9-30-2004

Comparison of Energy and Water Use of Five Garment Care Technologies: Evaluation the Potential for an Electricity Rebate Program for Professional Wet Cleaning

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UEPI Papers
Sep 2004
Report

EVALUATING ENERGY EFFICIENCY IN THE GARMENT CARE INDUSTRY:
A Comparison of Five Garment Care Technologies

Pollution Prevention Education and Research Center
Urban and Environmental Policy Institute
Occidental College
September, 2004

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UEPI

...for a more just, livable, and democratic region

Acknowledgements

This report required a wide range of input and technical review. A number of people provided significant support in terms of information, technical review, and comments. We would like to thank, among others:

Ed Becker, Southern California Gas Company; Eartha Brathwaite, Rosali Cleaners; Sylvia Chico, Urban and Environmental Policy Institute; Herman Cicekci, Hillcrest Cleaners; Occidental College; Sandy Cooper, Occidental College; Deborah Davis, Cleaner by Nature; Mark Gentili, Los Angeles Department of Water and Power; Robert Gottlieb, Urban and Environmental Policy Institute, Occidental College; Jorge Gutierrez, Southern California Gas Company; Hans Kim, Natures Best Cleaners; Barry Moschel, Del Rey Cleaners; Ray Mora, Southern California Gas Company; Angela Namkoong, Pollution Prevention Education and Research Center, Occidental College; Raj Patel, Ritz Dry Cleaners; Lana Penn, Rosali Cleaners; Ray Rangwala, Greater Los Angeles Dry Cleaning Association; Andre Saldivar, Southern California Gas Company; Steven Starks, Los Angeles Department of Water and Power; Paul Williams, Southern California Edison.

Support for this project was made available through: the Los Angeles Department of Water and Power, Innovative Technology Program; Southern California Edison; the Southern California Gas Company; and the South Coast Air Quality Management District.

Disclaimer

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Background

For more than fifty years, the vast majority of the 30,000 dry cleaners in the United States have relied on the toxic chemical perchloroethylene (PCE) as the solvent used to clean delicate garments. While design changes have been made to dry clean equipment to reduce environmental exposures, these changes have made dry cleaning a more energy intensive process.

As a consequence of ongoing health risks associated with PCE dry cleaning and the lack of regulatory compliance, the South Coast Air Quality Management District voted to phase out PCE dry cleaning in the greater Los Angeles region in December 2002. For the 400 PCE dry cleaners in the City of Los Angeles, over half will have to purchase new professional cleaning equipment by November 2007.

Since the 1990's, while regulation of PCE dry cleaning increased, a number of alternatives to PCE dry cleaning have emerged. Because each alternative uses a different solvent requiring a different machine configuration, any evaluation of resource use had to account for the whole range of these technologies. This study was designed to characterize the energy and water use of five professional garment cleaning technologies: perchloroethylene dry cleaning, professional wet cleaning, petroleum dry cleaning, silicone dry cleaning, and CO2 dry cleaning.

Methods

To compare the energy and water use of different professional cleaning technologies, it was necessary to develop a new test procedure that would isolate the energy and water use of the professional cleaning process at each test facility from any other water and energy uses (e.g. air conditioning or laundry). Essential elements of the test procedure include: identifying test facilities willing to process (wash, dry, and finish) a number of garment loads without operating any other equipment on two separate test days; metering energy and water use at test facilities at the time the test is being conducted; collecting data on the specific characteristics of each test load including volume and weight, garment type, fiber types, and care label. The test procedure was refined at two beta sites before field tests were conducted at the test facilities.

Resource use of PCE dry cleaning and professional wet cleaning was measured at a single plant (Del Rey Cleaners) that switched to professional wet cleaning. The three other technologies were measured at three different cleaning facilities.

Results

The case study of Del Rey Cleaners revealed that electricity use, natural gas use, and water use were all substantially lower when the cleaner processed garments in the professional wet cleaning system compared to when the cleaner processed garments using the PCE dry cleaning system. Specifically, electricity use was 60% lower (30.1 vs.

12.0 kWh/100 pounds cleaned), natural gas use was 19% lower (22.0 vs. 15.9 therms/100 lb.), and water use was 52% lower (181 vs. 87 gallons/100 lb.).

Electricity use in professional wet cleaning at Del Rey Cleaners (12.0 kWh/100 lb.) was also lower when compared to each of the other garment care technologies – petroleum (23.8 kWh/100 lb), liquid carbon dioxide (29.0 kWh/100 lb.), and silicone (34.7 kWh/100 lb.).

On the other hand, natural gas and water use was higher at Del Rey Cleaners, for both PCE dry cleaning and professional wet cleaning, compared to the three other test facilities. The higher natural gas use at Del Rey Cleaners for both technologies was attributed to a highly inefficient boiler and steam system. The higher water use rate in PCE dry cleaning at Del Rey Cleaners was attributed to a broken cooling tower float valve.

Discussion

The finding that electricity use was lower in professional wet cleaning compared to other dry cleaning technologies is consistent with data from the beta test sites as well as prior research on cleaners switching from PCE dry cleaning to professional wet cleaning. The fact that natural gas use was lower at Del Rey Cleaners after their switch to professional wet cleaning suggests that there may be natural gas savings in professional wet cleaning compared to other garment care technologies. The high water use for PCE dry cleaning, due to a broken cooling tower system, was discussed in light of the endemic problem that malfunctioning cooling towers pose to water conservation programs in general. The risk of water supply contamination posed by PCE and non-PCE solvent-based dry cleaning technologies was also discussed.

The report concludes with a series of recommendations. These include:

- *Additional testing*. Additional research is recommended to provide a more stable estimate of electricity savings for professional wet cleaning to confirm whether natural gas use is also lower in professional wet cleaning, and to resolve issues in regards to water use.

- *Research on the prevalence of "once through water use."* The prevalence of "once through water use" in cooling towers at dry cleaners is unknown. Since this current research study identified a cleaner using a "once through cooling" system, a prevalence study would help quantify the amount of water lost at dry cleaners from malfunctioning cooling towers. Such a study would help quantify the potential water savings if cleaners switched to technologies that do not require cooling towers, such as professional wet cleaning.

- *Develop a rebate program*. The report recommends developing a rebate program for professional wet cleaning, based on the electricity savings characterized in this report. Two options are proposed: a program that provides a fixed percent of the capital cost of equipment and a program based on the lifetime savings in electricity. Based on the data developed in this study, the estimated rebate ranged from $6,329 to $13,515. The rebate program could be adjusted based on future research.

- *Policy context of a rebate program*. The report ends with a discussion of the policy context of creating a rebate program. Given that a majority of cleaners in the City of Los Angeles will have to purchase new cleaning technology by November 2007, the report recommends that an initial rebate program be initiated as soon as possible.

- *Educational outreach*. To publicize a rebate program, the report recommends that existing professional wet cleaning sites located in the City of Los Angeles be used as venues for workshops targeted to cleaners who need to purchase new cleaning equipment.

1. Introduction

1.1 Regulatory Background

For more than fifty years, the vast majority of 30,000 dry cleaners in the United States have relied on perchloroethylene (PCE) as the solvent used to clean clothes as part of the dry cleaning process. In the City of Los Angeles alone, there are currently over 400 PCE-based dry cleaners in operation. In recent years, a wide array of scientific studies and federal, state, and local regulatory actions have focused on PCE's health and environmental risks.[1]

In the 1980s, the United States Environmental Protection Agency as well as state and regional agencies began establishing standards to regulate PCE as a water, land, and air contaminant.[2] Solid waste contaminated with PCE must be disposed of as hazardous waste. Discharge of water contaminated with PCE is highly regulated. Soil and groundwater contaminated with PCE are subject to federal Superfund designation and clean-up requirements. There are currently twelve states that have created their own superfund program to clean up groundwater and soil contamination for dry cleaning; these programs require dry cleaners to pay annual fees, a solvent tax, and/or a percent of gross receipts. Of these state programs, all impose fees on PCE use and ten impose fees on other non-PCE solvent use.[3]

Regulatory oversight of PCE as an air contaminant increased substantially with the passage and subsequent implementation of the 1990 Clean Air Act Amendments. In 1993, in response to requirements in the 1990 Clean Air Act, the EPA implemented regulations to reduce emissions of PCE from dry cleaners. The regulations specified equipment and record keeping requirements designed to reduce emissions and encourage good operating practices among PCE dry cleaners. These regulations have been difficult to comply with and difficult to enforce in an industry dominated by thousands of small shops with a high percentage of ownership by recent immigrants.[4] Increasingly elaborate pollution control equipment has been added to dry clean machines to reduce these risks

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[1] PCE has been classified as a probable carcinogen by the International Association for Research on Cancer, was listed as a hazardous air pollutant in the 1990 Clean Air Act, and is classified as a toxic air contaminant by the California Air Resources Board.SCAQMD, "Staff Report to Propose Adoption of Rule 1421: Control of Perchloroethylene Emissions from Dry Cleaning Systems and Repeal Rule 1102.1: Perchloroethylene Dry Cleaning Systems" (Diamond Bar, CA, December 1994): 1-4. International Agency for Research on Cancer. Tetrachloroethylene. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 63, Dry Cleaning, Some Chlorinated Solvents and other Industrial Chemicals.

[2] *Cleaner Technologies Substitutes Assessment for Professional Fabricare Processes*, EPA 744-B-98-001; United States Environmental Protection Agency, Design for the Environment, 1998.

[3] (www.drycleancoalition.org/survey.pdf). Updated May 28, 2004

[4] For example, recent enforcement activity at the SCAQMD has revealed that 70% of dry cleaners inspected were not in compliance with Rule 1421. Edwin Pupka, SCAQMD, Senior Manager, Engineering & Compliance Administration, January 14, 2000. This figure was based on 1160 inspections of dry cleaners between March, 1999 through January 1, 2000.

and to comply with regulations, but reducing emissions to ever-smaller amounts has proven to an energy intensive activity.[5]

As a consequence of compliance problems and the availability of a number of non-PCE alternatives, the South Coast Air Quality Management District (SCAQMD) ruled in December 2002 to phase out PCE dry cleaning in the greater Los Angeles region by December 31, 2020.[6] The phase-out rule (Rule 1421) states that cleaners will not permitted to operate a PCE dry clean machine after December 2020. In addition, cleaners in the region will not be permitted to operate older primary-control only PCE dry clean machines after November 2007. Over two-thirds of cleaners in the region were estimated to have primary-control only machines at the time of the ruling. For the City of Los Angeles, this means that approximately 270 of the 400 PCE dry cleaners will need to purchase new cleaning technology by November 2007. Which technology purchased by cleaners will likely have a resource use impact.

On the heals of the SCAQMD phase out, new California state legislation (AB998) was enacted in October 2003 which imposes a fee on the purchase of PCE used in dry cleaning to create a trust fund for cleaners switching from PCE dry cleaning to non-toxic and non-VOC garment care technologies.[7] Professional wet cleaning and liquid CO2 dry cleaning have received preliminary approval for this program (See Section 1.3 below for more detail on alternative technologies).

1.2 Background of PCE Dry Cleaning Equipment

The dry cleaning industry dealt with the tightening regulation of PCE emissions by installing increasingly complex pollution control devices for recapturing PCE vapors and liquid PCE solvent. The use of modernized equipment has been successful in reducing PCE consumption and emissions. The PCE demand of the U.S. dry cleaning industry was 150 million pounds in 1993 compared to 47 million pounds in 2002.[8]

While improved pollution control devices have successfully lowered PCE emissions and consumption, their operation appears to be energy intensive. These devices require the consumption of additional electricity, natural gas, and water to operate effectively. The development of these devices and their implications on resource use is discussed below.

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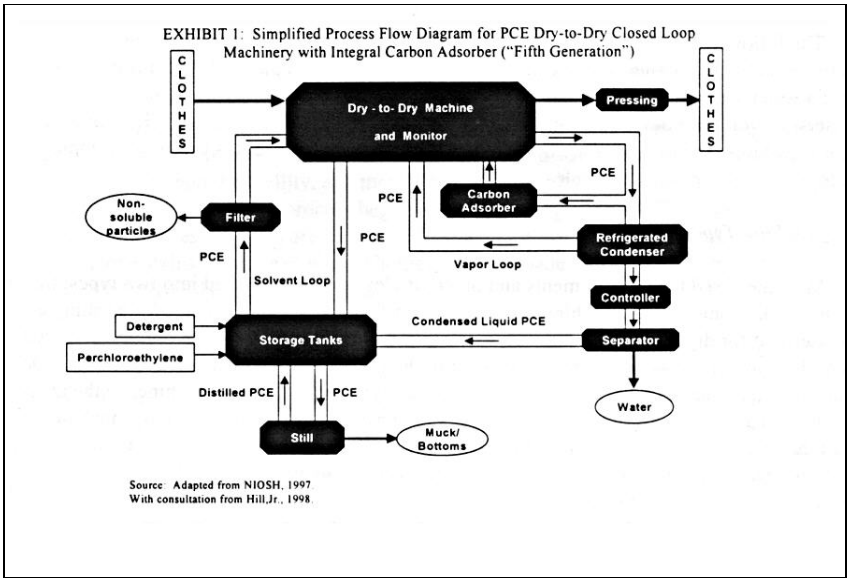
[5] USEPA. Cleaner Technology Substitutes Assessment, EPA 744-B-98-001, June 1998, p.7-19.
[6] www.aqmd.gov/rules/reg/reg14/r1421.pdf
[7] www.arb.ca.gov/toxics/dryclean/ab998factsheet.pdf
[8] Western Cleaner and Launderer. *TCATA Reports 2002 Perc Drycleaning Demand*. August 2003, p. 1-2.

Figure 1.1: Process Flow Diagram for PCE Dry Clean Machine ("Fifth Generation")[9]



1.3 Development of PCE Vapor Recovery Equipment[10]

The development of PCE vapor recovery equipment has led to the classification of dry clean machines in terms of "generation." "First Generation" equipment has the most primitive pollution controls and the "Fifth Generation" equipment has the most extensive controls. Two thirds of PCE dry cleaners in the region are currently operating "Third Generation" equipment (First and Second Generation equipment is more or less obsolete), but as per SCAQMD Rule 1421, all PCE dry clean machines must have at least "Fourth Generation" pollution control equipment by November 2007.

First Generation: All transfer machines are designated as "First Generation." These machines have separate cylinders for washing/extracting and for drying. After the extraction cycle, garments damp with PCE solvent are removed from the washer/extractor and transferred into the dryer. PCE vapors from the washer/extractor cylinder and from the damp garments escape into the shop air during the transfer of garments.

Second Generation: Second generation machines eliminated the emissions created during the transfer of garments by washing, extracting and drying in the same cylinder. These machines are referred to as "dry-to-dry" machines, because garments go in and come out dry. During the dry cycle, heated air is passed through the cylinder to vaporize the PCE on the garments. Second generation machines run the heated air through a conventional condenser, cooled by water from a cooling tower or water chiller, to recover some of the PCE vapors. The air is reheated and re-circulated through the cylinder and condenser until most of the PCE vapors are removed (25,000 to 75,000 ppm.). Machines using a conventional condenser also have an aeration cycle following the drying cycle, in which fresh air is forced through the cylinder to remove the residual odor of PCE from

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[9] USEPA. Cleaner Technology Substitutes Assessment, EPA 744-B-98-001, June 1998, p. 2-4.
[10] USEPA. Cleaner Technology Substitutes Assessment, EPA 744-B-98-001, June 1998, p. 2-2.

the clean garments. The air being flushed out is either vented directly into the atmosphere or is passed through another vapor recovery device.

Third Generation: Third generation machines, also referred to as "primary control, closed-loop" systems, operate in essentially the same way as a second generation machine, but use a refrigerated condenser (RC) instead of a conventional condenser.[11] A RC is capable of removing higher proportions of PCE vapor from the air (2,000 to 8,600 ppm) during the dry cycle because it generates lower temperatures, increasing the effectiveness of the condenser. Machines with a RC also use a cool down cycle to remove additional PCE vapor from the air. At the end of the dry cycle, the air is no longer heated, but continues to circulate between the cylinder and the RC. Because the RC removes more PCE vapor from the air than a conventional condenser, the aeration cycle is eliminated, and no air is vented to the outside atmosphere, making it a "closed loop" system. PCE vapor nevertheless remains in the cylinder, and some RC machines use a door fan to suck air into the cylinder when the door is opened, lowering the PCE exposure to the operator.

Fourth Generation: Fourth generation machines add a carbon adsorber (CA) to the RC as a secondary control. At the end of the dry cycle cool down period, the air in the cylinder is passed through the CA where PCE is adsorbed by the carbon, and the cleansed air is returned to the cylinder. Some machines use a sensor in the cylinder to monitor PCE concentrations during the adsorption process, and will continue the adsorption process until the desired concentration level is reached (e.g., 300 ppm). Once the CA reaches its capacity, it needs to be desorbed, which is accomplished by passing steam through the CA. The PCE vapors are then vented to a condenser to recover the desorbed PCE.

Fifth Generation: Fifth generation machines have the same primary and secondary controls as fourth generation machines, but also incorporate a door lock that will not allow the cylinder door to be opened until the PCE monitor reports that the PCE concentration in the cylinder has reached the desired level. This guarantees that the door will not be opened before the carbon adsorption cycle has been completed.

1.4 Development of Liquid PCE Recovery Equipment[12]

Dry cleaners use filtration and distillation to clean used PCE solvent, allowing it to be reused. The cleaner benefits from more advanced recovery equipment by having to purchase less replacement PCE and by producing less hazardous waste.

Cartridge Filters: Cartridge filters are the most commonly used filters in the U.S. Used PCE is pumped through the filter, which contains layers of paper, carbon, and a fine mesh. When the filter becomes full, it is drained and discarded as hazardous waste. Cartridge filters are simple to operate, but do not recover as high a percentage of PCE as other filter types and consequently have higher hazardous waste disposal and filter replacement costs.

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[11] The operation of a cooling tower is still needed in order to dissipate the heat absorbed by the refrigerator during the condensation process.
[12] USEPA. Cleaner Technology Substitutes Assessment, EPA 744-B-98-001, June 1998, p.2-5.

Spin Disk Filters: These filters operate in a similar manner to cartridge filters, and sometimes use a powder such as clay to assist in the filtration process. Spin disk filters remove a higher percentage of insoluble particles from solvent, and need to be replaced less often than cartridge filters. A disadvantage is that their daily operation and maintenance is more complex.

Distillation: Distillation is used to remove PCE-soluble impurities from the solvent. Impure solvent is pumped to a still where it is heated by steam coils and vaporized. The PCE vapors are passed through a condenser, while the impurities are left behind in the still bottom. The vapors are condensed back into a liquid state, and then passed through a water separator, which separates water from the solvent. The water separator uses the differing densities of PCE and water to separate, and the wastewater, which is lighter than PCE is drained off the top of the mixture.

Wastewater Evaporator: The wastewater drained off from water separator is still contaminated by PCE and must be disposed of as hazardous waste or evaporated. Given the high costs of hazardous waste disposal, most cleaners opt to evaporate their wastewater. Evaporators may use natural gas, steam, or electrical heat sources to evaporate the wastewater. Some cleaners simply place their wastewater in their boiler room for evaporation.

1.5 Alternative Cleaning Technologies

A number of alternatives to PCE dry cleaning have emerged since 1990 in response to increasingly stringent regulations. These technologies present the opportunity to reduce environmental risks while maintaining performance standards and financial viability.

Professional Wet Cleaning: Professional wet cleaning is the most commercially available non-toxic alternative to dry cleaning. It is a water-based process that uses computer-controlled washers and dryers, specially designed biodegradable detergents to clean sensitive and delicate garments, and specialized tensioning finishing equipment to restore shape and form. Both equipment and operating costs are lower in wet cleaning compared to PCE dry cleaning, and cleaners who have switched to professional wet cleaning have been able to process the full range garments they had previously dry cleaned. [13]

Petroleum Dry Cleaning: Petroleum solvent (also referred to as 'hydrocarbon') is the most widely used alternative to PCE. Equipment costs are slightly higher than PCE dry cleaning machines. Although petroleum solvents are not currently classified as hazardous air pollutants, they do emit smog-producing volatile organic compounds (VOC') and generate hazardous waste. Government regulations require that petroleum dry clean machines be equipped with solvent-recovering pollution control devices similar to those found on PCE equipment. Petroleum solvents also face regulations regarding its flammability. They are classified as Class III-A solvents, meaning it has a flash point between 140 and 170 degrees Fahrenheit. Fire codes often require the construction of

[13] Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.

firewalls between the machine and the rest of the facility, and many landlords are reluctant to allow the operation of petroleum dry clean machines on their property.

Silicone Dry Cleaning: Silicone solvent has become increasingly popular over the past few years, and has been aggressively marketed as a non-toxic alternative to PCE by GreenEarth Cleaning, L.L.C. Equipment costs are slightly higher than PCE dry cleaning machines. The Green Earth solvent, also known as D-5 or decamethylepentacyclosiloxane, is similar to the silicone substance formerly used in breast implants (D-6). Silicone dry clean machines are equipped with solvent recovery devices similar to those found on PCE equipment, and some machines are designed to handle both petroleum and silicone solvents. Although D-5 has been marketed as non-toxic, toxicity testing has not been completed, and a recent inhalation study of rats by Dow Corning has raised questions about its safety. [14] Like petroleum solvents, D-5 is a Class III-A solvent and has a flash point of 170 degrees Fahrenheit. Although it is less flammable than petroleum solvents, it is subject to the same fire codes and regulations.

CO2 Dry Cleaning: Liquid CO2 solvent used in dry cleaning is pressurized carbon dioxide gas, and is non-toxic and non-flammable. Equipment cost of a CO2 dry cleaning system is substantially higher than a PCE dry clean machine.

1.6 Resource Demands of Cleaning Equipment

1.6.1 Solvent-Based Dry Clean Equipment: PCE, Petroleum, and Silicone

Electricity: A dry clean machine uses electricity for mechanical action, the operation of fans and pumps, refrigeration, air compression, and operation of the computer. The figures in Table 1 are based on the specifications of a "Third Generation" 40 lb PCE dry clean machine. The table does not include the power demands of the cooling tower, which is in operation during the entire time the dry clean machine is switched on.

Natural Gas: Dry clean machines are never directly heated by natural gas because of safety hazards associated with the exposure of solvent to open flames. Dry clean machines instead use steam from a boiler as a source of heat. [15] Steam heat is used during the dry cycle, distillation, and to clean carbon filters.

Water: Dry clean machines rely on cooling towers to transfer heat away from the machine via evaporation of water. Water cycling through cooling towers and boilers is usually recycled, but should be periodically bled and replaced to prevent scaling.

1.6.2 Professional Wet Clean Equipment

Wet cleaning, a process of hand-laundering delicate garments, has long been practiced by cleaners. [16] *Professional* wet cleaning industrializes this practice by using computer-controlled washers and dryers, specially formulated detergents, and specialized

[14] Dow Corning. OPPT Public Docket #42071-A, February 4, 2003
[15] Models that use an electrical heat source are also available, but are less common.
[16] Encyclopedia Americana, 1970; Vol. 9.

finishing equipment to create a cost-effective alternative to dry cleaning. A number of features enhance the efficiency of professional wet clean systems:

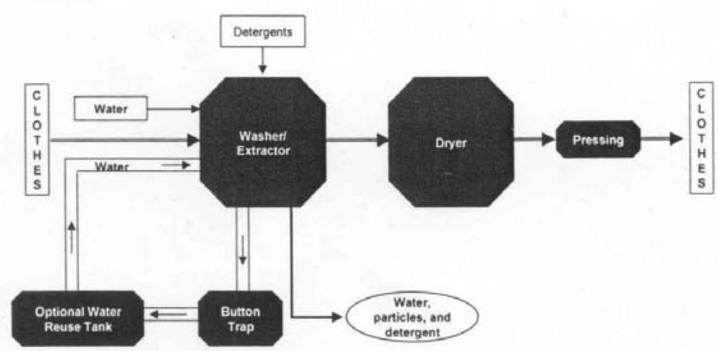
- A horizontally mounted cleaning drum enables the use of low water levels.
- Minimal agitation is used during the wash cycle.
- High-speed extraction removes moisture from garments and shortens dry times.
- Precision garment-sensitive moisture sensors in the dryer prevent over-drying.
- Tensioning finishing equipment maximizes the use of steam and lowers pressing times.

