Massachusetts is required to submit paperwork and annual fees to the Massachusetts Environmental Results Program (ERP). All regulated media (air, water, waste) are included in this program. The fee associated with the ERP is $250/year or an average of $21/month. A facility using no PCE, such as Silver Hanger, no longer has to pay this annual fee, fill out paperwork (a small savings of labor time), or have the regulatory oversight that goes along with using PCE.

2.3.1. Summary of operating expenses

In the first 12 months of operation as a dedicated wet cleaning facility, detergent and spotting agent costs have increased on a monthly basis. Others costs have been completely eliminated. As noted in the summary table below, the use of wet cleaning has increased operating costs in the first 12 months $89/month on average (Table 2).

2.4. Resource use

The cleaner collected data on resource use to compare resources used for operating a PCE facility versus a dedicated wet cleaning facility.

Table 4
Natural gas use and associated savings.

	2008 PCE data	2009 Wet cleaning data	Decrease in use (from PCE to wet cleaning)	Savings[a] (in dollars)
Total annual natural gas use for boiler (therms)	8547	7367	1180	$1090
Monthly average natural gas use for boiler (therms)	712 (8547/12)	614 (7367/12)	98 (1180/12)	$91 ($1090/12)

[a] Reflects average rates over the two years.

Table 5
Water usage.

	2008 PCE data	2009 Wet cleaning data	Decrease in use (from PCE to wet cleaning)	Savings (in dollars)
Total annual water usage (gallons)	223,000	217,000	6000	$20
Monthly average water usage (gallons)	18,583 (223,000/12)	18,083 (217,000/12)	500 (6000/12)	$1.67 ($20/12)

Electricity use. Electricity provided by National Grid is used to power the garment cleaning equipment in the facility as well as the general heating and cooling equipment. The washers and dryers use electricity for mechanical action and the operation of computers, sensor systems, and detergent pumps. Tensioning equipment uses electricity to operate fans and computer systems (Sinsheimer and Grout, 2004). The amount of electricity used to power the facility equipment declined after the conversion to wet cleaning. The electricity use for wet cleaning and laundry equipment dropped an average of 487 kWh/month, or a monthly decline in electricity use of 20%. This drop in electricity consumption most likely can be attributed to the fact that there is no longer a solvent recovery system in use, an energy intensive process. The electricity used to power the heating and cooling system also declined after the conversion to wet cleaning, dropping an average of 93 kWh/month or a monthly decline in electricity use of 20%.

To convert this data into dollar figures, National Grid delivery and supply charges were used. Rates for delivery service (aside from a consistent monthly customer charge) are currently 5.961 ¢/kWh, and rates for basic service supply have averaged 11 ¢/kWh during the time period of this study, making the total charges for electricity 16.961 ¢/kWh. This equates to a total savings of $1180 over 12 months for equipment and heating/cooling electricity use (Fig. 1, Table 3).

It is important to note the construction contractor completing major renovations at the strip mall where the facility is located was using the electricity from the cleaner's facility (by stringing a power cord through his window to power construction tools and equipment). Therefore, the decline in electricity use associated with the conversion to wet cleaning is actually lower than what is reflected here.

Natural gas use. Natural gas is used at the facility to provide steam for equipment and hot water for equipment and the facility. After the conversion to wet cleaning, the natural gas decreased from 8547 therms to 7367 therms for the entire facility, or an average of 98 therms/month. This is an average decrease in the use of natural gas at the facility of 14%. It is likely that this decrease was due to the elimination of the solvent distillation process used with the PCE machine.

To convert this data into dollar figures, Bay State Gas (the cleaner's gas provider) rates were used. Rates for gas service were 1.0645 $/therm in 2008 and 0.7812 $/therm in 2009. Assuming this drop in natural gas rates occurred at the beginning of January 2009, we estimate that the average cost of natural gas over the course of this study was 0.9229 $/therm. This equates to a total savings of $1090 (though actual savings were $3343 based on actual rates) (Fig. 2, Table 4).

Water use and sewage discharge. Water is used at the facility in the equipment as well as for the general sanitary uses. The amount of water used declined at the facility once wet cleaning was installed. As shown in Table 5, water use declined an average of 500 gallons/month or 2.7%. It is likely that this decline occurred due to the elimination of the condensing/chilling operations associated with the PCE process.

The water supply charge in 2008 and 2009 was $3.25/1000 gallons according to the Bellingham Department of Public Works which provides water and sewer services. This equates to a total savings of $20 over 12 months (Table 5).

As sewage discharge at the facility correlates to water usage, the decrease in the amount of sewage water discharge to the local treatment plant decreased the same 2.7%. The sewage costs did increase from 2008 ($4.15/1000 gallons) to 2009 ($4.80/1000 gallons), however, the costs were normalized for the purposes of comparison and an average rate of $4.48/1000 gallons was used. The savings based on this average rate is then $28 over the course of a year or $2.30/month. It should be noted here that in Massachusetts, any laundry or dry cleaning shop is not allowed to discharge their wastewater to a septic system without a groundwater discharge permit from the Department of Environmental Protection (Table 6).