Electricity: Professional wet clean 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.

Natural Gas: Some wet clean washers use natural gas directly or in the form of steam to heat water used in the wash cycle. Wet clean dryers use natural gas as a direct source of heat or in the form of steam heat from the boiler. Tensioning equipment uses steam from the boiler.

Water: Professional wet cleaning uses water as a solvent. Recycling systems that reuse rinse water in wash cycles are available, but are not widely used.

Figure 1.2: Process Flow Diagram for Professional Wet Clean System[17]



Sources: Adapted from USEPA, 1997 for the U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics Training Curriculum for Alternative Clothes Cleaning. With consultation from Star, 1998.

1.6.3 Liquid CO2

Electricity: Electricity is used by the CO2 system for mechanical action and to operate pumps, the computer, sensors, a chiller system, and a gas compressor.

Natural Gas: Natural gas is indirectly used by the CO2 system in its consumption of steam from the boiler. Steam heat is used by the CO2 system to dry garments and to distill solvent.

Water: The only water used by the Liquid CO2 system is that used by the boiler to produce steam. Steam heat is used by the CO2 system to dry garments and to distill solvent.

[17] USEPA. Cleaner Technology Substitutes Assessment, EPA 744-B-98-001, June 1998, p.2-5.

1.7 Previous Research

The only studies to compare resource use of different garment care technologies have been conducted by our Center.

In a 1997 evaluation of the first professional wet cleaner established in California, the actual electricity, natural gas, and water used at this cleaner was quantified and compared to an estimate of resource use based on machine specifications on advanced PCE dry clean equipment.[18] This study estimated that electricity use was 24% lower in professional wet cleaning, natural gas was 23% higher, and water use was 77% higher.

In October 2002, our Center completed an evaluation of a number of cleaners who switched from PCE dry cleaning to professional wet cleaning as part of a demonstration program.[19] This study looked at the billing records three cleaners who switched out their PCE dry cleaning machine immediately prior to installing professional wet cleaning equipment.

In March 2004, our Center completed an evaluation of four professional wet cleaning facilities that had switched from PCE dry cleaning.[20] This study included the three cleaners profiled in the October 2002 report along with one additional demonstration site cleaner. Data was compiled from monthly billing records as well as electrical and natural gas sub metering at three of the facilities. Results showed a systematic reduction in electricity use, natural gas reductions in all but one case, and water use increase in one case and reduction in another. In regards to the methods used, data from sub metering confirmed the observation from monthly billing records, and provided more precise quantification of resource use. In addition, problems with sub metering data collection procedures were noted. During the sub meter data collection period, data was collected on all garments processed at the cleaner; that is, both the professional cleaning operation and the laundry service. First, because both the professional wet clean operation and the laundry services use the same pressing finishing equipment, and because cleaners finish professionally cleaned garments and laundered garments simultaneously, it was difficult to separate out resource use associated with the professional cleaning equipment apart from the resource use associated with laundry service. A second problem had to do with the accuracy of the data collected by the cleaners during the sub metering data collection period; cleaners were asked to write down the weight, time, and program used for every load processed. In some cases the data appeared reliable while in other cases the cleaners did not always remember to write down load weight, load time, or program used.

[18] *Pollution Prevention in the Garment Care Industry: Assessing the Viability of Professional Wet Cleaning*, Pollution Prevention Education and Research Center, 1997.
[19] Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.
[20] Resource Use in Professional Wet Cleaning vs. Perchloroethylene Dry Cleaning, Occidental College, Pollution Prevention Education and Research Center, March 31, 2004.

2. Methods

2.1 Background

The current LADWP study was designed to evaluate the energy and water use of one cleaner switching from PCE dry cleaning to professional wet cleaning and to compared these results with three other cleaners using different garment care technologies: petroleum dry cleaning, silicone dry cleaning, and CO2 dry cleaning.[21]

The original test procedure for the LADWP study was to sub meter energy and water use at selected cleaners over a two-week period, have facility operators collect data on the volume of garments cleaned, standardize resource use for each technology based on 100 garments cleaned, and compared each technology based on this standard.

A recent study completed by our Center comparing resource use for cleaners converting from PCE dry cleaning to professional wet cleaning revealed problems with this data collection procedure. (See Section 1.5) The first problem was the ability to effectively separate out resources used in processing laundry items (e.g. dress shirts, khaki pants, etc.) from resources used in the professional cleaning system used for sensitive textiles (e.g. wool, silk, etc). The second problem was associated with lack of accurate record keeping by operators in characterizing each load of garments cleaned during a test period.

A new data collection protocol needed to be developed to overcome these problems.

2.2 Development of Data Collection Protocol

A new data collection protocol, designed to compare different professional cleaning technologies, was developed in conjunction with engineers from the Los Angeles Department of Water and Power, Southern California Edison, and Southern California Gas Company, and a member of Occidental College's Professional Wet Cleaning Commercialization Project Advisory Board who owns both professional wet cleaning facilities and dry cleaning facilities.[22]

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[21] While the original protocol stated that only electricity and water use be evaluated, it is imperative that a reduction in one energy source (e.g. electricity) not come at the expensive of increasing another energy source (e.g. natural gas). This being said, natural gas use was included as an outcome variable.

[22] Mark Gentili, LADWP; Paul Williams, SCE; Andre Saldivar, SCG; Jorge Gutierrez SCG; Ed Becker, SCG; Hans Kim, Professional Wet Cleaning Commercialization Project Advisory Board Member.

The goals for an effective protocol include the following:

- Compare different professional cleaning technologies operated at different cleaning facilities in terms of a standardized measure of electricity, natural gas, and water use.
- Isolate the processing of professionally cleaned garments from start to finish (washing through pressing) from other resource consuming operations (e.g. the laundry service).
- Reflect real-world operating practices of the cleaner (e.g. size of test loads reflecting what the cleaner typically processes).
- Compare comparably sized cleaning systems.
- Minimize the inconvenience to cleaners and minimize interference with daily operations.

2.3 New Data Collection Protocol

A new data collection protocol was developed that best captures the resource use generated by different garment care technologies and that allows for direct comparison between test facilities. The overall features of the protocol are as follows:

- Choose test facilities that agree to process (wash, dry, and finish) between two and four loads of garments in their professional cleaning system before operating any other cleaning process (e.g. laundry machines).
- Test facility agrees to conduct test on two specified test days.
- Data on load characteristics to be collected by Occidental College staff prior to process. Load characteristics include load weight, number of pieces, garment type (e.g. jacket, pants, etc.), care label, fiber type, and cleaning program used.
- When appropriate, test facility agree to have facility sub metered for water, electricity, and natural gas.

2.4 Beta Testing of New Data Collection Protocol

An agreement was developed to carry out beta testing at two facilities in Rancho Cucamonga owned by Hans Kim; a dedicated professional wet cleaning facility and petroleum dry cleaner. The beta testing was designed to develop specific test procedures that could be used as any professional cleaning facility. Southern California Edison agreed to sub meter the two facilities for electricity and Southern California Gas Company agreed to sub meter the two facilities for natural gas use and water use. Beta testing at the professional wet clean facility was held 4/16/04, 4/28/04, and 5/17/04. Beta testing at the petroleum cleaner was held 4/23/04, 4/30/04, and 5/14/04.

2.5 Specific Test Procedures

Based on the results from the beta-tests, the following specific test procedures were developed and implemented at each test facility to create a standard method of data collection.

Instrumentation Set Up

1. Water meters with pulsers and data loggers will be installed on the boiler and cooling tower and dry clean facilities and the boiler and washer at professional wet cleaning facilities.
2. Where necessary, electricity sub meters and data loggers will be installed to monitor energy consumption of the dry clean machine, cooling tower fan and pump, vacuum pump, air compressor, pressing equipment, and boiler.
3. If the facility does not have an accurate scale, a scale will be provided during the test period to weigh garments.

Day of the Test

Pre-Test

4. Take all the initial readings of gas, electric, and water meters, check and monitor equipment.
5. Shut off steam supply valves to equipment that will not be in use during the test.
6. Turn on the boiler and allow it to reach full pressure (e.g. 85 psi)
7. During testing, the cleaner will not operate any equipment that is not associated with the processing of the test garments that would use air compressor, vacuum pump, natural gas, the boiler, or cooling towers.

Washing and drying of garments

8. Two to four loads of garments to be processed in the cleaning machine(s), including at least one light and one dark load. Specialty loads such as comforters, rugs, or leather will not be included.
9. Before each load is processed, record the garment type, fiber type, and care label instructions on each garment.
10. Record the cleaning program used for each load, including each process step and step time.
11. Record the following information at the start and finish of each load: time, weight, water meter readings (boiler and cooling tower), natural gas sub meter reading, and boiler pressure.

Finishing of garments

12. Finishing of garments will start once the 1st load has been washed and dried. Pressing will be continuous throughout the test until the last garment of the final load has been pressed. Non-test loads may not be started until the all test garments have been pressed.
13. Any garment considered not clean enough to return to the customer by the facility's staff will be considered not successfully processed and will be considered a redo.

Weigh redo garments and subtract their weight from the standard amount of garments cleaned.
14. Testing will conclude once all loads have been cleaned, dried, and pressed. At this point, record final readings of gas and water meters, and download data from data loggers.

Final Distillation (For machines with distillation only)

Run a final distillation cycle when no other activities that would use natural gas, steam, or the cooling towers. Estimate the average number of loads processed per day in order to amortize the resource consumption associated with distillation over the number of loads processing during the testing period.

3. Results

Data for this study was collected at four facilities in Los Angeles, CA. The professional cleaning systems tested, and the facilities that participated in this study, are as follows:

- Perchloroethylene dry cleaning: Del Rey Cleaners (July 30, 2004).
- Professional wet cleaning: Del Rey Cleaners (August 2, 2004).
- Petroleum dry cleaning: Hillcrest Cleaners.
- Liquid CO2 dry cleaning: Rosali Cleaners.
- Silicone dry cleaning: Cleaner by Nature.

The Following sections describe the background of each facility and cleaning system tested, a description of data collection procedures carried out at each site, site specific results, and a comparative analysis of electricity, natural gas, and water use.

3.1 Del Rey Cleaners – Perchloroethylene Dry Cleaning[23]

Del Rey Cleaners is a central plant facility located in Playa Del Rey, a coastal community three miles north of the Los Angeles Airport. The owner, Barry Moschel, has been in the dry cleaning business for over thirty years, and had been using his 55 Lb Renzacci PCE dry clean machine for the past 15 years. In January 2004, he applied to Occidental College's Professional Wet Cleaning Grant Program in a decision to switch to a non-toxic cleaning technology. This transition provided the opportunity to compare the resource use of PCE dry cleaning with professional wet cleaning at one facility making a switch. The resource use associated with processing garments in the PCE dry clean machine was evaluated in May and June 2004.

3.1.1 PCE Dry Clean Equipment

The table below describes the specific equipment used at Del Rey Cleaners to process garments using the PCE dry cleaning system.

Table 3.1: Equipment Specifications at Del Rey Cleaners for Perchloroethylene Dry Cleaning

Equipment	Model	Capacity	Year	Power	Comments
Dry Clean Machine	Renzacci, Serena Sun	55 Lbs	1989	14.5 HP	Machine is visibly corroded in places, generally appear to be in poor condition
Boiler	Parker	N.A.	1992	25 HP	Boiler has extensive rusting in places. Boiler room is large and well ventilated. Steam distribution system is not insulated and has numerous leaks.
Air Compressor	Kellog American	200 Max PSI	1964	N.A.	There was no specification plate on the compressor. The year 1964 was printed on the main tank – the motor could be newer.
Cooling Tower	Liang Chi Industry LBC 15	58.5 K cooling capacity	N.A.	¼ HP Fan Motor	The cooling tower float was unattached, so the water make-up was constantly running. There was a steady flow of water draining out of the cooling tower.
Cooling Tower Pump	STA-RITE	N.A.	N.A.	1 HP, 0.75 kW	None
Vacuum Pump	No visible nameplate	N.A.	N.A.	N.A.	The vacuum pump motor was rebuilt in April 2004 after it had burnt out.
Pressing Equipment	The facility had three pressboards and 1 Susie. These pieces were not primary consumers of energy, but were fed from the boiler, air compressor, and vacuum pump. Several pieces had steam leaks and extensive dripping from water condensate.				

[23] See Appendix A for a more detailed presentation of the data collected on PCE dry cleaning.

3.1.2 Test Preparation

The data collection protocol allows for either of two methods to be used to quantify resource use at test facilities: sub-metering and/or observational readings of billing meters. The initial plan was to install electricity sub meters at Del Rey Cleaners, but the condition of the electric sub panel was such that it was deemed unsafe to do so.[24] This left the option of measuring electricity consumption based upon reading from the billing meters. Two kWh readings were taken while no equipment was in use to estimate the background electricity use of the shop (e.g. lights, ventilation, etc.). Del Rey has two electricity billing meters. When no equipment was in operation, the eastern meter recorded no consumption (disc was not rotating), while the western meter recorded approximately 2.2 kWh per hour. Therefore, consumption recorded by the eastern meter could be entirely attributed to the dry cleaning process, while consumption recorded by the western meter was adjusted to take into account background (i.e. non-process associated) electricity use.[25]

To quantify the total water use consumed in the dry clean process, water sub meters were installed on the boiler water make-up line and the cooling tower make-up line.[26] The water meters were attached to data loggers, which record a “pulse” for every gallon of water consumed. Direct readings of the meters were also taken during the test to verify the loggers’ accuracy.

Natural gas was measured by reading the facility meter. The only equipment using natural gas during testing of the dry clean system was the boiler.

Because the test protocol requires that no other garments be processed during the test period, testing was initially scheduled for Saturdays. During the week, Del Rey Cleaners washes and processes a high volume of shirt laundry; two full time employees work exclusively on processing laundry items. On Saturday, no laundry is processed, enabling the isolation of the professionally cleaned test garments.

3.1.3 Field Testing

PCE Test 1 – 5/15/04

The first field test at Del Rey Cleaners was completed on Saturday, May 15, 2004. Aside from the front counter and the processing of test garments, the facility was inactive. One staff member was present to operate the dry clean machine and press the garments. Two loads, one dark and one light, were processed and pressed over 3 hours and 10 minutes. A total of 77 garments, weighing 72 pounds, were processed.

The first load was 15 minutes shorter than the second load. (Table 3.2) This was most likely due to the lighter load, allowing for a shorter dry time.

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[24] LADWP technicians reported that circuit breakers in the panel were hanging loose, and that there was sparking within the panel. The electrical wiring at Del Rey Cleaners has since been upgraded.

[25] (2.2 kWh) X (length of test period) was subtracted from the total reading taken on the western meter on each test day.

[26] The water meters were installed on April 14, 2002. All water meter installations were contracted out by the LADWP to Orlie Galera, a licensed plumber. Mr. Galera was recommended by Mark Gentili, a water conservation specialist with the Water Resources Division of the LADWP.

Table 3.2: PCE Test 1 Process Times and Garment Volume

	Minutes[27]	Garments	Pounds
Load 1	43	40	33
Load 2	58	37	39
Total Test	190	77	72

Over half of the garments processed carried a dry clean or hand wash care label. In addition, there was a high percentage (12%) of garments with no care label; to be careful, cleaners often treat garments without a care instruction as delicate.

Table 3.3: PCE Test 1 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	43%	Blouse/Shirt	24%
MW/DC[28]	5%	Pants	38%
Hand Wash	5%	Dress/Skirt	13%
No Label	12%	Sweater	6%
Machine Wash	35%	Jacket	18%

PCE Test 2 – 6/25/04

The second field test at Del Rey Cleaners was completed on Friday, June 25, 2004. One staff member operated the dry clean machine, and the operator and an additional presser completed the pressing. Testing was possible on this Friday because the shop's shirt pressing machine had broken down, and all shirt laundry was being outsourced to another location. Three loads, two dark and one light, were processed and pressed over 3 hours and 47 minutes. (Table 3.4) A total of 105 garments weighing 106 lbs were processed.

Table 3.4: PCE Test 2 Process Times and Garment Volume

	Minutes[29]	Garments	Pounds
Load 1	54	35	30
Load 2	59	41	40
Load 3	44	39	36
Total Test	227	115	106

[27] Total test minutes is taken from the time the first load was loaded to the last garment pressed.
[28] MW/DC represents "Machine wash or Dry clean" care instructions.
[29] Total test minutes is taken from the time the first load is loaded to the time when the final garment is pressed.

Approximately two-thirds of the garments processed carried a dry clean care label, while almost three-quarters could be classified as delicate.

Table 3.5: PCE Test 2 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	45%	Blouse/Shirt	31%
MW/DC	17%	Pants	41%
Hand Wash	7%	Dress/Skirt	6%
No Label	4%	Sweater	12%
Machine Wash	28%	Jacket	9%
		Other	1%

3.1.4 PCE Field Test Results

Test results show that processing garments in the PCE dry clean system at Del Rey Cleaners used an average of 30.1 kWh/100 pounds of garment processed, 22.9 therms of natural gas /100 lbs., and 181 gallons of water/100 lbs. (Table 3.6) In terms of electricity and natural gas consumption, the second test day was more efficient. The presence of a second presser on the second test day may have contributed to this increased efficiency by reducing the amount of time that equipment was running.[30] The operation of the cooling tower may have also contributed to the reduction of electricity use on the second day. On the first day of test, the cooling tower was left running while the second load of garments was being pressed. On the second day, the cooling tower was shut off while the second load of garments was being pressed.

Table 3.6: PCE Test Results

	KWh per 100 Lbs	Therms per 100 Lbs	Gallons per 100 Lbs	
Date	**All Equipment**	**Boiler**	**Boiler**	**Tower**
5/15/04	33.3	24.4	14	162
6/2504	27.1	19.5	25	160
Average	**30.1**	**22.0**	**20**	**161**

[30] The process time during the first test averaged 2.6 minutes per pound of garments compared to 2.1 minutes per pound during the second test.

3.2 Del Rey Cleaners – Professional Wet Cleaning[31]

Del Rey Cleaners removed their PCE dry clean system July 30, 2004 and replaced it with a professional wet clean system. The professional wet clean system was fully installed by August 2, 2004. Professional wet cleaning at Del Rey Cleaners was evaluated in August 2004.

3.2.1 Professional Wet Clean Equipment

Del Rey Cleaners installed a 40-pound professional wet clean washer and 75-pound professional wet clean dryer.[32] The cooling tower system and two older presses, one for jackets/tops and one for pants, were removed. Two new pieces of finishing equipment were added: a tensioning pants topper and a tensioning form finisher for jackets and tops. A natural gas water heater was also installed to provide hot water to the washer. The switch to professional wet cleaning did not affect the rest of the equipment in the facility. The table below describes the specific equipment used at Del Rey Cleaners in processing garments using the professional wet cleaning system.

Table 3.7: Equipment Specifications at Del Rey Cleaners for Professional Wet Cleaning

Equipment	Model	Capacity	Year	Power	Comments
Wet Clean Washer	Wascomat EXSM230	65 lbs laundry; 40 lbs wet cleaning	2004	1 kW motor	A Beta pump system automatically pumps detergent to the washer. A hot water heater provides hot water to the washer.
Wet Clean Dryer	Wascomat TD75	75 lbs	2004	2 kW motor	The dryer is directly heated by natural gas. Electricity is used for mechanical action and to run the computer.
Boiler	Parker	N.A.	1992	25 HP	Boiler has extensive rusting in places. Boiler room is large and well ventilated. Steam distribution system is not insulated and has numerous leaks.
Air Compressor	Kellog American	200 Max PSI	1964	N.A.	There was no specification plate on the compressor. The year 1964 was printed on the main tank – the motor could be newer.
Vacuum Pump	No visible nameplate	N.A.	N.A.	N.A.	The vacuum pump motor was rebuilt in April 2004 following a burnt out.
Pressing Equipment	The facility had three pressboards and 1 tensioning form finisher, and 1 tensioning pants topper. The tensioning equipment uses electricity to operate blowers, compressed air from the compressor, and steam from the boiler.				

[31] See Appendix B for a more detailed presentation of the data collected on professional wet cleaning.

[32] The washer capacity for laundry cycles is 65 lb.

3.2.2 Test Preparation

Electricity consumption was measured by reading the electricity billing meters (see section 3.1.1 above). The water meter and data logger were left on the boiler make-up line. A new water meter and data logger was installed on the water line feeding the wet clean washer and the water heater, which feeds hot water to the washer.[33] Natural gas use was measured by reading the outside billing meter.

Testing was scheduled for Saturday, when it would be manageable to shut down all equipment not related to the processing of garments in the professional wet clean system; on weekdays, the facility processes a large amount of shirt laundry.

3.2.3 Field Testing

<u>Wet Cleaning Test 1 – 8/7/04</u>

The first professional wet clean test at Del Rey Cleaners was completed on Saturday, August 7th. One staff member was present to operate the wet clean system and press the test garments. Aside from the front counter, the facility was otherwise inactive. Three loads, two dark and one light, were processed over 3 hours and 2 minutes. (Table 3.8) The first and second loads were comprised mostly of khakis, while the third load was comprised mostly of wool suits. A total of 54 garments weighing 75 pounds were processed.

Table 3.8: Wet Cleaning Test 1 Process Times and Garment Volume

	Program	Minutes[34]	Garments	Pounds
Load 1	½ Cotton	48	13	15
Load 2	½ Cotton	63	16	20
Load 3	Full Wool	71	25	40
Total Test		182	54	75

Approximately half of the garments processed carried a delicate garment care label, which is consistent with other tests at this facility. Over 90% of the garments processed were either pants or jackets.

Table 3.9: Wet Cleaning Test 1 Garment Distribution

Garment Type		Care Label	
Dry Clean/Dry Clean Only	45%	Blouse/Shirt	4%
Machine Wash	52%	Dress/Skirt	0%
No Label	4%	Jacket	31%
		Pants	61%
		Sweater	4%

[33] The water meter installed on the wet clean washer line was installed August 6, 2004.
[34] Total test minutes is taken from the time the first load starts to the time when the final garment is pressed.

Wet Cleaning Test 2 – 8/29/04

The second professional wet clean test at Del Rey Cleaners was completed on Saturday, August 29th. One staff member was present to operate the wet clean system and press the test garments. Aside from the front counter, the facility was otherwise inactive. Three loads, two dark and one light were processed over 2 hours and 35 minutes. (Table 3.10) A total of 78 garments weighing 80 pounds were processed.

Table 3.10: Wet Cleaning Test 2 Process Times and Garment Volume

	Program	Minutes[35]	Garments	Pounds
Load 1	Wool Full	34	46	40
Load 2	Delicate	31	18	20
Load 3	½ Cotton	41	14	20
Total Test		155	78	80

Approximately half of the garments processed carried a delicate garment care label, which is consistent with other tests at this facility. Over 60% of the test garments were pants.

Table 3.11: Wet Cleaning Test 2 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	42%	Blouse/Shirt	22%
Hand Wash	7%	Dress/Skirt	4%
Machine Wash	46%	Jacket	12%
No Label	4%	Pants	62%
		Sweater	1%

3.2.4 Professional Wet Cleaning Field Test Results

Test results show that processing garments in the professional wet cleaning system at Del Rey Cleaners used an average of 12.0 kWh/100 pounds of garments processed, 15.9 therms of natural gas/100 lbs., and 87 gallons of water/ 100 lbs. (Table 3.12) In terms of electricity and natural gas use, the second test was more efficient. The process times during the second test were shorter, which may have contributed to the increased efficiency.[36] Also, during the first test, the system had been in use for less than a week and the staff was still getting used to using it. By the second test day, the new equipment had been in use for nearly a month.

Table 3.12: Professional Wet Cleaning Test Results

	KWh per 100 Lbs	Therms per 100 Lbs	Gallons per 100 Lbs	
Date	**All Equipment**	**Boiler & Dryer**	**Boiler**	**Washer**
8/09/04	13.9	17.5	16	73
8/27/04	10.0	14.3	19	65
Average	**12.0**	**15.9**	**18**	**69**

[35] Total test minutes is taken from the time the first load is loaded to the time the final garment is pressed.
[36] During the first test, the process took an average of 2.4 minutes per pound, compared to an average of 1.9 minutes per pound during the second test.

3.3 Petroleum Dry Cleaning – Hillcrest Cleaners[37]

Hillcrest Cleaners is a petroleum dry clean facility located in the community of Northridge in the San Fernando Valley. The cleaners serves as a showroom for the brand of dry clean machine installed at the facility. Hillcrest Cleaners was recommended as a test site by a member of the Professional Wet Cleaning Commercialization Project Advisory Board.[38] A new 60-pound Lindus petroleum dry clean machine was installed at the facility in 2000.

3.3.1 Equipment at the Petroleum Dry Clean Facility

The table below describes the specific equipment used at Hillcrest Cleaners to process garments using the petroleum dry clean system. In general, the equipment appeared to be new and well maintained.

Table 3.13: Equipment Specifications at Hillcrest Cleaners (Petroleum)

Equipment	Model	Capacity	Year	Power	Comments
Dry Clean Machine	Lindus PM60	60 lbs	2000	25 HP, 18.6 kW	
Boiler	Parker 15L	-	2000	15 HP	The Gas Company discovered the boiler's CO emissions levels to be dangerously high, so the boiler was serviced immediately prior to the first test day.
Air Compressor	Falcon tank, Lincoln motor	N.A.	N.A.	7.5 HP	
Cooling Tower	RSD TSC 15	N.A.	1999	0.5 HP	
Cooling Tower Pump	STA-RITE HF51HL	N.A.	1999	1.5 HP	
Vacuum Pump	Rema/Lesson motor	N.A.	N.A.	1.5 HP	
Pressing Equipment	Two pressing boards, 1 susie (for jackets and tops, 1 pants topper, and electric irons.				

3.3.2 Test Preparation

Electricity sub meters and data loggers were installed on the dry clean machine, cooling tower fan and pump, air compressor, vacuum, boiler, and an iron.[39] Water meters and data loggers were installed on the cooling tower and boiler make-up lines.[40] Natural gas was measured by reading the billing meter.

[37] See Appendix C for a more detailed presentation of the data collected on petroleum dry cleaning.
[38] As a member of Occidental College's Commercialization Project Advisory Board, Ray Rangwala represented the Greater Los Angeles Dry Cleaning Association
[39] Electricity sub meters were installed by Southern California Gas Company Technicians on June 18, 2004. Two irons were used during testing, but only one was metered because the availability of meters. The consumption of the metered iron would be doubled to account for the un-metered iron.
[40] Water meters were installed June 18, 2004.

Testing was scheduled for Saturdays, when the facility's laundry operation is shut down and only dry clean processing is conducted. Because garments processed on Saturdays are typically pressed the following Monday, the owner of the facility was willing to bring in his pressing staff on test days in order to finish garments immediately after each cleaning cycle was completed.

3.3.3 Field Testing

Petroleum Test 1 – 6/19/04

The first field test at Hillcrest Cleaners was completed on Saturday, June 19, 2004. One staff member was present to operate the dry clean machine, and two pressers pressed the garments. Three loads, two dark and one light, were cleaned and pressed over 5 hours and 14 minutes. (Table 3.14) A total of 146 garments weighing 136 pounds were processed. [41]

Table 3.14: Petroleum Test 1 Process Times and Garment Volume

	Start	Finish	Minutes[42]	Garments	Pounds
Load 1	6:38	7:45	67	56	47
Load 2	7:48	8:55	67	44	45
Load 3	8:58	10:05	67	46	44
Total Test	6:38	11:52	314	146	136

Over half of the garments processed carried a dry clean care label. Over 80% of the test garments were either pants or shirts/blouses.

Table 3.15: Petroleum Test 1 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	46%	Blouse/Shirt	43%
Machine Wash/Dry Clean	11%	Pants/Shorts	42%
Hand Wash	3%	Dress/Skirt	4%
No Label	1%	Sweater	3%
Machine Wash	38%	Jacket	6%
		Other	1%

[41] At the end of the test, the boiler room was discovered to be wet with water because the boiler was leaking. The owner was able to tighten a pipe connection and solve the problem. A pipe connection may have become loose when the boiler was being serviced.
[42] Total test minutes is taken from the time when the first load is loaded to the when the final garment is pressed.

Petroleum Test 2 – 6/26/04

The second test at Hillcrest Cleaners was completed on Saturday, June 26, 2004. One staff member was present to operate the dry clean machine, and two pressers pressed the garments. Three loads, two dark and one light, were cleaned and pressed over 5 hours and 4 minutes. (Table 3.16) A total of 160 garments weighing 137 pounds were processed.

Table 3.16: Petroleum Test 2 Process Times and Garment Volume

	Start	Finish	Minutes[43]	Garments	Pounds
Load 1	6:40	7:47	67	52	44
Load 2	7:50	8:57	67	57	44
Load 3	9:00	10:07	67	51	49
Total Test	6:40	11:44	304	160	137

Seventy-one percent of the garments processed carried a delicate care label, which is higher than what was processed during the first test (49%). Over half of the garments processed were pants.

Table 3.17: Petroleum Test 2 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	71%	Blouse/Shirt	28%
Machine Wash/Dry Clean	4%	Pants	53%
Hand Wash	0%	Dress/Skirt	6%
No Label	1%	Sweater	5%
Machine Wash	24%	Jacket	5%
		Other	3%

3.3.4 Petroleum Test Results

Test results show that processing garments in the petroleum system at Hillcrest Cleaners used an average of 23.8 kWh kWh/100 pounds of garments processed, 9.2 therms of natural gas/100 lbs., and 18 gallons of water/100 lbs. (Table 3.18) The electricity consumption was very consistent between the first and second test. The boiler may have used more natural gas and water during the first test because of a water leak around the boiler. Also, the profile of garments processed varied slightly. It is not clear why the cooling tower used more water on the second day, but it may have been affected by variations in the air temperature.

Table 3.18: Petroleum Test Results

Date	KWh per 100 Lbs	Therms per 100 Lbs	Gallons per 100 Lbs	
	All Equipment	Boiler	Boiler	Tower
6/19/04	24.5	9.6	12	6
6/26/04	23.1	8.8	8	10
Average	**23.8**	**9.2**	**10**	**8**

[43] Total test minutes is taken from the time when the first load is loaded to the when the final garment is pressed.

3.4 Rosali Cleaners – Liquid CO2 Dry Cleaning[44]

Rosali Cleaners, located in North Hollywood, operates as a local neighborhood cleaner as well as a wholesale leather specialist. In 2003, the business moved to a new location and replaced the PCE dry clean machine with a liquid CO2 dry clean machine. The shop is one of two cleaners in the Los Angeles region using a CO2 system without an additional solvent dry cleaning system. Due to the high cost of CO2 solvent, Rosali Cleaners processes as many garments as possible in their wet clean system.

3.4.1 Liquid CO2 Dry Clean Equipment

The table below describes the specific equipment used at Rosali Cleaners to process garments using the liquid CO2 dry clean system. The equipment appeared to be new and well maintained.

Table 3.19: Equipment Specifications at Rosali Cleaners (Liquid CO2)

Equipment	Model	Capacity	Year	Power	Comments
Dry Clean Machine	Chart CO2OL55	55 lbs	2003	N.A.	Total power was not listed on the plate, but the machine had a built in, 15 HP CO2 compressor.
Boiler	Parker	N.A.	2003	9.5 HP	Boiler was having trouble maintaining pressure, and was serviced by Parker Boiler before the test.
Air Compressor	N.A.	N.A.	N.A.	5 HP	
Chiller	York	N.A.	2003	¾ HP Fan, 1½ HP Pump	
Vacuum Pump	Leeson	N.A.	N.A.	1 HP	
Pressing Equipment	2 Press boards, 1 susie (for jackets and tops), steam irons.				

3.4.2 Test Preparation

Electricity sub meters were installed on CO2 dry clean machine, chiller fan and pump, air compressor, vacuum, boiler, Susie, and pressing board.[45] A water meter was installed on the make-up line to the boiler.[46] Natural gas was measured by reading the billing meter.

[44] See Appendix D for a more detailed presentation of the data collected on CO2 dry cleaning.
[45] The electricity sub meters were installed by Southern California Gas Company Technicians on July 19, 2004.
[46] The water meter was installed on the boiler on July 23, 2004.

3.4.3 Field Testing

CO2 Test 1 – 7/31/04

The first field test at Rosali Cleaners was completed on Saturday, July 31, 2004. The facility's laundry and wet cleaning operations were not active during testing. One staff member was present to operate the dry clean machine, and one presser pressed the test garments. Two loads, one dark and one light, were processed and pressed over 4 hours and 22 minutes. (Table 3.20) A total of 75 garments weighing 62 pounds were processed.

Table 3.20: CO2 Test 1 Process Times and Garment Volume

	Start	Finish	Minutes[47]	Garments	Pounds
Load 1	10:01	10:39	38	36	20
Load 2	10:55	11:32	37	39	40
Total Test	10:01	2:22	262	75	60

One quarter of the garments carried a dry clean care label while nearly two-thirds were labeled machine wash. The operator said that she would have normally processed most of the test garments in her wet clean system, but was processing them in the CO2 system in order to have enough garments to complete the test protocol. The shop had a low volume day on the test day, and the first load was smaller than a typical load (35-40 lbs).

Table 3.21: CO2 Test 1 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	20%	Blouse/Shirt	35%
HW/DC	3%	Jacket	3%
Hand Wash	7%	Dress/Skirt	7%
No label	5%	Sweater	9%
Machine Wash	65%	Pants/Shorts	46%

CO2 Test 2 – 8/2/04

The second test at Rosali cleaners was completed on Monday, August 2, 2004. The facility's laundry and wet cleaning operation were not active during testing. One staff member was present to operate the dry clean machine, and one presser pressed the test garments. Two loads, one dark and one light, were processed and pressed over 4 hours and 38 minutes. (Table 3.22) A total of 74 garments weighing 65 pounds were processed.

[47] Total test minutes is taken from the time when the first load is loaded to the when the final garment is pressed.

Table 3.22: CO2 Test 2 Process Times and Garment Volume

	Start	Finish	Minutes[48]	Garments	Pounds
Load 1	19:37	20:12	35	39	35
Load 2	20:34	21:09	35	35	30
Total Test	19:37	00:15	278	74	65

One quarter of the garments processed carried a dry clean label, while an additional quarter was treated as delicate garments – either hand wash or no label. The operator said that she would have normally processed most of the test garments in her wet clean system, but was processing them in the CO2 system in order to have enough garments to complete the test protocol.

Table 3.23: CO2 Test 2 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	23%	Blouse/Shirt	45%
HW/DC	3%	Jacket	4%
Hand Wash	4%	Dress/Skirt	4%
No label	14%	Sweater	10%
Machine Wash	56%	Pants/Shorts	35%
		Other	2%

3.4.4 Field Test Results

Test results show that processing garments in the CO2 system at Rosali Cleaners used an average of 29.0 kWh /100 pounds of garments processed,13.4 therms/100 lbs, and 16 gallons of water/100 lbs. (Table 3.24) The average load size of the first test was slightly smaller than the second test (30 lbs vs. 33 lbs), which may have contributed to the second test's lower electricity consumption per 100 lbs (30.8 kWh vs. 27.1 kWh).

Table 3.24: Liquid CO2 Test Results

	KWh per 100 Lbs	Therms per 100 Lbs	Gallons per 100 Lbs
Date	**All Equipment**	**Boiler**	
7/31/04	30.8	14.7	20
8/02/04	27.1	12.0	11
Average	**29.0**	**13.4**	**16**

[48] Total test minutes is taken from the time the first load is loaded to when the final garment is pressed.

More natural gas per 100 pounds was consumed in the first test. The higher ratio of number of garments to pounds of garments in the first test may have contributed to less efficient gas use.[49] The majority of the natural gas consumed during both field tests was associated with pressing. During the first test, 30% of the total natural gas consumption occurred while the dry clean machine was in operation.[50] During the second test, 31% of the total natural gas consumption occurred while the dry clean machine was in operation.[51]

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[49] More garments were processed in the first test than in the second test (75 vs. 74) in spite of more poundage being processed during the second test (60 vs. 65)

[50] During CO2 test 1, a total of 9.1 therms were consumed. During the first load 1.3 therms were consumed, and during the second load, 1.4 therms were consumed.

[51] During CO2 test 2, a total of 7.8 therms were consumed. During the first load, 1.2 therms was consumed, and during load 2, 1.2 therms was consumed.

3.5 Silicone Dry Cleaning – Cleaner by Nature[52]

Testing of a silicone dry clean system was originally set to take place at Ritz Cleaners in Los Angeles. Because of the facility's large garment volume and extensive laundry operations, electricity sub metering would have been necessary to collect accurate data. Electricity sub meters were scheduled to be installed, but the technicians were confronted by a number of factors that would have made doing so difficult.[53]

A replacement silicone site was found in Cleaner by Nature, located in Brentwood. Cleaner by Nature operates a Realstar dry clean machine using GreenEarth silicone solvent, and was one of the first cleaners in southern California to use silicone. The facility processes a large garment volume, and operates several drop shops around west Los Angeles.

3.5.1 Silicone Dry Clean Equipment

The table below describes the specific equipment used at Hillcrest Cleaners to process garments using the petroleum dry clean system. In general, the equipment appeared to be new and well maintained.

Table 3.25: Equipment Specifications at Cleaner by Nature (Silicone)

Equipment	Model	Capacity	Year	Power	Comments
Dry Clean Machine	Realstar KM500	60 lbs	N.A.	N.A.	
Boiler	Thermosteam	1,000 BTU	2004	15 HP	During the second test, the boiler wasn't able to maintain pressure. The boiler was serviced and the test rescheduled.
Air Compressor	Rol-Air Systems, Machester Tank	MAWP 200 PSI	1995	5 HP	The air compressor was having trouble maintaining pressure, and was running almost constantly during testing. An air and steam leak was found at the back of the dry clean machine, and may be the source of the problem.
Cooling Tower	RSD 620	N.A.	N.A.	½ HP, 0.37 kW	
Cooling Tower Pump	STA-RITE JHG-52HL	N.A.	N.A.	2 HP, 1.5 KW	
Vacuum Pump	No visible labels	N.A.	N.A.	N.A.	
Pressing Equipment	Hi-Steam tensioning pants topper and form finisher, two press boards, steam irons.				

[52] See Appendix E for a more detailed presentation of the data collection on silicone dry cleaning.
[53] There were not enough electricity sub meters available to meter all equipment associated with the processing of garments at Ritz Cleaners. The circuit panels in the facility were too crowded to install all of the necessary metering equipment. The circuit panels were located in a narrow hallway with heavy foot traffic, and installing metering equipment could have posed a safety hazard.

3.5.2 Test Preparation

Electricity sub meters were installed on the dry clean machine, cooling tower fan and pump, air compressor, vacuum pump, tensioning pants topper and form finisher, and the boiler.[54] Water meters were installed on the cooling tower and boiler make-up lines. Natural gas would be measured by reading the outside billing meter.[55]

Testing was scheduled for Mondays when volume tended to be lower and delays caused by testing would be manageable.

3.5.3 Field Testing

Silicone Test 1 – 8/23/04

The first test at Cleaner by Nature was completed on Monday, August 23, 2004. The test measured the first two loads processed that day. One staff member was present to operate the dry clean machine, and two pressers pressed the test garments. One dark and one light load were processed. A total of 165 garments weighing 110 pounds were processed.

Table 3.26: Silicone Test 1 Process Times and Garment Volume

	Start	Finish	Minutes	Garments	Pounds
Load 1	5:53	7:13	80	85	55
Load 2	7:16	8:26	70	80	55
Total Test	5:53	10:14	261	165	110

Silicone Test 2 – 9/14/04

The second test at Cleaner by Nature was completed on Tuesday, September 14, 2004.[56] The test measured the first three loads processed that day. One staff member was present to operate the dry clean machine, and two pressers pressed the test garments. One dark and two light loads were processed. The third load was a half load because enough garments were not available to fill a full load. A total of 200 garments weighing 145 pounds were processed.

Table 3.27: Silicone Test 2 Process Times and Garment Volume

	Start	Finish	Minutes[57]	Garments	Pounds
Load 1	6:02	7:12	70	83	58
Load 2	7:19	8:23	64	72	55
Load 3	8:29	9:37	68	45	32
Total Test	6:02	10:58	296	200	145

[54] Electricity sub meters were installed by Southern California Gas Company Technicians on August 20, 2004.
[55] Water meters were installed by a licensed plumber on August 27, 2004.
[56] The second test was originally scheduled for Monday, August 30, 2004. During the dry cycle of the first load, the boiler was unable to maintain pressure, and the processing of additional loads and the pressing of garments was not possible. Testing was rescheduled for September 14, 2004.
[57] Total test minutes is taken from the time when the first load is loaded to the when the final garment is pressed.

Approximately two-thirds of the garments processed carried a dry clean care label. A relatively large percentage of garments did not carry any care label.[58]

Table 3.28: Silicone Test 2 Garment Distribution

Care Label		Garment Type	
Dry Clean/Dry Clean Only	62%	Blouse/Shirt	30%
Machine Wash/Dry Clean	2%	Pants	30%
Hand Wash	7%	Dress/Skirt	13%
No Label	13%	Sweater	19%
Machine Wash	18%	Jacket	8%
		Other	1%

3.5.4 Field Test Results

Cleaner by Nature used an average of 44.7 kWh, 11.3 therms, and 51 gallons per 100 pounds of garments processed. (Table 3.29) There was little variation in electricity use between Test 1 and Test 2, although the level of consumption is probably overstated due to an apparent air leak that resulted in the air compressor having trouble maintaining pressure.[59] The air compressor motor was running almost constantly during both tests.

Natural gas use was consistent between Test 1 and Test 2. The boiler required servicing between the first and second test, but it does not appear that whatever was ailing the boiler before the second test impacted the results of the first test in any significant way.

Table 3.29: Silicone Test Results

	KWh per 100 Lbs	Therms per 100 Lbs	Gallons per 100 Lbs	
Date	**All Equipment**	**Boiler**	**Boiler**	**Tower**
8/23/04	45.7	11.7	N.A.[60]	N.A.
9/14/04	43.6	10.9	32	19
Average	**44.7**	**11.3**	**32**	**19**

[58] A garment profile for the first day of testing was not completed due to a non-occupationally-related injury sustained by Occidental College personnel (Cyrus Grout), which limited his mobility during the period of the test.

[59] The air compressor motor ran almost constantly throughout the test, and was not able to maintain pressure for more than a minute or two without having to recharge. The pressure appeared to be set at approximately 125 PSI. An air leak at the back of the dry clean machine was identified as the probable source of the problem.

[60] Water meters were not installed in time for the first test. However, between the first and second test, a data logger was recording the consumption of the cooling tower. On October 30, 2004, the cooling tower used 71 gallons between 6:00 am and 5:00 pm, during which time five loads weighing 275 lbs were processed. This works out to 14.2 gallons per load, and 26 gallons per 100 lbs. Between August 30, 2004and September 3, 2004, during which time 27 loads were processed, 380 gallons, or 14.1 gallons per load, were consumed. Assuming that each load was filled to capacity, this works out to 26 gallons per 100 lbs of garments. This is higher than the consumption measured during the second test. Two factors contributed to this higher consumption: 1) Testing occurred in the morning, when temperatures are cooler and evaporation rates will be lower; 2) During testing, there was virtually no delay between loads, but during the week the cooling tower would have been running during down time between loads.

Water use data was not available from the first test, but a data logger recorded the consumption of the cooling tower during the week of October 30 to September 3, 2004. During that week, an average of 14.2 gallons per load, or 26 gallons per 100 pounds, was consumed by the cooling tower. This is higher than what was recorded during testing. Factors such as cooler air temperature (testing took place early in the morning) and limited down time between loads may have contributed to the lower usage recorded during testing.

3.6 Summary Results and Comparative Analysis

This section will compare and analyze the data collected for each technology. The data collected on PCE dry cleaning and professional wet cleaning at Del Rey Cleaners will first be analyzed separately in a before-and-after comparative analysis of resource use at that facility. The section will then proceed to compare the electricity use, natural gas use, and water use, among the five technologies evaluated.

3.6.1 Resource Use Impacts of Switching from PCE Dry Cleaning to Professional Wet cleaning at Del Rey Cleaners

Del Rey Cleaners' switch from PCE dry cleaning to professional wet cleaning provides the opportunity to compare the two technologies while holding other important variables constant. During the testing of each technology, the same boiler, air compressor, vacuum, pressing staff, and pressing equipment were used.[61] Therefore, changes in resource use after the switch to professional wet cleaning can be attributed to the cleaning technology.

3.6.1.1 Electricity Use – PCE vs. Professional Wet Cleaning

Del Rey Cleaners consumed an average of 30.1 kWh/100 pounds of garments using the PCE dry clean system compared to an average of 12.0 kWh/100 lb using the professional wet clean system. This 18.1 kWh/100 lb. difference represents a 60% reduction in electricity used in the professional cleaning process. (Table 3.30) The removal of the dry clean machine, cooling tower fan, and cooling tower pump, appear to be the primary factors driving this reduction.

The field data also showed that the average kW Demand during the professional wet cleaning tests (3.2 kW) was 58% lower than for the PCE dry cleaning tests (7.7 kW).[62] (Table 3.30) These Demand figures roughly correspond to the faceplate rating of the equipment. The rating of dry clean equipment (including the dry clean machine, cooling tower fan, and cooling tower pump) was 12.1 kW while the total demand for the wet clean washer and dryer was3.0 kW.[63]

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[61] The switch to professional wet cleaning included the installation of tensioning pressing equipment. This equipment is considered to be an integral part of a professional wet clean system. The South Coast Air Quality Management District's incentive program requires cleaners applying for professional wet clean equipment grants to also purchase tensioning equipment. A water heater was also installed as part of the wet clean system in order to provide hot water to the wet clean washer.

[62] KW Demand was calculated by taking the total kWh use during the field test and dividing by the length of the test period (in hours).

[63] KW Demand ratings for the dry clean system were as follows: dry clean machine = 10.8, Cooling tower fan = 0.55, Cooling tower pump = 0.75. kW Demand ratings for the professional wet clean system were as follows: Wet clean washer = 1.0, Wet clean dryer = 2.0.

Table 3.30: Electricity Consumption at Del Rey Cleaners

	Average kWh per 100 Lbs	**Average kW Demand During Testing**
PCE Dry Cleaning	30.1	7.7
Professional Wet Cleaning	12.0	3.2
Reduction	**18.1**	**4.5**
Percent Savings	**60%**	**58%**

Monthly billing records corroborate the field test results for electricity use.[64] Between August 2003 and July 2004, when Del Rey Cleaners was operating its PCE dry clean machine, the facility consumed an average of 2,867 kWh per month. In September 2004, the first full month billed since switching to professional wet cleaning, Del Rey Cleaners consumed 2,435 kWh. The value of 2,435 kWh was the lowest kWh consumption recorded for Del Rey Cleaners during the past 14 billing periods.[65] This amounts to a reduction of 432 kWh per month. The reduction has been achieved in spite of a substantial increase in laundry volume reported by the owner, during July, August, and September.[66]

3.6.1.2 Natural Gas Use – PCE vs. Professional Wet Cleaning

Del Rey Cleaners consumed an average of 22.0 therms per 100 pounds of garments using the PCE dry clean system compared to an average of 15.9 therms per 100 pounds of garments using the professional wet clean system. This amounts to a 19% reduction of 4.1 therms per 100 pounds of garments. (Table 3.31) Eliminating the use of the inefficient boiler for steam drying and distillation, and the addition of tensioning finishing equipment are factors that may have contributed to this reduction.