3. Additional savings and benefits

In addition to the various costs and savings noted in the data reported above, there are non-tangible savings associated with a conversion to wet cleaning. Many cleaners are concerned that wet cleaning takes more time than traditional PCE cleaning. The cleaner states that the process, in fact, does not take any longer once the wet cleaning system is learned. In fact, less time is spent on pre- and post-spotting. Just a few months in to using the new technology, his finisher was completing his work earlier each day than when they were using PCE.

Both the cleaner and his employees are happy with the new technology and the significantly improved air quality in the facility. As a facility using PCE, there was a noticeable smell of solvent in the air. Using wet cleaning, that odor has been eliminated. The cleaner

Table 6
Summary of costs/savings – resource use.

Item	Increased use/month (areas where use is higher with wet cleaning)	Reduced use/month (areas where use is lower with wet cleaning)	Savings per month (in dollars)	Savings per year (in dollars)
Electricity use for equipment (kWh)	–	487 or 20%	–$83	–$991
Electricity use for heating/cooling (kWh)	–	93 or 20%	–$16	–$189
Natural gas for boiler (therms)	–	98 or 14%	–$91[a]	–$1090[a]
Water use (gallons)	–	500 or 2.7%	–$1.67	–$20
Sewer discharge (gallons)	–	500 or 2.7%	–$2.30[a]	–$28[a]
Total savings	–$193[a]			–$2318[a]

[a] Reflects average rates over the two years.

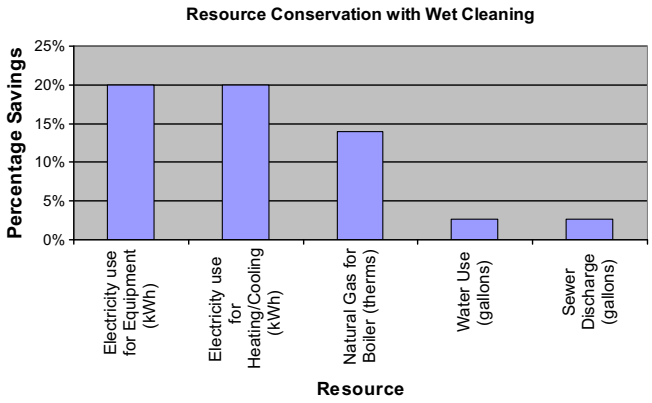

Fig. 3. Resource use and savings.

also states that customers are happy with the conversion to wet cleaning – as more and more consumers are looking for environmentally friendly services. The cleaner chose not to promote the use of wet cleaning as he was concerned that customers would not trust the use of water on their dry clean only garments. However, he would inform customers about the new technology if they inquired. He did post signs noting that he was an environmentally friendly cleaner and has a section on his web site about his non-PCE practices.

4. Conclusions and recommendations

This report has provided an analysis of capital, performance, operational, and resource use costs for one facility which converted from the use of PCE to professional wet cleaning equipment in their garment care business. The facility analyzed realized a $2749 savings during the first year of operation as a wet cleaner and a considerable reduction in their use of natural resources (Fig. 3, Table 7).

With more time, it is hoped that annual savings could even increase. It is also the indirect benefits, not measured in this study, that help make the case for wet cleaning as a feasible and desirable alternative technology to solvent cleaning. The hope is that this analysis can serve to educate policy makers, pollution prevention programs in other states, and cleaners, to the financial benefits of wet cleaning.

It should also be noted that this case study is specific to one cleaner in Massachusetts. However, the data and results are comparable to similar studies conducted in California (Sinsheimer et al., 1997; Sinsheimer and Grout, 2004). This demonstrates that results from studies conducted in both locations are not geographically specific to either region.

It is recommended that Massachusetts continues to work with this small business sector to create healthier work environments within our neighborhoods – as garment care shops are prevalent in so many communities. Though Massachusetts has designated PCE as a higher hazard substance under the Toxics Use Reduction Act, further policy shifts towards a phase out of the solvent would help urge the sector to more seriously consider the wet cleaning alternative.

A more comprehensive assistance program would compliment a PCE phase-out policy and should focus on and support the conversion of more shops to professional wet cleaning. Due to the electricity and gas savings noted in this study, further partnerships with utility companies would help create a program with additional depth. The establishment of a national professional wet cleaning assistance program would help provide support to cleaners across the country who currently work with PCE on a daily basis.

Table 7
Total wet cleaning cost/savings.

Item	Annual costs	Annual savings
Equipment		$500
Performance (Claims)		$1000
Operations	$1069	
Resource use		
Electricity		$1180
Natural gas		$1090
Water		$20
Sewer		$28
Total cost/savings in 12 months	$1069	$3818
Total savings	$2749/year	

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