Table 3.31: Natural Gas Use at Del Rey Cleaners

	Average Therms per 100 Lbs
PCE Dry Cleaning	22.0
Professional Wet Cleaning	15.9
Therms Savings per 100 Lbs	4.1
Percent Savings	19%

[64] See Appendix B. Monthly billing record history was provided by Mark Gentili, LADWP, September 27, 2004.
[65] The billing period for September 2004 began on August 19, 2004, and ended September 20, 2004. The billing period included 32 days. Only one billing period out of the previous thirteen included more days – 33 days in January 2004.
[66] Personal Communications, Barry Moschel, , September 27, 2004. Mr. Moschel reported that Del Rey Cleaners' garment volume and revenue had increased substantially over the last three months, especially in late August and September, 2004, due to a new commercial contract. Mr. Moschel was not able to provide an estimate of what percentage volume had increased, but emphasized that it was substantial.

As was discussed in the case study of the cleaner (Section 3.1.1), the boiler is aging and appeared to be in poor condition, and the system of pipes distributing steam throughout the shop were not insulated and numerous steam leaks were observed. The PCE dry clean machine relied on the boiler to provide steam heat during the dry cycle, while the wet clean dryer uses natural gas as a direct source of heat.

The first dry cycle of each test was isolated from the other test operations, and provides some measure of how much natural gas the dry clean machine and wet clean dryer consume. On average, the wet clean system used 1.9 therms less natural gas per load. (Table 3.32) In PCE dry cleaning, regulations require the removal of virtually all PCE from garments before they are removed from the machine, which means that garments must be dry very thoroughly. Wet cleaning, on the other hand, gives the cleaner the flexibility to remove garments from the dryer at any moisture level or to not use the dryer at all.

Table 3.32: 1st Load Natural Gas Consumption at Del Rey Cleaners

PCE	Therms per 100 Lbs	Wet Cleaning	Therms per 100 Lbs
Load 1, Test 1	4.4	Load 1, Test 1	2.2
Load 1, Test 2	4.2	Load 1, Test 2	2.5
Average	4.3	Average	2.4

The potential natural gas savings available to a professional wet cleaner depends in large part on the extent of hang drying practiced by the cleaner. At Del Rey Cleaners, the amount of hang drying versus machine drying varied on the two test days. This is reflected in a comparison of the two wet clean tests at Del Rey Cleaners. The average machine dry time in Wet Clean Test Day 1 was twice as long as Wet Clean Test Day 2 (28 minutes/load versus 14 minutes/load).[67] As would be expected, natural gas use was higher on Wet Clean Test 1 (17.5 therms/100 lbs.) compared to Test Wet Clean Day 2 (14.3 therms/100 lbs.). The shorter machine dry times in Wet Clean Test 2 may be more representative of the long term drying habits at Del Rey Cleaners; the first test occurred less than two weeks after the wet clean system had been installed, whereas the second test occurred over a month after the installation. The operators are learning to take advantage of wet cleaning's flexibility and use the system more efficiently.

3.6.1.3 Water Use – PCE vs. Professional Wet Cleaning

Del Rey Cleaners consumed an average of 181 gallons per 100 pounds of garments using the PCE dry clean system compared to an average of 87 gallons per 100 pounds of garments using the professional wet clean system. (Table 3.33) This reduction of 94 gallons per 100 pounds of garments reduction amounts to a 52% decrease in water use. The cause of the large reduction can be attributed exclusively to the removal of the cooling tower.

[67] See Appendix B.

Table 3.33: Water Consumption at Del Rey Cleaners

	Average Gallons per 100 Lbs
PCE Dry Cleaning	181
Professional Wet Cleaning	87
Gallon Savings per 100 Lbs	94
Percent Savings	52%

The cooling tower's float, which regulates its reservoir's water level, was not attached to any part of the cooling tower. Consequently, the make-up line was constantly filling the reservoir and water was constantly draining out the reservoir's overflow hole. Water from the cooling tower was being used at a rate of approximately one gallon per minute. Had the cooling tower been functioning properly, it would have consumed substantially less water.[68] The water consumed by the boiler did not appear to be affected by the switch to professional wet cleaning.

Monthly billing records obtained from the LADWP corroborate the field test results. Between August 2003 and July 2004, when Del Rey Cleaners was operating its PCE dry clean machine, the facility consumed an average 107 HCF[69] per month. In September 2004, the first full month billed since switching to professional wet cleaning, Del Rey Cleaners consumed 38 HCF. This amounts to a 64% reduction of 69 HCF per month. The reduction has been achieved in spite of a substantial increase in laundry volume reported by the owner, during July, August, and September.[70]

It appears that the field test substantially underestimated the amount of water savings created by the switch to professional wet cleaning. The field test data results reported savings of 94 gallons per 100 pounds of garments. The monthly billing record data indicates that Del Rey Cleaners is saving 51,612 gallons per month. Based on the reported volume of garment dry cleaned at Del Rey Cleaners, a standardize measure of saving comes to 755 gallons per 100 pounds of garments.[71] This seems to suggest that the cooling tower water make-up line was running all day and night, whether the cooling tower itself was in operation or not.[72]

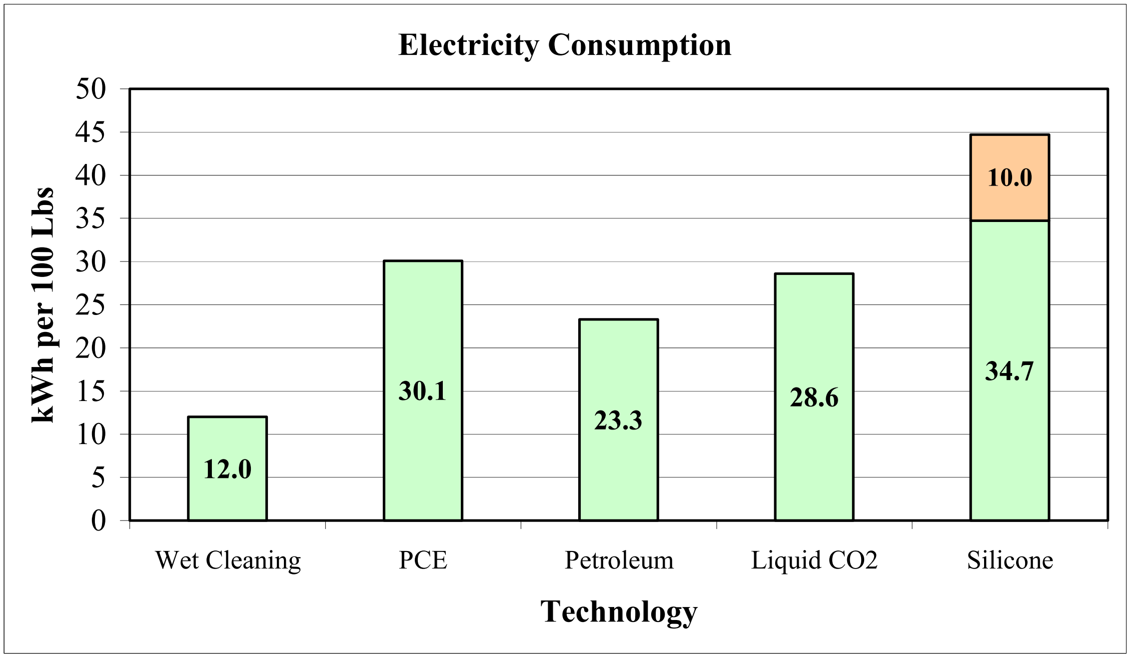
3.6.2 Electricity Consumption – Summary Analysis

The professional wet clean system used less electricity than any other technology. Professional wet cleaning used 12.0 kWh per 100 pounds of garments, compared to between 23.8 and 34.7 kWh per 100 pounds of garments for the other cleaning

[68] See Figure 3.3 for comparison of water tower use at petroleum and silicone facilities.
[69] One HCF (Hundred Cubic Feet) is equivalent to 748 gallons.
[70] See section 3.5.1.1.
[71] In their application to Occidental College's Professional Wet Cleaning Del Rey Cleaners reported a volume of 350 garments cleaned in PCE per day. Based in the field test, average garment weight was 1.1 pounds per piece. At 1.1 lbs/garment average daily volume by weight comes to 318 lbs per day. 318 lbs. per day * 5 days per week * 4.3 weeks per month = 6.837 lbs per month.
[72] This was corroborated by field test observation. When collecting the sub meter reading in the cooling tower, water was observed draining from the cooling tower before the dry clean machine was turned on and after the dry clean machine was turned off.

technologies. (Figure 3.1) The most efficient technology behind wet cleaning was petroleum, used approximately twice as much energy as wet cleaning in terms of kWh per 100 pounds of garments processed.

Figure 3.1: Electricity Consumption Summary[73]



A fundamental difference between professional wet cleaning and the dry cleaning technologies is that the dry cleaning technologies work to recover solvent vapors during the dry cycle. PCE, petroleum, and silicone recover solvent through condensation, which is accomplished by cooling the air circulated through the drum during the dry cycle. In the case of liquid CO2, the system must also work to pressurize the solvent vapors back into liquid.

Solvent recovery in dry clean machines is accomplished by the refrigerated condenser (RC) and cooling tower or chiller. [74] The RC generates temperatures at which the solvent vapors condense back into liquid form and the cooling tower or chiller dissipates the heat generated by the dry clean machine. The process could be equated to boiling water on the stove and then putting in the refrigerator to cool it back down to its original temperature. The dry clean systems must work to accomplish these two tasks at the same time, for they are heating garments and at the same time cooling the heated vapors released from the garments. The sub meter data suggest that the recovery of solvent is an energy intensive process.

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[73] As discussed in section 3.4.4, the electricity consumption of the silicone dry clean system is probably overstated because of an air leak that caused the air compressor motor to consume an excessive amount of electricity. The upper portion of the Silicone bar represents this excess consumption. The lower portion has been adjusted downwards by 10 kWh per 100 lbs of garments based on the consumption of air compressors at the other test sites.

[74] The CO2 system evaluated in this study used a chiller and while the PCE, petroleum, and silicone systems used cooling towers.

Figure 3.2: Dry Clean System Electricity Demand[75]

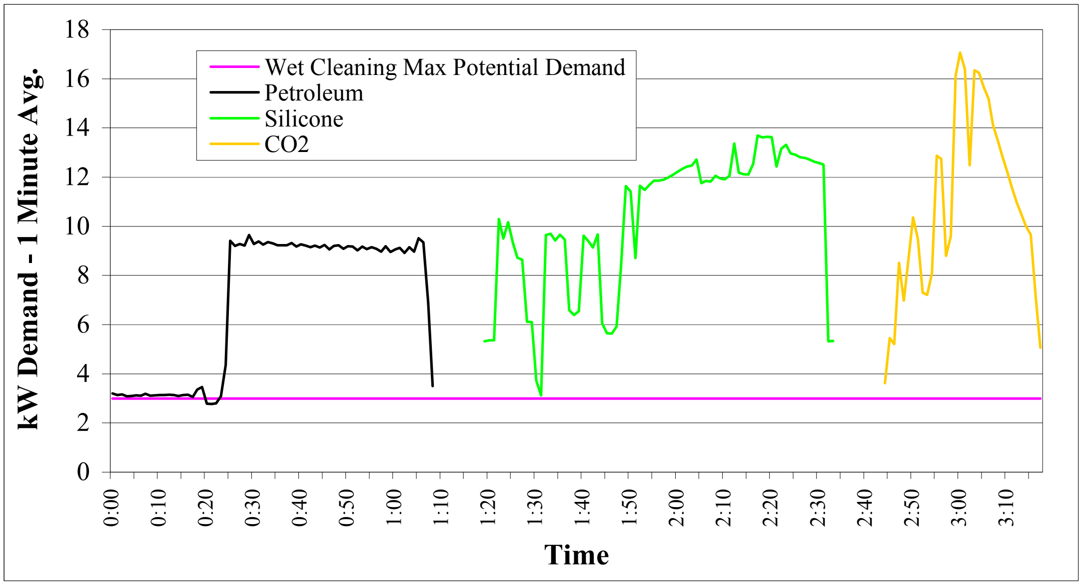

Figure 3.2 above represents electricity sub meter data collected during field testing on the petroleum, CO2, and silicone dry clean systems. The kW demand plotted in Figure 3.2 includes the demand generated by the dry clean machine and cooling tower (petroleum and silicone) or chiller (CO2). Although no sub meter data was recorded for the PCE machine at Del Rey Cleaners, it would be expected to have a profile similar to the petroleum system, as it is equipped essentially the same solvent control devices.[76] Sub meter data was not recorded for the professional wet clean system at Del Rey Cleaners, but the wet clean washer and dryer were rated at 1.0 and 2.0 kW respectively, and should never have generated a kW demand over 3 kW.

The dry cycles, or solvent recovery cycles, of each technology are characterized by a period of high electricity demand, as represented in Figure 3.2. The jump in kW demand is particularly stark in the petroleum system, where kW demand jumps from around 3 kW to over 9 kW. The CO2 system demanded the most power, but had a shorter dry cycle than the petroleum and silicone systems.

3.6.3 Natural Gas Consumption – Summary Analysis

At Del Rey Cleaners, natural gas use was substantially higher when processing garments use the PCE dry clean machine compared to when garments were processed in professional wet cleaning. Yet, each of the other non-PCE test facilities used less natural gas to process garments than professional wet cleaning at Del Rey Cleaner. (Figure 3.3)

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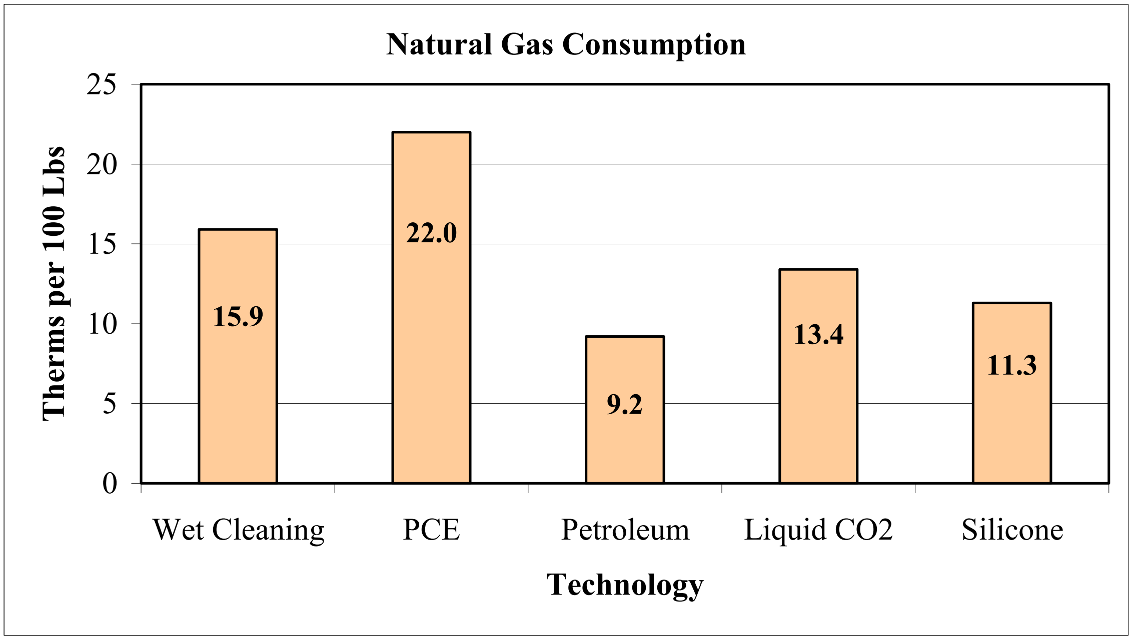
[75] The graph in Figure3.2 represents the following sub meter data: Petroleum – 1st load at Hillcrest Cleaners, 6/26/04; CO2 – 1st load at Rosali Cleaners, 8/2/04; Silicone – 1st load at Cleaner by Nature, 9/14/04.

[76] The PCE system would probably have had shorter cycle times, because the solvent is more aggressive, requiring a shorter wash cycle, and is more easily condensed, and would have a shorter dry cycle.

Figure 3.3: Natural Gas Consumption Summary



In interpreting the natural gas consumption results it is important to consider that the boiler at Del Rey Cleaners was considerably older and less efficient than the boilers at the other three facilities at which data was collected (see Sections 3.1 – 3.4). The boiler at Del Rey Cleaners was built in 1992 and had not been serviced for over two years prior to field-testing, while the boilers at each of the other facilities were no more than three years old and were serviced within one month of when field-testing occurred.[77]

This boiler efficiency discrepancy makes it difficult to compare the natural gas consumption of the PCE and wet clean systems with the natural gas use of the petroleum, CO2, and silicone systems.[78] Assuming that all systems had boilers of comparable efficiencies, the PCE system could be expected to consume less natural gas than the petroleum and silicone systems, because PCE systems tend to have shorter dry cycles. The PCE system had an average cycle time of 51 minutes, compared to average cycle times of 67 and 73 minutes for the petroleum and silicone systems respectively. The fact that the wet clean system at Del Rey Cleaners consumed less natural gas than the PCE system suggests that the wet clean system would have consumed less natural gas than the petroleum, CO2, and silicone systems.[79]

In analyzing the results from the facilities at which the boilers were of comparable age and efficiency, it is useful to compare the first loads processed during each field test when the respective cleaning systems were isolated from pressing in their demand for steam from the boiler. The results presented in Table 3.30 below suggest that the CO2

[77] Personal Communications, Barry Moschel, September 29, 2004.
[78] See section 3.5.1 for comparison of the wet clean and PCE systems, which were tested using the same boiler.
[79] This theory is born out when looking at data from the professional wet clean beta site data (See Section 4.3 below).

system is more efficient than the petroleum and silicone systems. This contradicts the total natural gas consumption figures per 100 pounds of garments presented in Figure 3.3 above.

Table 3.34: First Load Natural Gas Consumption

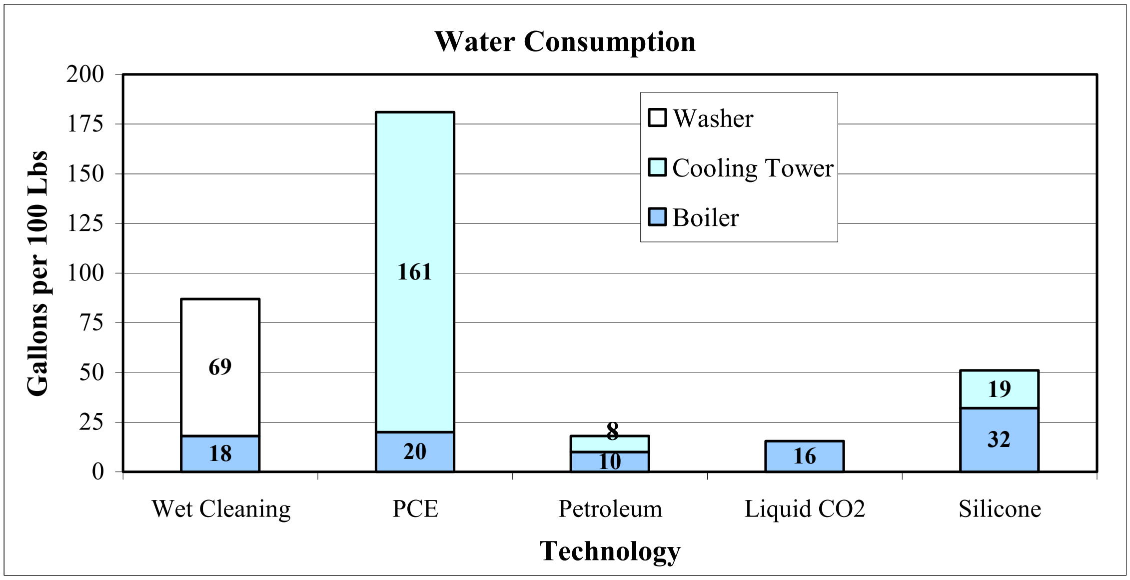
Cleaning System	Average Therms Consumed During First Test Load
Petroleum	2.4
CO2	1.3
Silicone	4.1

It is possible that the higher overall natural gas consumption attributed to the CO2 system is related to higher consumption during the pressing of garments. The owners of Rosali cleaners stated that the presser who pressed garments during both field tests was less experienced and slower than some of their other pressers. The comparison of the dry clean systems' natural gas consumption in Table 3.30 suggests that the CO2 system's higher overall consumption may be attributable to the pressing process rather than the cleaning system. Intuitively, it would be expected that the CO2 system would use less natural gas than the petroleum and silicone systems, given its short cycle times and low operating temperature.

3.6.4 Water Consumption – Summary Analysis

Water consumption by the petroleum, CO2, and silicone systems was minimal, while the PCE and wet clean systems consumed substantially more water per 100 pounds of garments processed. (See Figure 3.4) Higher water consumption by the wet clean system is not surprising, as the wet clean system uses water as a solvent. The high consumption by the PCE system may be considered an aberration because of the broken cooling tower (see section 3.5.1), but it is indicative of the potential inefficiencies that can occur when equipment is not maintained. The installation of a professional wet clean system at Del Rey Cleaners dramatically reduced water consumption because it eliminated a piece of equipment that is essential to most dry clean systems.

Figure 3.4: Water Consumption Summary



The CO2 system also eliminated the cooling tower as a potential source of enormous water consumption, using a closed loop chiller system. The cooling towers at the petroleum and silicone facilities appeared to be relatively new and in good condition, and their consumption of water was minimal. In general, the boilers do not appear to be a major source of water consumption, regardless of the cleaning technology.

4. Discussion

4.1 Summary

This study was designed to provide preliminary data characterizing the energy and water use of five professional garment cleaning technologies: professional wet cleaning, perchloroethylene dry cleaning, petroleum dry cleaning, silicone dry cleaning, and CO2 dry cleaning. Resource use of PCE dry cleaning and professional wet cleaning was to be measured at a single plant (Del Rey Cleaners) switching from one technology to the other. The three remaining technologies were to be measured at three different cleaning facilities.

A new standardized test procedure was developed to the compare resource use of different technologies used at different cleaning plants.

The case study of Del Rey Cleaners revealed that electricity use, natural gas use, and water use were all substantially lower when processing garments in the professional wet cleaning system compared to processing garments using the PCE dry cleaning system.

Electricity use in professional wet cleaning at Del Rey Cleaners was also lower when compared to three other facilities, each using different garment care technologies—petroleum, silicone, and liquid carbon dioxide.

On the other hand, natural gas and water use was higher at Del Rey Cleaners, for both PCE dry cleaning and professional wet cleaning, compared to the three other test facilities. The higher water use rate in PCE dry cleaning at Del Rey Cleaners was attributed to a broken cooling tower float valve. The higher natural gas use at Del Rey Cleaner for both technologies was attributed to a highly inefficient boiler and steam delivery system.

Detailed discussions of the results, how they compare with other studies, and other factors influencing the interpretation of these results, are presented below.

4.2 Electricity

Data from the case study at Del Rey Cleaners showed substantially lower electricity use when processing garments in professional wet cleaning compared to when the cleaner processed garments in a PCE dry cleaning machine. Professional wet cleaning was also substantially lower than cleaners using other alternative dry clean solvent systems that were tested.

The results from the test sites were consistent with data from the two beta test facilities.[80] At the professional wet cleaning test site, electricity use averaged 12.0 kWh per 100 pounds cleaned compared to 11.9 kWh per 100 pounds professionally wet cleaned at the beta site.

[80] See Appendices G and H for beta test Data.

For petroleum, electricity use was lower at the Test site than at the beta site: 23.3 vs. 31.07 kWh per 100 lbs. cleaned. This difference appears to be attributable to a difference in load size and load capacity. While the average electricity use per load was slightly higher at the TEST facility (10.44 vs. 9.67 kWh per 100 pounds cleaned), the petroleum test site averaged 46 pounds per load while the beta site averaged 31 pounds per load.

These results are also consistent with a prior study of cleaners converting from PCE dry cleaning to professional wet cleaning, which showed reductions in electricity use at the billing meter of between 19% and 44%.[81]

Lower electricity consumption in professional wet cleaning compared to the other garment care technology systems appears to be related to the fact that wet cleaning does not require an electricity-intensive closed-loop solvent recovery system; a requirement of all other technologies studied.

4.3 Natural Gas

Concern has been raised that while electricity use in professional wet cleaning may be lower than dry cleaning, this savings comes at the expense of an increase in natural gas use.[82] To assess whether professional wet cleaning was able to achieve a net energy savings, natural gas use at the different test sites were evaluated.

Natural gas use at Del Rey Cleaners dropped 25% after switching from PCE dry cleaning to professional wet cleaning; from 22 therms per 100 lbs to 16 therms per 100 lbs.

On the other hand, natural gas use was lower at each of the other three dry clean test facilities (9-13 therms per 100 lbs) compared to professional wet cleaning at Del Rey Cleaners. The lower natural gas use at the three non-PCE dry clean test facilities compared to Del Rey Cleaners, in all likelihood, was due to more efficient boilers and steam delivery systems and not to the cleaning process per se. Of the three non-PCE dry clean facilities, two had new boilers installed less than one year before testing, while the third installed its boiler less than three years prior to testing and had a boiler tune-up immediately prior to the first test date. In addition, the steam delivery systems at all three non-PCE facilities were well maintained; no steam leaks were observed and all steam pipes were insulated. By contrast, the boiler at Del Rey Cleaners was over 12 years old, was poorly maintained, and appeared to be highly inefficient. In addition, the steam delivery system was also in very poor condition; steam leaks were observed in lines going to a number of pieces of finishing equipment and none of the steam lines were insulated. Since the only device that uses natural gas in the dry clean process is the boiler, the efficiency of the boiler and steam delivery system is likely to have a substantial impact on natural gas use. Indeed, Del Rey Cleaners, with a highly inefficient boiler, used approximately twice as much natural gas in processing dry clean garments

[81] Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.

[82] Pollution Prevention in the Garment Care Industry: Assessing the Viability of Professional Wet Cleaning, Pollution Prevention Education and Research Center, 1997.

compared to the other three non-PCE dry clean facilities; 22 therms per 100 lbs vs. 9-13 therms per 100 lbs.

The beta site results, which used the identical test procedures, appear to reinforce the importance of boiler and steam line efficiency.[83] The professional wet cleaning beta site, which operated with a new boiler and an efficient steam line system, used half the amount of natural gas used by wet cleaning system at Del Rey Cleaners -- 7.8 vs. 16 therms/100 lbs. The petroleum beta site, which had a boiler tune up immediately prior to testing, used slightly more natural gas compared to the petroleum test site – 11.4 vs. 9.2 therms per 100 lbs. Yet, this difference in the petroleum sites is more likely due to the higher load capacity of the test site.[84]

A prior study of four other cleaners in the greater Los Angeles region who have switched from PCE dry cleaning to professional wet cleaning showed highly variable results in regards to natural gas use; two of the cleaners experienced a slight reduction (5%), one experienced a substantial reduction (35%), while another experienced a 12% increase.[85] In this prior study, the substantial reduction in the one facility was attributed to a difference in drying technique; this cleaner typically tumbled wet cleaned garments in his dryer with no heat and hung them overnight to be finished the next day. All other cleaners in the study used at least some heat from their dryer in processing wet clean garments.

The results from the current LADWP study suggest that natural gas use is very sensitive to the efficiency of the boiler and steam systems at a cleaner. Therefore, when comparing natural gas use at different facilities, it is essential to take into account the efficiency of the boiler and steam delivery systems. One method to reduce variability would be select only facilities with efficient boiler and steam systems. While this selection method may allow for easier comparison between facilities, it does not provide data concerning natural gas use under less than optimal conditions. Since many cleaners operate with inefficient boilers and steam delivery systems, it is important to quantify how this inefficiency interacts with the specific cleaning technology and how this would affect overall natural gas use.

Beyond natural gas use, because less efficient boilers require a greater water demand to create the required level of steam pressure, and because leaky and uninsulated steam systems waste steam, the efficiency of the boiler and steam delivery system is likely to have an impact on water use.

[83] See Appendices G and H for beta test data.
[84] When standardizing the two petroleum sites by load, as opposed to by 100 lb, the LADWP site shows a slightly higher natural gas use compared to the beta site – 4.3 vs. 3.5 therms/load.
[85] Resource Use in Professional Wet Cleaning vs. Perchloroethylene Dry Cleaning, Occidental College, March 2004.

4.4 Water Use

The case study results from Del Rey Cleaners showed that water use was over twice as high when processing garments in the PCE dry clean system compared to professional wet cleaning – 181 vs. 81 gallons/100 lbs. The high rate of water use at Del Rey Cleaners when operating the PCE dry cleaning machine was attributed to a broken reservoir float on the cooling tower, allowing make-up water line to run constantly. Professional wet cleaning does not use a cooling tower. The other three non-PCE solvent systems showed lower water use than Del Rey Cleaners.

Results from beta site testing showed higher water use at the beta site wet cleaner compared to wet cleaning at Del Rey Cleaners – 108 vs. 81 gallons /100 lbs.[86] The petroleum dry clean beta site also showed higher water use compared to the petroleum test site – 30 vs. 18 gallons/100 lbs. As with natural gas use, the water use difference in the petroleum sites is more likely due to the higher load capacity of the test site.[87]

A prior study of four cleaners in the greater Los Angeles region who have switched from PCE dry cleaning to professional wet cleaning showed that, for the two cleaners for whom billing records were available, one experienced a 17% increase in water use after the switch while the other experience a 2% reduction.[88]

Cooling Tower Operating Practices

To evaluate the water use results of the current LADWP study, it is important to understand issues related to cooling tower efficiency. In discussions with the Metropolitan Water District, problems with cooling tower operations are seen as a significant water conservation issue.[89] One source of the water conservation problem is the creation of "once through cooling", in which water is continuously drained from the tower and new water added into the system. Operators can purposefully create "once through cooling" by propping open the cooling tower drain valve. Operators may be motivated to create "once through cooling" because it reduces scale deposit from minerals dissolved in cooling tower; scale build-up acts as a barrier to heat transfer from the water to the air.[90] While "once through cooling" operations are not legal in the MWD service area, due to the excess water use that is created, it is not an uncommon practice.[91] The cooling tower at Del Rey Cleaners, operating with a broken reservoir float, functioned as a "once through cooling" system.

One technology solution to the problems of cooling tower inefficiency is to install a "cooling tower conductivity controller." MWD offers a $500 rebate towards the purchase of a conductivity controller. To add a new conductivity controller system costs

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[86] See Appendices G and H for beta test data.
[87] When standardizing the two petroleum sites by load, the beta site shows only a slightly higher water use compared to the LADWP site – 9 vs. 8 gallons/load.
[88] Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.
[89] Personal Communications, William McDonnell, MWD, September 19, 2003.
[90] Cooling towers use the principle of evaporative cooling in order to cool water. Underlying problem with cooling tower efficiency includes: scale deposits, clogged spray nozzles, poor air flow, and poor pump performance. (www.eere.energy.gov/femp/operations_maintenance/technologies/cooling/maintenance.cfm)
[91] Personal Communications, Jon Sweeten, MWD, September 24, 2004.

at least $2,500. Since most dry cleaners do not pay for their water use, they are not motivated to pay for such a system. In fact, cleaners who do not pay their own water utility may be motivated to practice "once through cooling" because it reduces the need to practice other labor and material intensive maintenance procedures.

Even when the cleaner pays their own water bill, as was the case of Del Rey Cleaners, increased water utility cost does not necessarily create sufficient motivation to maintain an efficient cooling tower system. This is because the cost of water represents a small fraction of a cleaners overall operating cost.[92] Historically, dry cleaners have had a hard time maintaining the pollution control devices on their solvent recovery machines, which would suggest that the maintenance of their cooling tower system is likely to be very poor.[93] Poor maintenance may also be compounded by the fact that the cooling tower is on the roof of the facility, and therefore out of site and inconvenient to access.

It is important to note that since professional wet cleaning does not use a cooling tower, the problems with water use efficiency associated with cooling towers are eliminated for cleaners that operate exclusively with professional wey cleaning and/or CO2 technology.

Water Supply Contamination Issues

Another issue to consider when evaluating water use of different garment care technologies is water supply contamination. Water and soil contamination caused by PCE dry cleaning has become a significant environmental and financial issue. Water supply planners have long been concerned about the loss of groundwater wells from PCE-related contamination; in the Metropolitan Water District service area there are 158 wells contaminated with PCE.[94] City well water contamination, attributed to PCE contamination from dry cleaners, have prompted two cities in California, Lodi and Modesto, to file suit against the manufacturers and distributors of PCE, as well as machine manufacturers and individual cleaners, to pay clean up costs.[95] An increasing number of states have created remediation programs in which cleaners and/or solvent distributors are assessed fees that go into a state superfund to pay for ground water and soil contamination clean-up. Of the twelve states that have a superfund fee program for PCE use, ten have also added a fee for other non-PCE solvent technology, with seven states specifically targeting petroleum dry cleaning.[96]

[92] Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.
[93] Sinsheimer, P.; Gottlieb, R. Supporting Pollution Prevention in the Garment Care Industry: An Assessment of Factors Influencing a Switch from Dry Cleaning to Professional Wet Cleaning, Pollution Prevention Education and Research Center, 2000.
[94] Pollution Prevention in the Garment Care Industry: Assessing the Viability of Professional Wet Cleaning, Pollution Prevention Education and Research Center, 1997.
[95] Lee Ronmey, "Wine Town With a Water Problem Is in Deep", Los Angeles Times, July 19,2004. Superior Court of the State of California: City of Modesto Redevelopment Agency vs. Dow Chemical Company, PPG Industries, Inc., et al.
[96] www.drycleancoalition.org/survey.pdf.

5. Recommendations

Based on the findings of this report, a series of research and policy recommendations should be considered to further our understanding of the energy and water use implications of different garment care technologies as well as to develop positive public policy.

5.1 Further Research

The current LADWP study was designed to evaluate electricity, water, and natural gas use of PCE dry cleaning and professional wet cleaning at one facility before and after it converted to the water-based technology in addition to an evaluation of three other facilities each using different garment care technologies – petroleum, CO2, and silicone.

Because the scope of the study was limited to a single estimate for each of the five technologies, it is important to be cautious in regards to generalizing the results. This is particularly important because there is a variety of available machine configurations and features for each of the five technologies evaluated in this study.

For each of the five technologies evaluated in this study, there are different machine manufacturers and machine configurations that are likely to have energy and water use consequences.

- *Professional Wet Cleaning*: The wet clean washer evaluated in this study was a fixed mount machine that can safely extract at a maximum of 550 rpm. Another popular wet clean washer can safely extract at 1,100 rpm. Extracting at the higher rpm eliminates more moisture from the garments, thus reducing the length of time required in drying. Another new wet clean washer, which is designed to lower water temperature to slightly above freezing, requires the addition of a refrigerated condenser.

- *PCE Dry Cleaning*: The PCE dry cleaning machine evaluated in this study was fifteen years old and classified as a third generation machine. Newer fifth generation PCE dry cleaning machines have many additional pollution control devises designed to further reduced PCE emissions. These advances are also likely to have resource use consequences.

- *Petroleum and Silicone Dry Cleaning*: There are a variety of different manufacturers of petroleum and silicone dry cleaning machines on the market, with a range of different solvent recovery systems.

- *CO2 Dry Cleaning*: There are currently five manufacturers of CO2 garment care systems worldwide. Each manufacturer has designed its machine differently from its competitors.

To more systematically study these technologies, Southern California Edison and Southern California Gas Company are implementing a joint research plan, administered by Occidental College, to develop a stable estimate of electricity and natural gas use for the five garment care technologies evaluated in this study. The scope of the research plan is to evaluate twenty-two test sites: five professional wet cleaning, five petroleum, five PCE, five silicone, and two CO2. This study will use the same data collection protocol used in the LADWP study, but is limited to measuring electricity and natural gas use; no funding is available to quantify water use. Additional funding from LADWP would help increase the number of facilities tested and/or add a water use component to the study.

An additional research area to study is the prevalence of cooling towers at dry cleaners that utilize "once through cooling." As was observed in the current study, the greater water use at the cleaner using the PCE dry clean machine was due to a broken reservoir float valve on the cooling tower, creating a water-intensive "once through cooling" system. While MWD recognizes "once through cooling" in cooling towers as a significant water use problem, there has been no study to quantify the prevalence of this problem in general or specifically in the garment care industry. A study designed to quantify the prevalence of this phenomenon is important to provide a more accurate estimate of water use in dry cleaners.

5.2 Potential for LADWP Energy Rebate Program

Based on the results of this LADWP study, professional wet cleaning appears to use substantially less electricity compared to other garment care technologies, without creating an increase in natural gas consumption.

While additional study is necessary to create a more stable estimate of electricity savings associated with the use of professional wet cleaning, it is useful to discuss developing a LADWP incentive program to encourage cleaners to switch to professional wet cleaning.

5.3 Existing Energy Rebate Programs for Professional Wet Cleaning

To date there are two energy-efficient rebate programs that have used data from our prior research to encourage cleaners to switch to professional wet cleaning. Burbank Water and Power, as part of their "general efficiency" program to the business/commercial sector, provided a $10,000 rebate for professional wet cleaning equipment after a cleaner switched from PCE dry cleaning.[97] As part of BWP's program, when a customer elects to make energy-efficient upgrades, BWP provides up to 25% of the cost of the upgrade.[98]

In 2004, professional wet cleaning was added to Southern California Edison's Early Retirement Program; this program provides multiple year incentives to commercial customers who replace less efficient equipment with more energy efficient equipment

[97] Olive Cleaners converted from PCE dry cleaning to professional wet cleaning in April 2004 as part of Occidental College's Professional Wet Cleaning Demonstration Program.
[98] http://www.consumerenergycenter.org/rebate/resultnew.php

before the expected life of the less efficient equipment has been reached.[99] For professional wet cleaning, the one-year incentive provided by Edison is $528; this is based on an average yearly electricity reduction of 6,600 kWh and a rate of $0.08/kWh. The estimated lifetime use for dry clean equipment was thirteen years. Thus, the maximum total amount of incentive provided is $6,864.[100]

Both the BWP program and the SCE program require cleaners to remove existing dry cleaning equipment to qualify for the rebate.

5.4 Options for an LADWP Rebate Program for Professional Wet Cleaning

There are many factors to consider when developing any energy-efficiency rebate program. These include the amount of energy saved by the technology, the amount of incentive that can influence the decision to purchase the technology, the ease in communicating the incentive program to the target audience, and the relative ease in administering the program.

Two options for an LADWP incentive program for professional wet cleaning are outlined below.

Fixed Percent Rebate Option

LADWP could develop a rebate program similar to BWP's program, which provides a fixed percent of the cost of professional wet cleaning equipment, up to a maximum amount. The BWP program provides up to 25% of the cost of an energy-efficient upgrade with a $10,000 maximum.

Besides the BWP rebate, the Burbank cleaner also received $12,500 to become one of Occidental College's professional wet cleaning demonstration sites. Our experience with this cleaner was that, without the full BWP rebate, the owner would not have made the decision to convert to professional wet cleaning.

Lifetime Savings Rebate Option

Another option is to base a rebate on the expected electricity savings over the lifetime of new equipment. The structure of such a rebate program could be modeled on SCE's early retirement program. One method for deriving this figure is as follows:

- Take the standardized estimate of savings in electricity. For example, at Del Rey Cleaners, the saving in switching from PCE dry cleaning to professional wet cleaning was 18.1 kWh/100 pounds cleaned.

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[99] www.sce.com/spc.

[100] The Southern California Edison program was based on the results of our 2002 study of cleaners switching to professional wet cleaning. See: Sinsheimer, P; Grout, C; Namkoong, A; Gottlieb, R. Commercialization of Professional Wet Cleaning. Occidental College, October 28, 2002.

- Multiply by the average yearly volume of garments professionally cleaned each year. USEPA estimates the yearly volume professionally cleaned garments to be 53,333 pounds. [101]

- Multiply by the expected life of professional wet cleaning equipment. In prior research, we estimated the minimum lifetime use of wet cleaning machines was fifteen years, with an expected average of twenty years. [102]

- Multiply by a set billing rate $/kWh. For this example, $0.07 will be used.

For this example, the total rebate comes to $13,515. [103]

Since PCE dry cleaning is being phased out in the greater Los Angeles region and since most cleaners in the region in purchasing new petroleum dry cleaning systems, the kWh savings figure for the rebate could be based on cleaners purchasing petroleum systems. In addition, one could take a conservative estimate of fifteen years to be the lifespan of professional wet cleaning equipment of fifteen years.

Based on these assumptions the total rebate comes to $6,329. [104] Any rebate program can be adjusted, based on additional data.

5.5 Policy Context of Creating a Rebate Program for Professional Wet Cleaning

Most cleaners in the City of Los Angeles will need to replace their old PCE dry cleaning machines in the next several years, so a rebate program for professional wet cleaning has a good chance of swaying cleaners towards the most energy-efficient technology.

While the South Coast Air Quality Management District phase-out rule allows cleaners to use PCE dry cleaning through 2020, older PCE machines are being phased out by 2007. [105] Of the 400 PCE dry cleaners in City of Los Angeles, an estimated 268 cleaners will need to purchase new professional cleaning equipment by November 2007.

An LADWP incentive for professional wet cleaning would also work in conjunction with new California state legislation (AB998) that provides a $10,000 grant to PCE dry cleaners replacing their machines with non-toxic, non-VOC technology. Professional wet cleaning and liquid CO2 are the two technologies that have received

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[101] *Cleaner Technologies Substitutes Assessment for Professional Fabricare Processes*, EPA 744-B-98-001; United States Environmental Protection Agency, Design for the Environment, 1998. This works out to 1,033 pounds per week (53,333 per year/12 months per year/4.3 weeks per month). At Del Rey Cleaners, weekly volume was estimated to be a minimum of 1,750 pounds.

[102] Pollution Prevention in the Garment Care Industry: Assessing the Viability of Professional Wet Cleaning, Pollution Prevention Education and Research Center, 1997.

[103] 18.1 kWh savings/100 lbs * 53,333 lbs * $0.07/kWh * 20 years.

[104] Using the estimate from this LADWP study, the savings in choosing professional wet cleaning over petroleum comes to 11.3 kWh/100 lbs – 23.3 kWh/100 lbs – 12 kWh/100 lb. Using a 15 year lifespan of equipment, the total estimate is as follows: 11.3 kWh savings/100 lbs * 53,333 lbs * $0.07/kWh * 15 years.

[105] www.aqmd.gov/rules/reg/reg14/r1421.pdf

preliminary approval for this program. Grants from this problem are due to be administered beginning in Spring 2005.

If LADWP does move forward with an incentive for professional wet cleaning, existing professional wet cleaning sites in the city could be used to educated cleaners about the program. There are currently five professional wet cleaning sites located in the city.

Appendix A

PCE DRY CLEAN TEST 1 – MAY 15, 2004 AT DEL REY CLEANERS

PCE Test 1 – Summary Results

	Time	Garments	Gas Meter	KWh Meter 1	kWh Meter 2	Boiler Water	Tower Water
Start Load 1	12:42	33 Lbs	64.8	42280.0	51276.0	180.0	70.5
Start Load 2	13:26	39 Lbs	69.0	42285.5	51278.5	182.5	121.0
End Load 2	14:24	--	74.6	42293.2	51281.8	186.3	187.0
End Pressing	15:52	--	82.4	42297.5	51287.5	190.0	--
	Minutes	**Load Lbs**	**Therms**	**kWh**	**kWh**	**Boiler Gallons**	**Tower Gallons**
Load 1	44	33	4.2	5.5		2.5	50.5
Load 2	58	39	5.6	7.7		3.8	66.0
Pressing	88	--	7.8	4.3	6.5[1]	3.7	--
Total	**190**	**72**	**17.6**	**24.0**		**10.0**	**116.5**
Per 100 Lbs	**--**	**--**	**24.4**	**33.3**		**13.9**	**161.8**

PCE Test 1 – kWh Background Readings

	Time	KWh Meter 1	KWh per Hr	KWh Meter 2	KWh per Hr
Start Pre-Test	11:57	280.0		274.0	
End Pre-Test	12:27	280.0	0.0	275.1	2.2

[1] The values recorded by kWh Meter 2 were adjusted down by 2.2 kWh per hour: (51287.5 kWh – 51276.0 kWh) - (3.2 hrs *2.2 kWh/hr) = 6.5 kWh.

APPENDIX A – PCE DRY CLEANING

PCE Dry Clean Test 1 – Dry Clean Machine Load Data

Load 1: Dark	
Garment Weight (lbs)	33.00
Program Number	Dark
Cycle Start Time	12:42
Cycle End Time	1:25
Total Time	43 min
Load 2: Light	
Garment Weight (lbs)	39.00
Program Number	Light
Cycle Start Time	1:26
Cycle End Time	2:24
Total Time	58 min

PCE Test 1 Garment Profiles[2]

Load 1: Dark Load			
#	Garment	Fiber	Care Label
1	BL	P	MW
2	SK	P/ACE	DCO
3	SK	C	MW
4	SW	R/N/SP	DC
5	SW	R/P/N/SP	HW
6	SW	R/N	MW
7	SK	P/R	DCO
8	BL	C	MW
9	BL	NL	NL
10	SW	C/SP	HW
11	SK	W	DCO
12	SK	NL	DCO
13	BL	P/ACE	DCO
14	S	C	MW
15	BL	LYOCELL	DCO
16	J	P/R	DCO
17	J	W/ACE	DCO
18	J	P	DCO
19	DR	NL	NL
20	S	L/R	HW
21	J	W/ACE	DCO
22	P	W	DCO
23	P	P	DCO
24	P	C/SP	MW
25	P	C	MW
26	P	C/SP	MW
27	P	C	MW
28	P	P/R/SP	DCO
29	J	W	DCO
30	P	NL	NL
31	P	P	MW/DC
32	P	P	MW/DC
33	P	P/R/SP	MW
34	P	C	MW
35	P	P/R/SP	NL
36	P	P/R/SP	NL
37	J	W	DCO
38	P	P/R/SP	NL
39	J	W	DC
40	P	W	DCO

[2] See Appendix F for key to garment profile terms.

Load 2: Light Load			
#	Garment	Fiber	Care Label
1	SK	P	DCO
2	BL	NL	NL
3	BL	R/P	MW/DC
4	S	C	MW
5	S	S	MW
6	SK	P/C	MW
7	S	L	MW
8	SK	C	MW
9	S	NL	NL
10	S	S	DCO
11	S	S	HW
12	S	S	DCO
13	DR	ACE/C/P	DCO
14	SW	NL	NL
15	BL	NL	MW
16	J	R/P	DCO
17	J	P/ACE	DCO
18	J	R/W/ACE	DCO
19	J	ACE/R	DCO
20	J	W	DCO
21	S	S	MW
22	J	P/ACE	DCO
23	S	S	MW
24	J	C/R/P/ACR	DCO
25	P	W	DCO
26	P	C	MW
27	P	C	MW
28	P	C/SP	MW
29	P	S/C	MW/DC
30	P	P/R/SP	DC
31	P	W	DCO
32	P	W	DCO
33	P	C	MW
34	P	C/SP	MW
35	P	C	MW
36	P	C	MW
37	P	C	MW

PCE DRY CLEAN TEST 2 – JUNE 25, 2004 AT DEL REY CLEANERS

PCE Test 2 – Summary Results

	Time	**Garments**	**Gas Meter**	**kWh Meter 1**	**kWh Meter 2**	**Boiler Water**	**Tower Water**
Start Load 1	8:03	30 Lbs	93.1	44511.8	52680.0	667.0	65680
Start Load 2	8:57	40 Lbs	97.5	44517.8	52683.0	669.0	65728
Start Load 3	10:04	36 Lbs	103.8	44526.1	52686.8	672.0	65800
End Load 3	10:48	--	108.0	44532.4	52689.8	680.0	65850
End Pressing	11:50		113.8	44536.0	52692.8	693.0	--
	Minutes	**Load Lbs**	**Therms**	**kWh**	**kWh**	**Boiler Gallons**	**Tower Gallons**
Load 1	54	30	4.4	6.0		2.0	48
Load 2	67	40	6.3	8.3		3.0	72
Load 3	44	36	4.2	6.3		8.0	50
Pressing	62	--	5.8	3.6	4.5[3]	13.0	--
Total	**227**	**106**	**20.7**	**28.7**		**26**	**170**
Per 100 Lbs	--	--	**19.5**	**27.1**		**24.5**	**160**

[3] The values recorded by kWh Meter 2 were adjusted down by 2.2 kWh per hour: (52680.0 kWh – 552692.8 kWh) - (3.8 hrs * 2.2 kWh/hr) = 4.5 kWh.

PCE Test 2 – Dry Clean Machine Load Data

Load 1: Dark	
Garment Weight (lbs)	30
Program Number	Dark
Cycle Start Time	8:03
Cycle End Time	8:57
Total Time	54 min
Load 2: Light	
Garment Weight (lbs)	40
Program Number	Light
Cycle Start Time	9:04
Cycle End Time	10:03
Total Time	59 min
Load 3: Dark	
Garment Weight (lbs)	36
Program Number	Dark
Cycle Start Time	10:04
Cycle End Time	10:48
Total Time	40 min

PCE Test 2 Garment Profiles[4]

Load 1: Dark Load			
#	Garment	Fiber	Care Label
1	J	W	DCO
2	J	P	MW
3	S	S	MW/DC
4	J	W	DCO
5	J	P	MW/DC
6	S	C	MW
7	S	S	MW
8	SK	S	DCO
9	B	C	MW
10	P	P	DC
11	S	R/P	MW/DC
12	S	C	MW
13	S	S	DCO
14	S	S	MW/DC
15	S	S	MW
16	S	S	MW/DC
17	S	C	NL
18	B	S	DCO
19	SW	C/W	MW/DC
20	SW	W	DC
21	J	W	DCO
22	P	P	MW/DC
23	P	L	MW/DC
24	P	ACE/P	DC
25	P	L	MW
26	P	W	DC
27	P	P/R/SP	DCO
28	P	P/R/SP	DCO
29	P	L	DCO
30	P	P	MW/DC
31	P	W	DCO
32	P	W	DCO
33	P	P/R/SP	DCO
34	P	P/R	HW
35	P	C/SP	MW

[4] See Appendix F for key to garment profile terms.

APPENDIX A – PCE DRY CLEANING

Load 2: Light			
#	**Garment**	**Fiber**	**Care Label**
1	S	POLYSONIC/P	MW/DC
2	P	C/P	MW
3	SW	ACR/C/N/SP	HW/DC
4	P	C/P	MW/DC
5	SK	C	MW
6	S	L	MW
7	SK	S	DCO
8	S	C	MW
9	P	ACE/P	DCO
10	SW	C	MW
11	SK	C/N/SP	MW/DC
12	BLANKET	C	NL
13	S	S	DC
14	P	NL	NL
15	P	C	MW
16	B	C/N/LYO	DCO
17	D	S	DCO
18	B	C	HW
19	P	W	DCO
20	P	P	MW/DC
21	P	W	DCO
22	SW	S/C	DCO
23	P	L	DCO
24	P	TEN/P	MW/DC
25	S	C	MW
26	SW	W	HW
27	S	C	MW/DC
28	S	L	DC
29	P	L	DCO
30	P	P	MW/DC
31	S	S	DCO
32	S	R	MW/DC
33	S	S	MW/DC
34	P	L	MW
35	B	C/SP	HW/MW
36	SW	S/N	DC
37	S	C/SP	MW
38	SW	C/SP	MW
39	SW	S/C/SP	DCO
40	SW	S/C	DCO
41	S	S	DCO

Load 3: Dark			
#	Garment	Fiber	Care Label
1	P	C/LY/SP	DCO
2	S	POLYSONIC/P	MW/DC
3	S	R	MW
4	P	W	DCO
5	J	W	DCO
6	SW	TEN	MW
7	P	W	DCO
8	P	C/LY/SP	MW
9	S	R/P	MW
10	P	ACE/R	DCO
11	P	L/R	DC
12	S	L/R	DCO
13	SK	C/LY/SP	MW
14	SK	C/N/SP	MW
15	B	S	NL
16	P	C/SP	HW/DC
17	J	C/SP	MW
18	S	C/N/SP	MW
19	P	VISC/P	DCO
20	P	P	DCO
21	P	C	MW
22	P	P	DCO
23	P	W	DCO
24	J	W	DCO
25	SW	NL	NL
26	S	POLYSONIC/P	MW
27	P	P	DC
28	P	W	DC
29	J	W	DCO
30	P	C	MW
31	P	W	DCO
32	J	W	DC
33	SW	S	DCO
34	SW	R/N	MW
35	B	P/SP	MW/DC
36	S	R/N	HW/MW
37	P	P/W	DCO
38	P	P	MW
39	P	P	MW

Del Rey Cleaners Monthly Billing Record Summary (LADWP)

	Days	HCF[5]	kWh 1	kWh 2
9/20/2004	32	38	1,432	1,003
8/19/2004	29	53	1,633	958
7/21/2004	30	110	1,626	983
6/21/2004	32	105	1,613	1,003
5/20/2004	29	100	1,940	1,009
4/21/2004	29	101	1,849	963
3/23/2004	29	103	1,903	982
2/23/2004	30	109	2,050	973
1/24/2004	33	114	1,772	962
12/22/2003	32	105	1,637	1,253
11/20/2003	30	109	1,753	1,328
10/21/2003	32	116	1,727	1,344
9/19/2003	30	97	1,506	1,405
8/20/2003	29	112	1,547	1,271
7/22/2003	32	101		
6/20/2003	30	109		
5/21/2003	29	102		
4/22/2003	29	103		

[5] One HCF is equivalent to 748 gallons of water.

Appendix B

PROFESSIONAL WET CLEAN TEST 1 – AUGUST 7, 2004 AT DEL REY CLEANERS

Wet Clean Test 1 – Summary Results

	Time[6]	Lbs	Gas Meter	kWh Meter 1	kWh Meter 2	Washer Water	Boiler Meter
Start Load 1	13:38		40.2	28.0	18.7	44	
End Load 1	14:29	15	42.2	29.8	20.5	63	56
End Load 2	15:09	20	45.5	32.0	22.0	82	58
End Load 3	15:50	40	49.8	35.0	24.2	99	61
End Pressing	16:40		53.3	37.8	26.0	-	66
	Minutes	**Load Lbs**	**Therms**	**kWh**	**kWh**	**Washer Water**	**Boiler Gallons**
Load 1	0:51	15	2.0	1.8		19	2
Load 2	0:40	20	3.3	2.2		19	2
Load 3	0:41	40	4.3	3.0		17	3
Pressing	0:50	-	3.5	2.8	0.6[7]		5
Total	**3:02**	**75**	**13.1**	**10.4**		**55**	**12**
Per 100 Lbs	-		**17.5**	**13.9**		**73.3**	**16.0**

[6] The start and end times refer to the time period starting when the wet clean washer load begins, and ending when all garments have been removed from the dryer. After the first wash load is completed, the washer and dryer units tended to be in operation at the same time.

[7] The values recorded by kWh Meter 2 were adjusted down by 2.2 kWh per hour: (26.0 kWh – 18.7 kWh) - (3.0 hrs *2.2 kWh/hr) = 0.6 kWh.

Wet Clean Test 1 – Washer and Dryer Load Data

Load 1: Light (Khakis)		
Wash		**Dry**
Garment Weight (lbs)	15	15
Program Number	4 (1/2 Cotton)	P3 Low
Cycle Start Time	13:38	14:06
Cycle End Time	14:05	14:26
Total Time	0:27	0:20
Load 2: Dark		
Wash		**Dry**
Garment Weight (lbs)	20	20
Program Number	6 (1/2 Cotton)	P3 High/Med
Cycle Start Time	14:06	14:06
Cycle End Time	14:34	14:34
Total Time	0:28	0:28
Load 3: Dark		
Wash		**Dry**
Garment Weight (lbs)	40	40
Program Number	1 (Wool Full)	P3 Low
Cycle Start Time	14:39	14:39
Cycle End Time	14:54	14:54
Total Time	0:15	0:15

Wet Clean Test 1 – Garment Profiles[8]

Load: 1 Light Cotton (Khakis Mostly)			
#	Garment	Fiber	Care Label
1	P	C	MW
2	P	C	MW
3	P	C	MW
4	P	C	MW
5	P	C	MW
6	P	C	MW
7	P	C	MW
8	J	C	MW
9	S	C	MW
10	P	C	MW
11	P	C	MW
12	P	C/P	MW
13	P	C/P	MW

Load: 2 Dark Cotton			
#	Garment	Fiber	Care Label
1	P	C	MW
2	P	P/R/SP	DCO
3	P	C/P/LY	MW
4	P	C	MW
5	P	C	MW
6	P	C/P/LY	MW
7	P	C	MW
8	P	C	MW
9	P	C	DCO
10	P	C/SP	MW
11	P	C	MW
12	P	C	MW
13	P	C	MW
14	P	C	MW
15	SW	C	MW
16	SW	C	MW

[8] See Appendix F for key to garment profile terms.

Load: 3 Dark Wool			
#	**Garment**	**Fiber**	**Care Label**
1	J	W	DCO
2	J	W	DCO
3	J	W/VISC	NL
4	S	P	MW
5	J	W	DCO
6	P	P/R/SP	DCO
7	P	W	NL
8	P	W	DCO
9	P	W	DCO
10	J	W	DCO
11	J	W	DCO
12	J	C/P	DCO
13	P	W/R	DCO
14	P	C/P	DCO
15	J	W	DCO
16	J	W	DC
17	J	S/W	DCO
18	P	W	DCO
19	P	P/VISC	DCO
20	J	W	DCO
21	J	W	DCO
22	J	W	DC
23	J	W	DCO
24	J	W	DCO
25	J	W/R	DCO

PROFESSIONAL WET CLEANING TEST 2 – AUGUST 28, 2004

Wet Clean Test 2 – Summary Results

	Time	Lbs	Gas Meter	kWh Meter 1	kWh Meter 2	Washer Water	Boiler Water
Start Load 1	12:57		23.5	98.2	51.1	-	-
End Load 1	13:31	40	25.0	100.4	52.3	17	56
End Load 2	13:50	20	26.5	101.5	53.4	14	59
End Load 3	14:23	20	29.4	103.0	54.2	18	63
End Pressing	15:32		34.9	105.5	57.0	-	67
	Minutes	**Load Lbs**	**Therms**	**kWh**	**kWh**	**Gallons**	**Boiler Gallons**
Load 1	0:34	40	1.5	2.2		17	-
Load 2	0:19	20	1.5	1.1		14	3
Load 3	0:33	20	2.9	1.5		18	4
Pressing	1:09	-	5.5	2.5	0.2[9]	-	4
Total	**2:35**	**80**	**11.4**	**7.5**		**49.0**	**14.0**
Per 100 Lbs	-	-	**14.3**	**10.0**		**65.3**	**18.7**

[9] The values recorded by kWh Meter 2 were adjusted down by 2.2 kWh per hour: (57.0 kWh – 51.1 kWh) - (2.6 hrs *2.2 kWh/hr) = 0.2 kWh.

Wet Clean Test 2 – Washer and Dryer Load Data

Load 1: Dark; Wool Full		
Wash		**Dry**
Garment Weight (lbs)	40	40
Program Number	1	P3 High
Cycle Start Time	12:57	13:18
Cycle End Time	13:17	13:31
Total Time	0:20	0:13
Load 2: Dark; Extra Fragile		
Wash		**Dryer Data**
Garment Weight (lbs)	20	20
Program Number	9	P3 Med
Cycle Start Time	13:19	13:33
Cycle End Time	13:31	13:50
Total Wash Time	0:12	0:17
Load 3: Light, Cotton		
Wash		**Dryer Data**
Garment Weight (lbs)	20	20
Program Number	4	P2 High
Cycle Start Time	13:42	14:11
Cycle End Time	14:10	14:23
Total Wash Time	0:28	0:12

Wet Clean Test 2 – Garment Profiles[10]

Load 1: Dark			
#	Garment	Fiber	Care Label
1	S	R/P	MW
2	S	R/P	MW
3	SW	W	HW
4	S	S	MW
5	S	S	MW
6	S	C/P	MW
7	SK	C/SP	DCO
8	S	R/SP	HW
9	S	TEN	DCO
10	S	R/P	MW
11	J	W	DCO
12	J	W	DCO
13	DR	R/SP	DC
14	P	C	MW
15	P	C/P/SP	MW
16	P	C/S/SP	MW
17	P	C	MW
18	P	P	MW
19	S	C	MW
20	P	W	DCO
21	P	C/SP	DCO
22	P	W	DCO
23	P	W	DCO
24	P	P	MW
25	P	W	DCO
26	P	P/W	DC
27	P	C	MW
28	P	C	MW
29	P	P	MW
30	SK	L	HW
31	P	W	DCO
32	P	W	DCO
33	P	W	DCO
34	P	C/P	NL
35	P	C/P	NL
36	P	W	DCO

10 See Appendix F for key to garment profile terms.

Load 1: Dark			
#	Garment	Fiber	Care Label
37	P	W	DCO
38	P	W	DCO
39	P	C	MW
40	P	C	MW
41	P	C	MW
42	P	P	DC
43	P	C	MW
44	P	W	DCO
45	P	W	DCO
46	P	P	DCO

Load 2: Dark			
#	Garment	Fiber	Care Label
1	BL	N/P/SP	HW
2	J	R	NL
3	BL	S/SP	DC
4	J	P	DCO
5	S	L	HW
6	J	ACE/R	DCO
7	BL	C/SP	MW
8	J	P	DCO
9	BL	S/SP	DCO
10	S	C/P	MW
11	BL	S	DC
12	BL	S/L	HW/DC
13	P	W	DCO
14	P	W	DCO
15	P	W	DCO
16	J	W	DCO
17	J	W	DCO
18	J	W	DCO

Load 3: Light			
#	**Garment**	**Fiber**	**Care Label**
1	P	C	MW
2	P	C	MW
3	P	C	MW
4	P	C	MW
5	P	P	MW
6	P	P	MW
7	P	C	MW
8	P	P	MW
9	P	C	MW
10	P	C	MW
11	P	C	MW
12	P	C	MW
13	P	C	MW
14	P	C	MW

Del Rey Cleaners Monthly Billing Record Summary (LADWP)

	Days	HCF	kWh 1	kWh 2
9/20/2004	32	38	1,432	1,003
8/19/2004	29	53	1,633	958
7/21/2004	30	110	1,626	983
6/21/2004	32	105	1,613	1,003
5/20/2004	29	100	1,940	1,009
4/21/2004	29	101	1,849	963
3/23/2004	29	103	1,903	982
2/23/2004	30	109	2,050	973
1/24/2004	33	114	1,772	962
12/22/2003	32	105	1,637	1,253
11/20/2003	30	109	1,753	1,328
10/21/2003	32	116	1,727	1,344
9/19/2003	30	97	1,506	1,405
8/20/2003	29	112	1,547	1,271
7/22/2003	32	101		
6/20/2003	30	109		
5/21/2003	29	102		
4/22/2003	29	103		

Appendix C

PETROLEUM DRY CLEAN TEST 1 – JUNE 19, 2004 AT HILLCREST CLEANERS

Petroleum Test 1 – Summary Results

	Time	Lbs	Gas Meter	kWh Meter	Tower Water	Boiler Water
Start Load 1	6:38	47	9791.0			
Start Load 2	7:48	45	9793.0			
Start Load 3	8:58	44	9796.5			
End Load 3	10:05		9799.6			
End Pressing	11:52		9804.0	Data based on data recorded by data loggers.		
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Gallons**	**Boiler Gallons**
Load 1	1:10	46	2.0	9.2	0	4
Load 2	1:10	45	3.5	10.3	3	7
Load 3	1:07	44	3.1	9.8	5	2
Pressing	1:47		4.4	3.0	-	3
Total	**5:14**	**135**	**13.0**	**32.3**	**8**	**16**
Per 100 Lbs	-	-	**9.6**	**23.9**	**6**	**12**

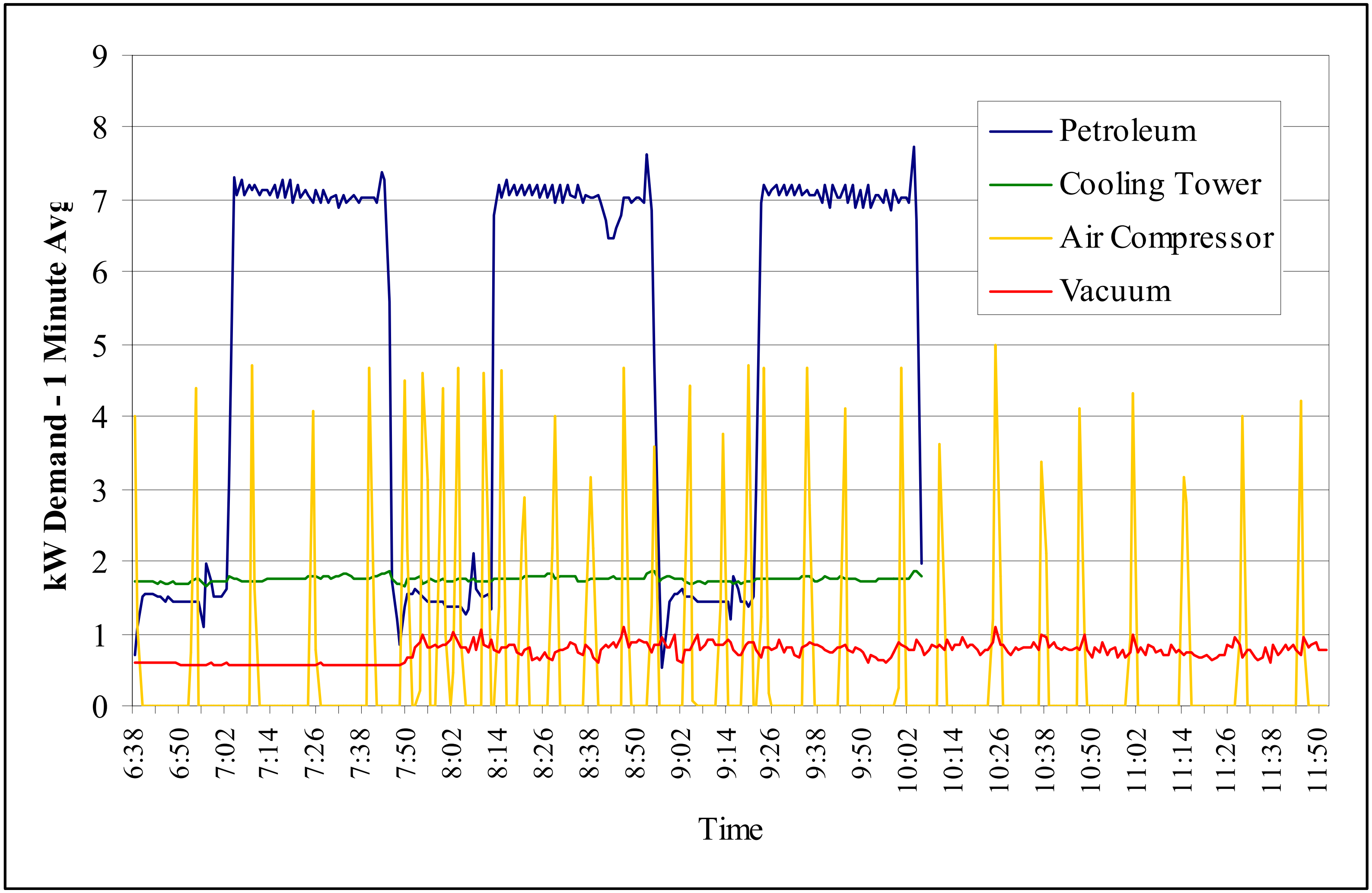
Petroleum Test 1 – Dry Clean Machine Load Data

Load 1: Dark Load	
Dry to Dry Data	
Garment Weight (lbs)	46.70
Program Number	8
Cycle Start Time	6:38
Cycle End Time	7:45
Total Time	1:07

Load 2: Light Load	
Dry to Dry Data	
Garment Weight (lbs)	45.40
Program Number	7
Cycle Start Time	7:48
Cycle End Time	8:55
Total Time	1:07

Load 3: Dark Load	
Dry to Dry Data	
Garment Weight (lbs)	44.00
Program Number	8
Cycle Start Time	8:58
Cycle End Time	10:05
Total Time	1:07

Petroleum Test 1 – Electricity Sub Meter Data



Petroleum Test 1 – Electricity Consumption by Equipment

Equipment	**kWh**
Petroleum Dry Clean Machine	16.91
Cooling Tower Pump	3.99
Cooling Tower Fan	2.09
Air Compressor	3.04
Vacuum	3.9
Boiler	1.49
Irons	0.83
Total	33.08
Per 100 Lbs	24.50

Petroleum Test 1 – Garment Profiles[11]

Load 1: Dark Load			
#	**Garment**	**Fiber**	**Care Label**
1	Pants	Cotton	Machine Wash/Dry Clean
2	Shirt	Cotton	Machine Wash
3	Shirt	Rayon	Machine Wash/Dry Clean
4	Shirt	Polyester	Machine Wash
5	Jacket	Cotton/Spandex	Dry Clean Only
6	Jacket	Cotton/Spandex	Dry Clean Only
7	Pants	Rayon/Visco/Spandex	Dry Clean Only
8	Shirt	Cotton	Machine Wash
9	Pants	Cotton	Machine Wash
10	Pants	Polyester/Rayon	Dry Clean Only
11	Jacket	Polyester	Dry Clean Only
12	Pants	Linen/Rayon	Machine Wash
13	Pants	Wool	Dry Clean Only
14	Pants	Wool	Dry Clean Only
15	Pants	Cotton/Spandex	Machine Wash
16	Shirt	Cotton	Machine Wash
17	Shirt	Cotton	Machine Wash
18	Pants	Cotton	Machine Wash
19	Pants	Lyocell/Cotton	Machine Wash
20	Shirt	Wool	Dry Clean Only
21	Pants	Wool/Polyester	Machine Wash
22	Pants	Wool	Dry Clean Only
23	Pants	Wool	Dry Clean Only
24	Shirt	Silk	Machine Wash
25	Shirt	Cotton	Machine Wash
26	Shirt	Cotton	Machine Wash
27	Shirt	Silk	Machine Wash
28	Pants	Polyester/Rayon	Dry Clean Only
29	Shirt	Silk	Machine Wash/Dry Clean
30	Shirt	Silk	Machine Wash/Dry Clean
31	Pants	Wool	Dry Clean Only
32	Pants	Lycra/Wool	Dry Clean Only
33	Shirt	Silk	Dry Clean Only
34	Shirt	Silk	Dry Clean Only
35	Skirt	Cotton	Hand Wash/Machine Wash
36	Pants	Cotton/Spandex	Dry Clean
37	Pants	Cotton	Machine Wash
38	Skirt	Cotton	Machine Wash
39	Pants	Lycra/Wool	Dry Clean Only
40	Blouse	Polyester	Machine Wash
41	Pants	Polyester	Dry Clean Only
42	Jacket	Wool	Dry Clean Only

[11] See Appendix F for key to garment profile terms.

APPENDIX C – PETROLEUM DRY CLEANING

Load 1: Dark Load			
#	**Garment**	**Fiber**	**Care Label**
43	Shirt	Cotton	Machine Wash
44	Pants	Cotton/Spandex	Machine Wash
45	Shirt	Rayon/Nylon/Polyester	Dry Clean Only
46	Shirt	Silk/Nylon	Dry Clean Only
47	Dress	Rayon	Dry Clean Only
48	Pants	Cotton	Machine Wash
49	Pants	Cotton	Machine Wash
50	Pants	Rayon/Spandex	Dry Clean Only
51	Shirt	Silk/Cotton	Machine Wash
52	Pants	Linen	Machine Wash
53	Pants	Cotton	Machine Wash
54	Shirt	Silk	Machine Wash/Dry Clean
55	Shirt	Cotton	Machine Wash
56	Skirt	Cotton	Machine Wash

Load 2: Light Load			
#	**Garment**	**Fiber**	**Care Label**
1	Skirt	Polyester	Machine Wash
2	Blouse	Silk	Dry Clean Only
3	Pants	Cupro/Acetate	Dry Clean Only
4	Shirt	Cotton	Dry Clean Only
5	Shirt	Silk	Dry Clean Only
6	Shirt	Silk	Dry Clean Only
7	Jacket	Wool	Dry Clean Only
8	Pants	Acetate	Dry Clean Only
9	Pants	Rayon/Polyester/Spandex	Dry Clean Only
10	Pants	Wool	Dry Clean
11	Jacket	Cotton	Machine Wash
12	Shirt	Cotton	Dry Clean
13	Shirt	Silk	Dry Clean Only
14	Shirt	Cotton	Dry Clean
15	Pants	Cotton	Machine Wash
16	Pants	Cotton	Machine Wash
17	Shirt	Cotton	Machine Wash
18	Pants	Cotton	Machine Wash
19	Pants	Polyester	Machine Wash
20	Blouse	Silk	Dry Clean Only
21	Shirt	Linen/Rayon	Dry Clean Only
22	Pants	Linen/Cotton	Machine Wash/Dry Clean
23	Shirt	Silk	Dry Clean Only
24	Pants	Cotton	Machine Wash
25	Shirt	Silk	Dry Clean Only
26	Blouse	Cotton/Polyester	Dry Clean
27	Jacket	Viscose/Polyester/Cotton	Dry Clean Only
28	Shirt	Polyester	Dry Clean Only

Load 2: Light Load			
#	**Garment**	**Fiber**	**Care Label**
29	Shirt	Cotton	Machine Wash
30	Shirt	Silk	Dry Clean Only
31	Blouse	Lycra/Rayon	Dry Clean Only
32	Shirt	Rayon	Dry Clean Only
33	Pants	Linen/Rayon	Dry Clean Only
34	Hat	Cotton	Dry Clean
35	Skirt	Cotton	Dry Clean
36	Shirt	Rayon	Dry Clean Only
37	Pants	Rayon	Dry Clean Only
38	Pants	Cotton/Polyester/Spandex	Dry Clean Only
39	Pants	Wool	Dry Clean Only
40	Jacket	Wool/Polyester/Spandex	Dry Clean Only
41	Blouse	Cotton	Machine Wash
42	Sweater	Cotton	Dry Clean
43	Shirt	Rayon/Polyester	Dry Clean Only
44	Pants	Wool	Dry Clean Only

Load 3: Dark Load			
#	**Garment**	**Fiber**	**Care Label**
1	Skirt	Wool/Rayon/Acetate	Dry Clean
2	Dress	Polyester/Cotton	Machine Wash
3	Shirt	Polyester/Cotton	Machine Wash
4	Pants	Cotton/Spandex	Machine Wash
5	Shirt	Cotton/Polyester	Machine Wash
6	Pants	Linen/Cotton	Machine Wash
7	Skirt	Linen/Spandex	Machine Wash
8	Shorts	Cotton	Machine Wash
9	Pants	Cotton/Spandex	Machine Wash
10	Pants	Cotton/Spandex	No Label
11	Shirt	Silk	Machine Wash/Dry Clean
12	Pants	Wool	No Label
13	Pants	Polyester	Machine Wash
14	Shorts	Cotton	Machine Wash
15	Shorts	Lyocell/Cotton	Machine Wash
16	Shirt	Silk	Hand Wash/Dry Clean
17	Shirt	Silk	Machine Wash/Dry Clean
18	Skirt	Polyester	Machine Wash/Dry Clean
19	Sweater	Cashmere	Dry Clean Only
20	Shirt	Silk	Dry Clean Only
21	Jacket	Polyester	Machine Wash/Dry Clean
22	Blouse	Cotton	Machine Wash
23	Pants	Cotton/Polyester	Machine Wash
24	Shorts	Silk	Machine Wash/Dry Clean
25	Shorts	Lyocell/Cotton	Machine Wash
26	Shirt	Silk	Machine Wash/Dry Clean
29	Pants	Rayon/Cotton/Polyester/Spandex	Dry Clean Only

Load 3: Dark Load			
#	**Garment**	**Fiber**	**Care Label**
30	Shorts	Cotton/Polyester	Machine Wash
31	Shorts	Silk	Machine Wash/Dry Clean
32	Shirt	Silk/Cotton/Acetate	Dry Clean
33	Pants	Polyester	Machine Wash/Dry Clean
34	Pants	Cotton/Spandex	Machine Wash
35	Pants	Cotton/Spandex	Dry Clean
36	Shirt	Polyester/Spandex/Rayon	Dry Clean
37	Pants	Polyester/Wool	Machine Wash/Dry Clean
38	Pants	Wool/Silk	Dry Clean
39	Blouse	Linen/Cotton	Machine Wash
40	Shirt	Silk	Dry Clean
41	Sweater	Linen/Cotton	Dry Clean
42	Shirt	Silk	Machine Wash/Dry Clean
43	Shirt	Viscose	Hand Wash/Dry Clean
44	Shirt	Silk	Machine Wash
45	Sweater	Silk/Nylon/Lycra/Spandex	Dry Clean Only
46	Shirt	Silk	Machine Wash
47	Blouse	Cotton	Hand Wash
48	Sweater	Rayon/Nylon	Hand Wash

PETROLEUM TEST 2 – JUNE 26, 2004 AT HILLCREST CLEANERS

Petroleum Test 2 – Summary Results

	Time	Lbs	Gas Meter	kWh Meter	Tower Water	Boiler Water
Start Load 1	6:40	44	986.3			
Start Load 2	7:52	44	989.0			
Start Load 3	9:00	50	992.4			
End Load 3	10:07		995.0			
End Pressing	11:44		998.4	Data based on data recorded by data loggers.		
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Tower Gallons**	**Boiler Gallons**
Load 1	1:12	44	2.7	9.8	2	0
Load 2	1:08	44	3.4	9.7	4	4
Load 3	1:07	50	2.6	9.5	9	2
Pressing	1:37		3.4	2.7	-	4
Total	**5:04**	**138**	**12.1**	**31.7**	**15**	**10**
Per 100 Lbs	**-**	**-**	**8.8**	**23.0**	**10.9**	**7.2**

APPENDIX C – PETROLEUM DRY CLEANING

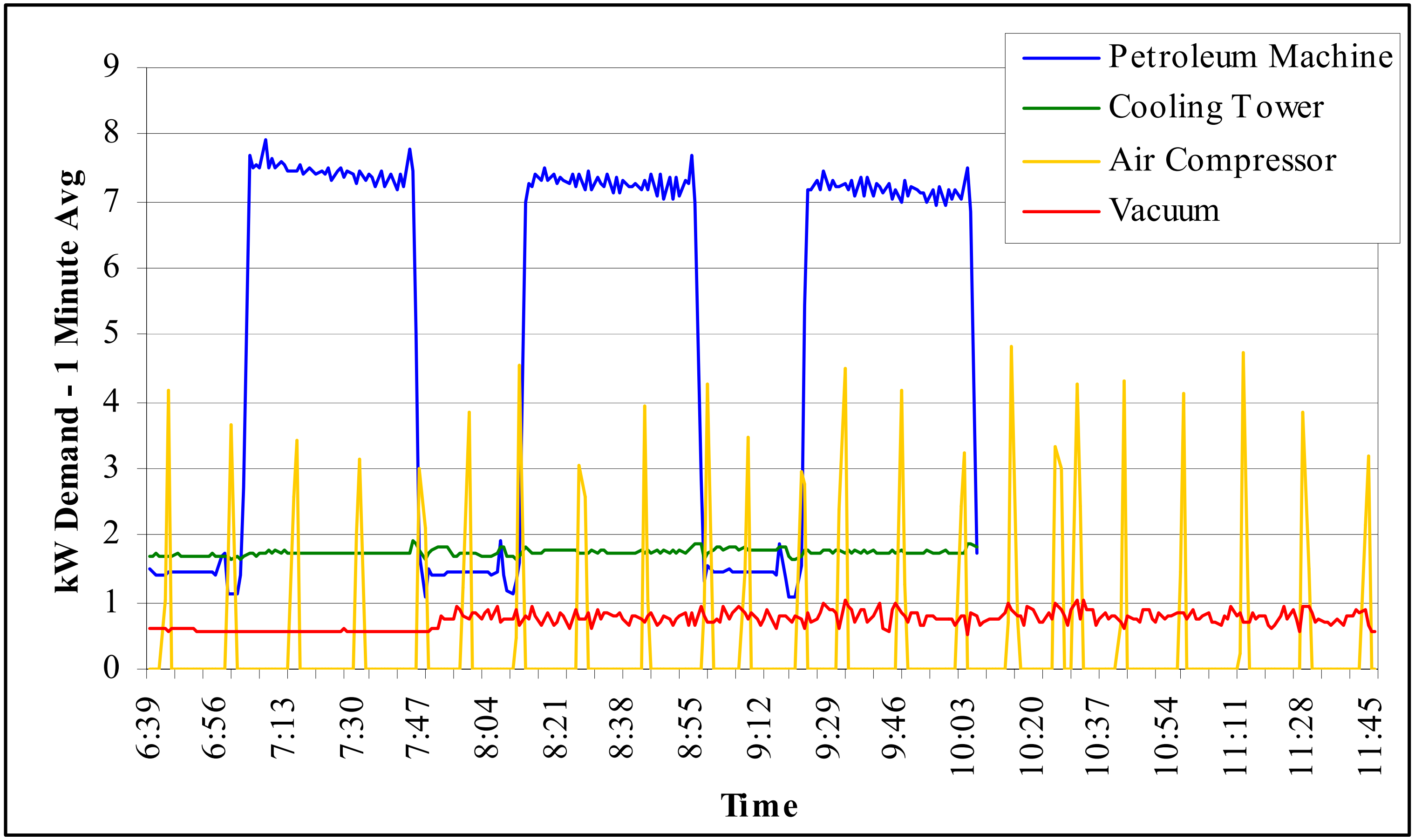
Petroleum Test 1 – Dry Clean Machine Load Data

Load 1: Dark Load	
Dry to Dry Data	
Garment Weight (lbs)	44
Program Number	8
Cycle Start Time	6:40
Cycle End Time	7:47
Total Time	1:07

Load 2: Light Load	
Dry to Dry Data	
Garment Weight (lbs)	44
Program Number	7
Cycle Start Time	7:50
Cycle End Time	8:59
Total Time	1:09

Load 3: Dark Load	
Dry to Dry Data	
Garment Weight (lbs)	50
Program Number	8
Cycle Start Time	9:00
Cycle End Time	10:07
Total Time	1:07

Petroleum Test 2 – Electricity Sub Meter Results



Petroleum Test 2 – Electricity Consumption by Equipment

Equipment	**kWh**
Hydrocarbon	17.65
Tower Pump	3.96
Tower Fan	2.10
Air Compressor	2.11
Vacuum	3.76
Boiler	2.20
Irons	0.01
Total	31.80
Per 100 Lbs	23.10

Petroleum Test 2 – Garment Profiles[12]

Load: 1 Dark			
#	Garment	Fiber	Care Label
1	S	R/P	MW/DC
2	P	P/R/LY	DCO
3	P	P/R/LY	DCO
4	P	W	DCO
5	P	C/LY	DCO
6	P	P/W/LY	DCO
7	P	P/W/LY	DCO
8	D	R	DCO
9	P	C/SP	MW
10	P	W	DC
11	S	R/P	MW
12	S	C	MW
13	P	P/R/SP	DCO
14	SW	ACR/C	MW/DC
15	P	P/W	MW/DC
16	P	P/W	DCO
17	SK	P/W	DCO
18	J	W	DCO
19	D	R	DCO
20	P	W	DCO
21	P	P/C	MW
22	SK	P/W	DC
23	SK	P/W	DC
24	V	P/W	DC
25	SK	P/W	DCO
26	P	C/LY	MW
27	P	P/R/SP	DCO
28	B	C/P	NL
29	D	P	MW
30	S	W	DCO
31	S	W	DCO
32	S	W	DCO
33	P	W	DCO
34	P	C/LY	DCO
35	P	C/SP	DC
36	P	C/SP	DCO
37	S	R	DCO
38	D	P	DCO
39	P	W/N/SP	DCO
40	SW	C	DC
41	P	W	DCO
42	S	W	DCO

[12] See Appendix F for key to garment profile terms.

APPENDIX C – PETROLEUM DRY CLEANING

Load: 1 Dark			
#	**Garment**	**Fiber**	**Care Label**
43	P	W	DCO
44	J	P	DCO
45	P	W	DCO
46	P	W	DCO
47	S	W	DCO
48	P	W	DCO
49	P	C/SP	MW
50	SW	S	DCO
51	P	P/R	DCO
52	B	C	MW

Load: 2 Light			
#	**Garment**	**Fiber**	**Care Label**
1	P	W	DCO
2	D	S	DCO
3	P	P/R	DCO
4	B	S	DCO
5	P	C/P	MW
6	B	C	MW
7	P	C	MW
8	P	P	MW/DC
9	P	C	MW
10	V	L/VISC	DCO
11	S	VISC	DCO
12	P	P/R/SP	DCO
13	P	P/R/SP	DCO
14	P	C	MW
15	P	L/C	MW
16	SW	C/SP	DC
17	B	C	MW
18	P	R/P/SP	**DCO**
19	S	L	DCO
20	S	C	MW
21	S	R/P/SP	DCO
22	P	C	MW
23	BLANKET	W	DCO
24	S	S	DCO
25	B	C/SP	MW
26	P	W	DCO
27	B	S	DCO
28	J	W	DCO
29	S	C	DCO
30	SW	RAMIE/C	DCO
31	S	C	DCO
32	P	L	MW

Load: 2 Light			
#	**Garment**	**Fiber**	**Care Label**
33	P	L	DCO
34	P	W	DCO
35	J	W	DCO
36	P	C	MW
37	B	S	DCO
38	S	S	DCO
39	S	R	MW
40	P	P/VISC/SP	DCO
41	S	S	DCO
42	P	C/SP	MW
43	P	C	DCO
44	P	C	MW
45	S	R/P	DCO
46	SW	R/N	DCO
47	J	W	DCO
48	P	P/R	MW
49	T	S	DCO
50	T	S	DCO
51	B	S	DCO
52	P	W	DCO
53	P	R/P	DCO
54	B	R/P	DCO
55	SW	R/N	MW/DC
56	P	C/LY	DCO
57	S	C	MW

Load: 3 Dark			
#	**Garment**	**Fiber**	**Care Label**
1	P	W	DCO
2	S	W	DCO
3	J	W	DCO
4	S	W	DCO
5	S	W	DCO
6	P	C/SP	MW
7	P	C/SP	MW
8	J	W	DC
9	S	S	DC
10	S	R	MW
11	P	W	DCO
12	B	R	MW/DC
13	S	R	DCO
14	S	W	DCO
15	B	L	DCO
16	P	C/R	DCO
17	P	C/SP	DCO

APPENDIX C – PETROLEUM DRY CLEANING

Load: 3 Dark			
#	**Garment**	**Fiber**	**Care Label**
18	P	P/W/LY	DC
19	P	LYOCELL/P	DC
20	P	W	DCO
21	P	W	DCO
22	B	C	MW
23	P	W	DCO
24	P	W	DCO
25	P	W	DCO
26	S	W	DCO
27	P	P/R	DCO
28	P	W	DCO
29	P	W	DCO
30	J	P/R	DCO
31	P	P	MW
32	P	P	MW
33	P	P	DCO
34	P	C	MW
35	P	P	MW/DC
36	P	L	MW
37	P	P/R	MW
38	P	W	DCO
39	P	W	DCO
40	P	C	MW
41	P	L	DCO
42	P	W	DCO
43	P	C	MW
44	SW	C	MW
45	S	LYOCELL	DCO
46	P	L	MW
47	S	S	DCO
48	P	R/P	DCO
49	P	P	MW
50	P	S	DCO
51	B	R	DC

Appendix D

LQUID CO2 DRY CLEAN TEST 1 – JULY 31, 2004 AT ROSALI CLEANERS

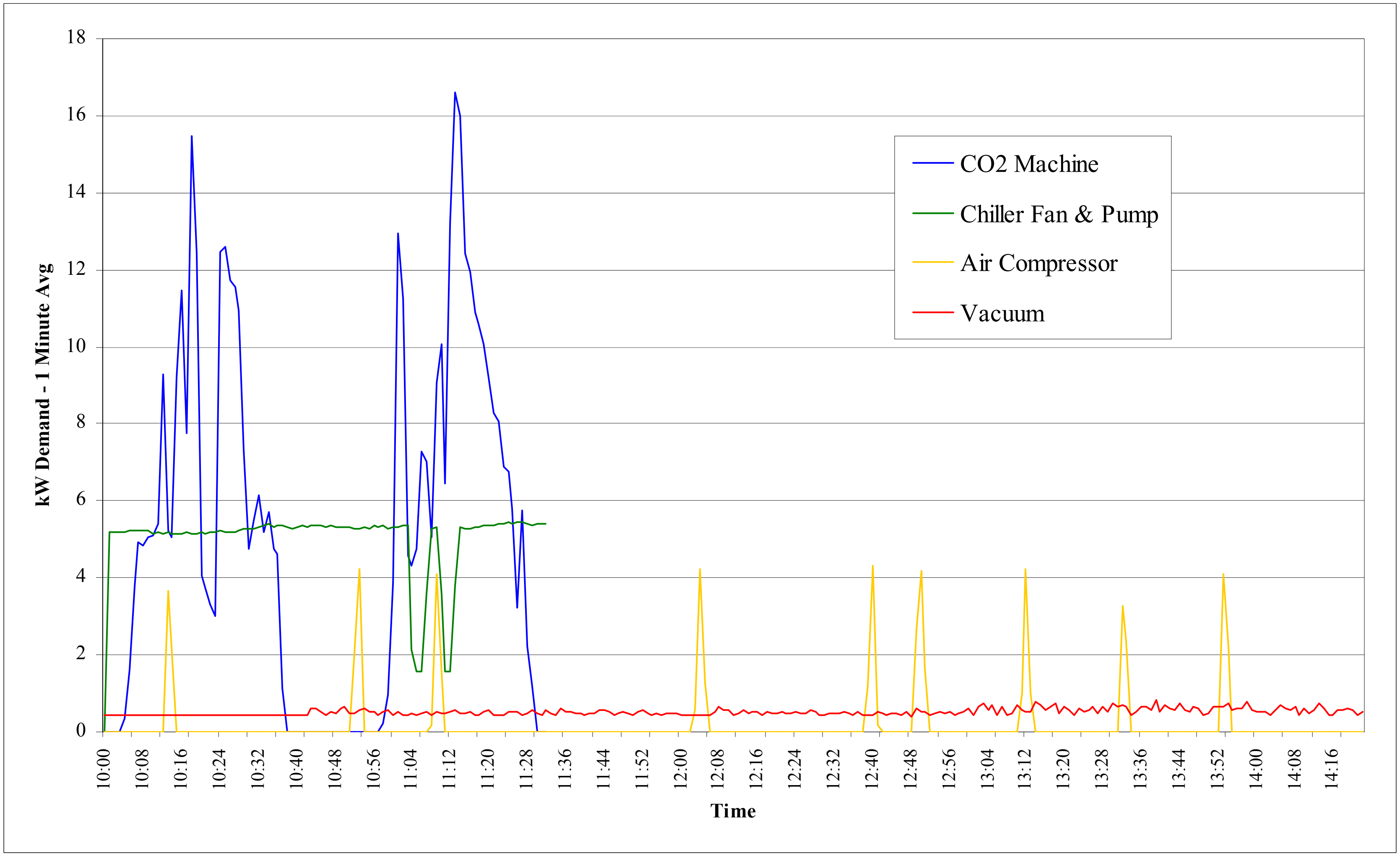
CO2 Test 1 – Summary Results

	Time	**Lbs**	**Gas Meter**	**kWh Meter**	**Boiler Water**
Start Load 1	10:01	22	5887.1	Results based on data recorded by data logger	825.6
End Load 1	10:39		5888.5		825.6
Start Load 2	10:55	40	5888.9		825.6
End Load 2	11:32		5890.2		828.9
End Pressing	14:22		5896.0		837.8
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Boiler Gallons**
Load 1	0:38	22	1.4	9.3	0.0
Load 2	0:37	40	1.3	7.5	3.3
Pressing	2:50		5.8	2.3	8.9
Total	**4:21**	**62**	**8.9**	**19.0**	**12.2**
Per 100 Lbs	**-**	**-**	**14.4**	**30.7**	**19.7**

CO_2 Test 1 – Dry Clean Machine Load Data

Load 1: Light	
Garment Weight (lbs)	22
Program Number	1 Bath Cycle
Cycle Start Time	10:01
Cycle End Time	10:39
Total Time	0:38
Load 2: Dark	
Garment Weight (lbs)	40
Program Number	1 Bath Cycle
Cycle Start Time	10:55
Cycle End Time	11:32
Total Time	0:37

CO2 Test 1 – Electricity Sub Meter Data



CO2 Test 1 – Electricity Consumption by Equipment

Equipment	kWh
CO2 Machine	7.87
Chiller Pump	2.40
Chiller Fan	5.33
Air Compressor	0.94
Vacuum	2.25
Boiler	0.22
Pressing Board	0.00
Susie	0.00
Total	19.01
Per 100 Lbs	30.79

CO2 Test 1 – Garment Profiles[13]

Load 1: Light			
#	Garment	Fiber	Care Label
1	P	C/SP	MW
2	B	C/SP	MW
3	P	L	MW
4	B	L/C	MW
5	P	C/SP	MW
6	S	C/SP	MW
7	P	L/R	MW
8	B	L/C	MW
9	SW	C/SP	MW
10	B	R	MW
11	P	R	MW
12	P	L	MW
13	S	B	DCO
14	B	R/N	DC
15	B	N/SP	MW
16	B	S	DCO
17	S	S	MW
18	DR	S	NL
19	S	C/SP	MW
20	P	C/SP	MW
21	DR	S	NL
22	P	L	DCO
23	P	W	DCO
24	J	L	DCO
25	B	C/SP	HW
26	SK	C/N	DCO
27	SW	C	HW
28	P	L	MW
29	SW	R/N/SP	HW
30	P	L	MW
31	SW	C	DC/HW
32	B	C	MW
33	SW	C	HW
34	B	L	MW
35	DR	R	DC/HW
36	S	C	MW

[13] See Appendix F for key to garment profile terms.

APPENDIX D – CO2 DRY CLEANING

Load 2: Dark			
#	Garment	Fiber	Care Label
1	P	C	MW
2	P	C	MW
3	P	C	MW
4	P	W	NL
5	S	C	MW
6	S	C/VISC	MW
7	SK	S/C	MW
8	P	P/R/SP	MW
9	P	P/W/LY	MW
10	P	P/R	MW
11	P	P/R/SP	DCO
12	S	C	NL
13	S	C	MW
14	S	C/MODAL/SP	MW
15	SW	C	MW
16	P	W	DCO
17	J	W	DCO
18	P	C/LY	DC/MW
19	P	C	MW
20	P	C	MW
21	B	S/C	DCO
22	S	C	MW
23	P	C	MW
24	S	C	MW
25	P	C	MW
26	P	C	MW
27	P	L	MW
28	P	C	MW
29	P	C	MW
30	P	C	MW
31	P	C	MW
32	P	C	MW
33	P	P/W	MW
34	S	C	MW
35	B	C/SP	HW
36	S	S/C	DC
37	SW	ACR/W/N	DCO
38	P	W	DCO

LIQUID CO2 TEST 2 – AUGUST 2, 2004 AT ROSALI CLEANERS

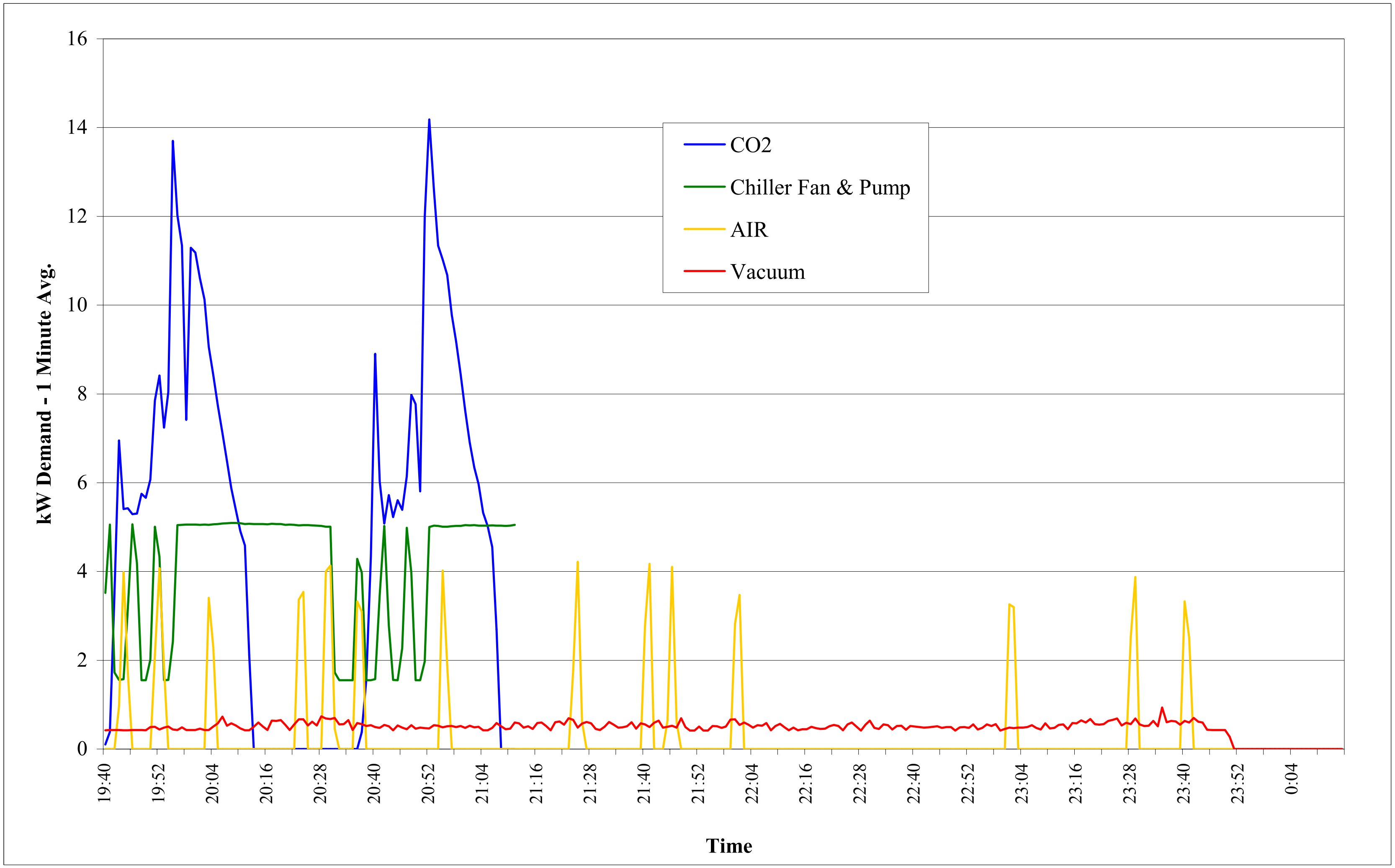
CO2 Test 2 – Summary Results

	Time	**Lbs**	**Gas Meter**	**kWh Meter**	**Boiler Water**
Start Load 1	19:37	35	5932.8	Results based on data recorded by data logger	880.6
End Load 1	20:12		5934.0		881.4
Start Load 2	20:34	30	5934.9		881.9
End Load 2	21:09		5936.1		883.1
End Pressing	0:15		5940.6		887.9
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Boiler Gallons**
Load 1	0:35	35	1.2	8.9	0.8
Load 2	0:35	30	1.2	6.5	1.2
Pressing	3:06	-	4.5	2.2	4.8
Total	**4:38**	**65**	**7.8**	**17.6**	**7.3**
Per 100 Lbs	-	-	**12.0**	**27.1**	**11.2**

CO2 Test 2 – CO2 Machine Load Data

Load 1: Dark	
Garment Weight (lbs)	35
Program Number	1 Bath Cycle
Cycle Start Time	7:37
Cycle End Time	8:12
Total Time	0:35
Load 2: Light	
Garment Weight (lbs)	30
Program Number	1 Bath Cycle
Cycle Start Time	8:34
Cycle End Time	9:09
Total Time	0:35

CO2 Test 2 – Electricity Sub Meter Data



CO2 Test 2 – Electricity Demand by Equipment

Equipment	**kWh**
CO2 Machine	7.51
Chiller Pump	2.39
Chiller Fan	3.86
Air Compressor	1.53
Vacuum	2.18
Boiler	0.16
Pressing Board	0.00
Susie	0.00
Total	17.64
Per 100 Lbs	27.13

CO2 Test 2 – Garment Profiles[14]

Load 1: Dark			
#	**Garment**	**Fiber**	**Care Label**
1	P	P/W	DC
2	P	P/W/LY	MW
3	P	P/R	MW
4	P	P/R/SP	MW
5	P	W	DCO
6	P	C	MW
7	S	C/LY	MW
8	P	C/TEN	MW
9	COAT	ACR/P	MW
10	S	W	DC/HW
11	S	R	HW
12	S	C/LY/SP	MW
13	SH	C	MW
14	S	P/C	MW
15	S	C	MW
16	S	C	MW
17	S	C./LY	MW
18	SH	L	NL
19	P	C	MW
20	S	C	MW
21	S	C	MW
22	J	P	DCO
23	P	C	MW
24	P	P/R	MW
25	P	P	NL
26	S	C	MW
27	S	C	MW
28	SW	W	NL
29	SW	P/C	HW
30	P	C/SP	MW
31	P	P/R/SP	DCO
32	S	S	MW
33	P	C/LY	DCO
34	S	C	MW
35	S	P/C	MW
36	P	P	NL
37	P	C	MW
38	TIE	S	NL

[14] See Appendix F for key to garment profile terms.

Load 2: Light			
#	**Garment**	**Fiber**	**Care Label**
1	S	C	MW
2	P	L	DCO
3	SW	R/N	DC
4	DR	P	DC
5	SW	R/N	NL
6	DR	P/SP	DCO
7	SW	C	MW
8	BL	NL	NL
9	BL	NL	NL
10	S	C	DCO
11	P	C	MW
12	P	W	DCO
13	P	C	MW
14	P	S	DCO
15	P	C/SP	MW
16	SW	W	DC/HW
17	J	W	DCO
18	S	C/R	MW
19	S	R/N	HW
20	P	P	NL
21	S	P	MW
22	BL	C/R	DCO
23	S	C	MW
24	S	TEN	MW
25	S	C	MW
26	S	P	MW
27	S	C	MW
28	SK	L/R	MW
29	S	C	MW
30	SW	C	DCO
31	S	C	MW
32	S	C	MW
33	S	S	DCO
34	S	ACE/R/C	DCO
35	J	L	NL

Appendix E

SILICONE DRY CLEAN TEST 1 – AUGUST 23, 2004 AT CLEANER BY NATURE

Silicone Test 1 – Summary Results

	Time	Lbs	Gas Meter	kWh Meter	Tower Water	Boiler Water
Start Load 1	5:53	55	60.0	Electricity results are based on data recorded by a data logger	Water meters were not installed in time for the first test	
Start Load 2	7:16	55	64.2			
End Load 2	8:26		68.0			
End Pressing	10:14		72.9			
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Tower Gallons**	**Boiler Gallons**
Load 1	1:23	55	4.2	20.8	Water meters were not installed in time for the first test	
Load 2	1:10	55	3.8	19.4		
Pressing	1:48		4.9	10.1		
Total	**4:21**	**110**	**12.9**	**50.3**		
Per 100 Lbs	-	-	**11.7**	**45.7**		

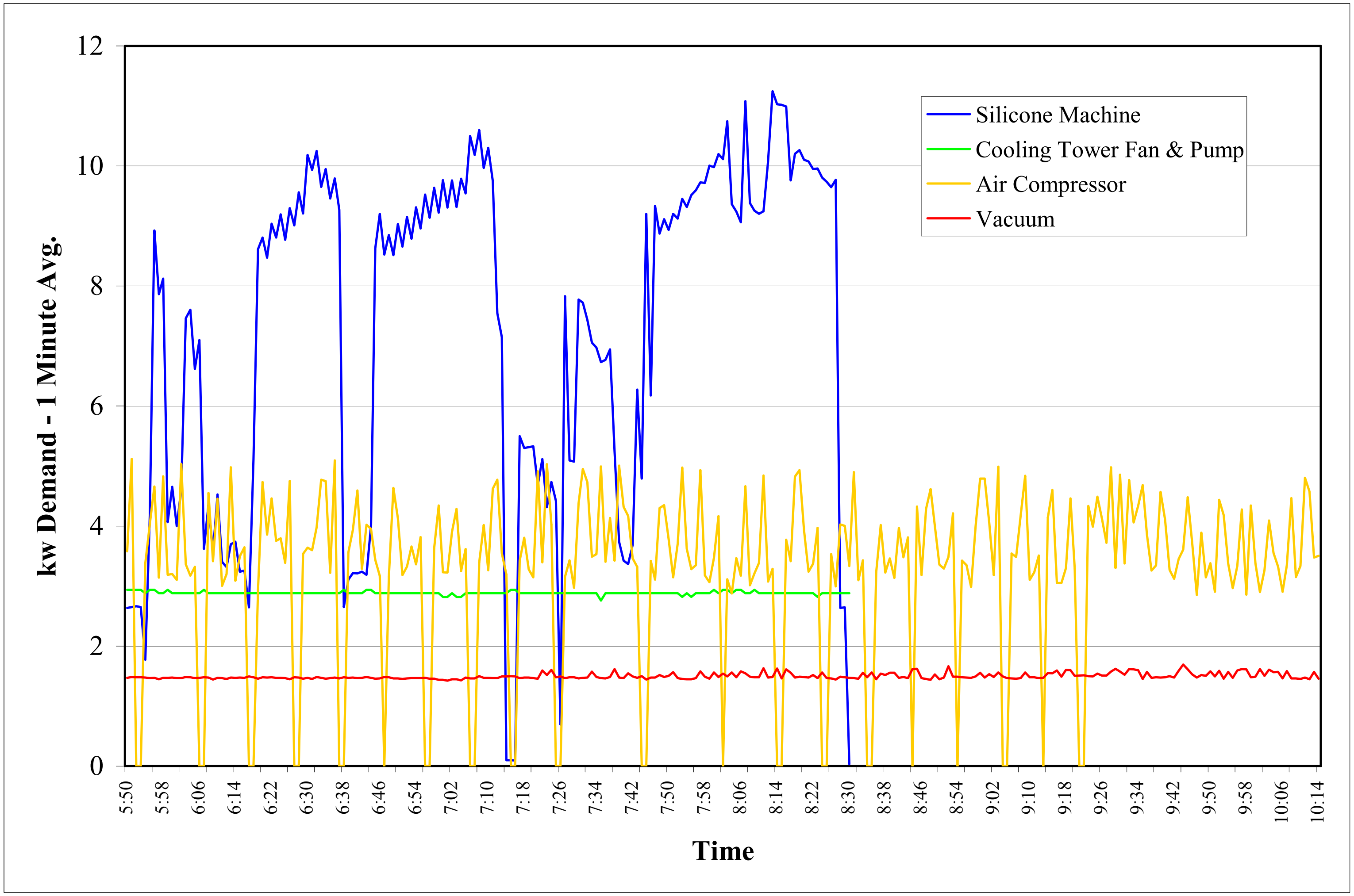
APPENDIX E – SILICONE DRY CLEANING

Silicone Test 1 – Dry Clean Machine Load Data

Load 1: Dark Load	
Dry to Dry Data	
Garment Weight (lbs)	55
Program Number	6
Cycle Start Time	5:53
Cycle End Time	7:13
Total Time	1:20

Load 2: Light Load	
Dry to Dry Data	
Garment Weight (lbs)	55
Program Number	2
Cycle Start Time	7:16
Cycle End Time	8:26
Total Time	1:10

Silicone Test 1 – Electricity Sub Meter Data



Silicone Test 1 – Electricity Consumption by Equipment

Equipment	**kWh**
Silicone Machine	19.59
Tower Pump	6.13
Tower Fan	1.61
Air Compressor	14.5
Vacuum	6.62
Boiler	1.83
Form Finisher	0.03
Pants Topper	0.00
Total	50.31
Per 100 Lbs	45.74

SILICONE TEST 2 – JUNE 26, 2004 AT CLEANER BY NATURE

Silicone Test 2 – Summary Results

	Time	Lbs	Gas Meter	kWh Meter	Tower Water	Boiler Water
Start Load 1	6:02	58	99.6	Results are based on data recorded by data loggers.	6496	470.8
Start Load 2	7:19	55	103.5		6505	480.5
Start Load 3	8:29	32	107.5		6515	492.8
End Load 3	9:37		111.5		6525	505.4
End Pressing	10:58		114.8		-	516.9
	Minutes	**Load Lbs**	**Therms**	**kWh**	**Tower Gallons**	**Boiler Gallons**
Load 1	1:17	58	3.9	20.3	9	10
Load 2	1:10	55	4.0	18.0	10	12
Load 3	1:08	32	4.0	18.3	10	13
Pressing	1:21		3.3	6.6		12
Total	**4:56**	**145**	**15.2**	**63.2**	**29**	**46**
Per 100 Lbs	-	-	**10.9**	**43.6**	**21**	**33**

APPENDIX E – SILICONE DRY CLEANING

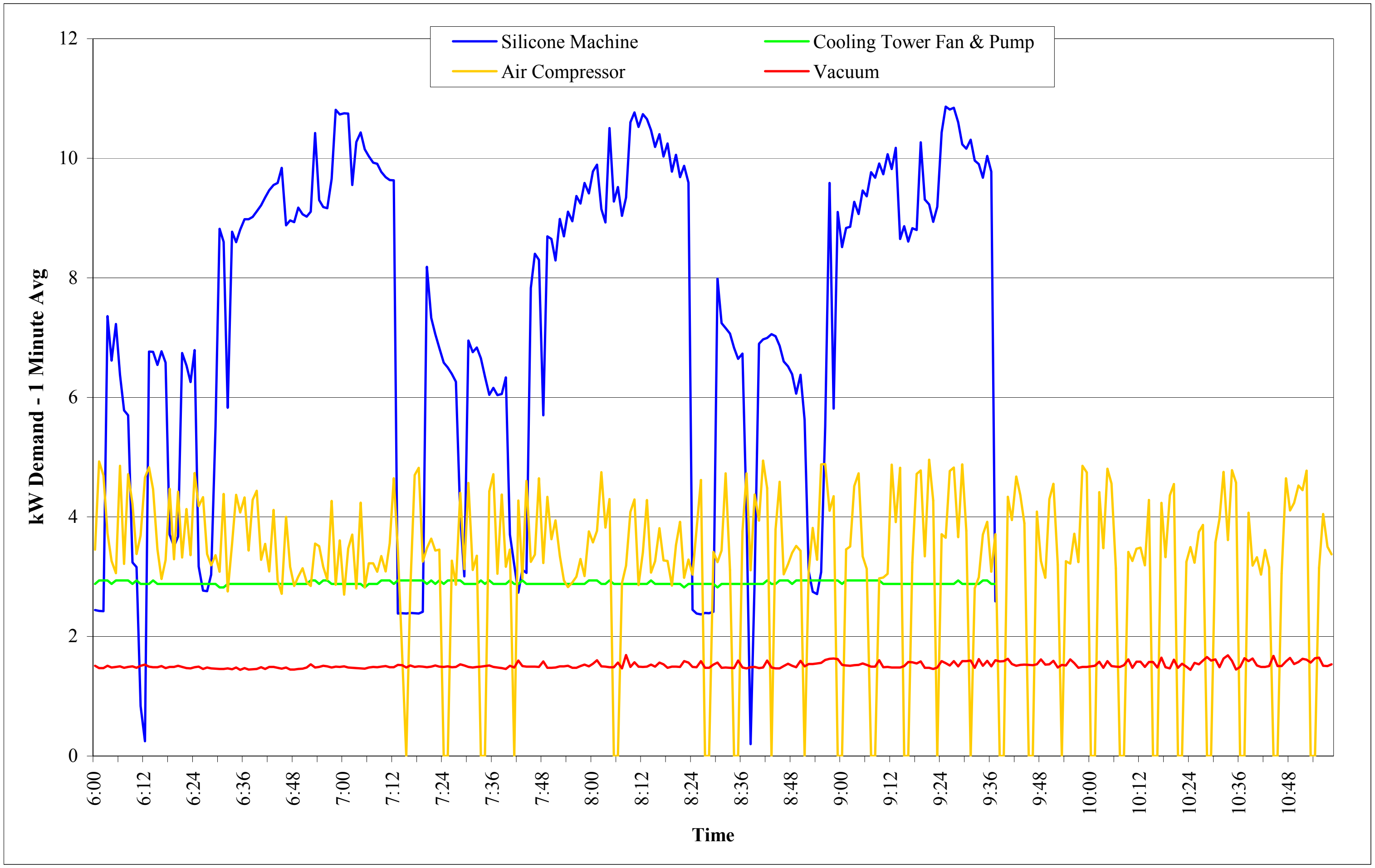
Silicone Test 1 – Dry Clean Machine Load Data

Load 1: Light	
Dry to Dry Data	
Garment Weight (lbs)	58
Program Number	2
Cycle Start Time	6:02
Cycle End Time	7:12
Total Time	1:10

Load 2: Dark	
Dry to Dry Data	
Garment Weight (lbs)	55
Program Number	1
Cycle Start Time	7:19
Cycle End Time	8:23
Total Time	1:04

Load 3: Light (1/2)	
Dry to Dry Data	
Garment Weight (lbs)	32
Program Number	4
Cycle Start Time	8:29
Cycle End Time	9:37
Total Time	1:08

Silicone Test 2 – Electricity Sub Meter Results



Silicone Test 2 – Electricity Consumption by Equipment

Equipment	**kWh**
Silicone Machine	27.1
Cooling Tower Pump	8.34
Cooling Tower Fan	2.18
Air Compressor	15.89
Vacuum	7.56
Boiler	2.07
Pants Topper	0.05
Form Finisher	0.06
Total	63.25
Per 100 Lbs	43.62

APPENDIX E – SILICONE DRY CLEANING

Silicone Test 2 – Garment Profiles[15]

Load 1: Light			
#	Garment	Fiber	Care Label
1	SW	R/C/N/SP	HW
2	S	R	DC/HW
3	SW	S	DCO
4	S	P/N/SP	MW
5	P	C	DCO
6	J	C	NL
7	SW	R/C/N/SP	HW
8	SK	S	DC
9	BL	S/N	DC
10	P	R/P/SP	MW
11	P	P/R/C	MW
12	BL	S	HW
13	S	R	DCO
14	P	P/R/SP	MW
15	S	C	MW
16	P	P/R/SP	MW
17	P	P/R/SP	MW
18	P	P/R/SP	MW
19	P	W	DCO
20	P	C	NL
21	COAT	W/R	NL
22	SW	C/R	DC
23	SW	C/R	DC
24	DR	S	DCO
25	S	S	DCO
26	BL	N/SP	DCO
27	SK	S	DCO
28	BL	R/N/SP	DCO
29	BL	S	DCO
30	BL	S	DCO
31	SW	S/C/N/SP	DC
32	S	S/L	MW
33	DR	S/C	DCO
34	P	W	DC
35	BL	S	DCO
36	P	P	DCO
37	J	P	DCO
38	P	W/LY	DCO
39	SW	S	HW/MW
40	SW	W/N/ACR	DC
41	S	C	DCO

[15] See Appendix F for key to garment profile terms.

APPENDIX E – SILICONE DRY CLEANING

Load 1: Light			
#	**Garment**	**Fiber**	**Care Label**
42	P	R/N/SP	DCO
43	J	W	DC
44	SW	CASH	DC
45	J	P/L	DCO
46	SW	CASH	DC
47	J	C	DCO
48	BL	ACE/R	DCO
49	DR	R	DCO
50	P	R/C	DCO
51	S	S	MW
52	SW	S	DC
53	SK	R/L	DC
54	BL	S/SP	DC
55	J	C	DC
56	SW	CASH	DC
57	SW	S/C/N/LY	DC
58	S	L	DCO
59	SW	CASH	DC
60	BL	R	DCO
61	SW	W	DCO
62	SK	S	DCO
63	P	C	MW
64	S	R	DCO
65	BL	L/R/SP	DCO
66	S	C/SP	MW
67	P	C/SP	DCO
68	SW	S	DC
69	BL	R/S	DC/HW
70	BL	C/R	DCO
71	SW	CASH	DCO
72	DR	L/C/SP	DCO
73	S	R/SP	HW/DC
74	P	C/N/SP	DCO
75	DR	R	MW
76	SW	S/SCASH	DC
77	COAT	W	DCO
78	P	C/SP	DCO
79	SW	CASH	NL
80	BL	S	DCO
81	DR	S	DCO
82	BL	C	MW
83	BL	S/C/N/SP	DCO

Load 2: Dark			
#	**Garment**	**Fiber**	**Care Label**
1	P	C	MW
2	BL	S	DC
3	DR	R	DCO
4	P	W	DCO
5	SW	CASH	NL
6	DR	S	NL
7	P	S/C	DC
8	SW	W	DC
9	J	S	NL
10	J	W	DCO
11	SW	R/C/SP	DCO
12	SW	CASH	DCO
13	P	R/W/SP	DC
14	P	W	NL
15	J	W	DC
16	SW	S/SP	DCO
17	BL	C	NL
18	P	W	**NL**
19	J	W	DCO
20	P	S/C	DC
21	P	ACE/P	DCO
22	P	W	NL
23	P	W	DCO
24	SW	R/C/SP	MW
25	J	W	DCO
26	BL	S	DC
27	SW	C/SP	MW
28	BL	S	MW
29	P	N/C/SP	DCO
30	SK	R	DCO
31	DR	S	DCO
32	P	W	NL
33	SW	R/C/N/SP	HW
34	SW	R/C/N/SP	HW
35	P	W	DCO
36	S	R	DCO
37	SW	R/S	NL
38	SW	W	DCO
39	P	W	DCO
40	SK	C/N/SP	DCO
41	J	W	DCO
42	S	S/C	MW
43	P	C/SP	DCO
44	S	L	MW

APPENDIX E – SILICONE DRY CLEANING

Load 2: Dark			
#	Garment	Fiber	Care Label
45	P	R/W/P	MW/DC
46	J	R/P/SP	MW/DC
47	P	W	NL
48	P	C	MW
49	SK	C/SP	DCO
50	S	S	MW
51	S	R	MW
52	SK	W	DCO
53	DR	R	DCO
54	P	C/N/SP	DCO
55	S	C/P	MW
56	BL	P	DCO
57	J	C/SP	DCO
58	S	C/SP	MW
59	BL	P	MW/DC
60	P	P/R/LY	DCO
61	P	W/LY/SP	DCO
62	S	R/SP	HW/DC
63	S	R	NL
64	P	L/C	MW
65	P	L	MW
66	DR	P/SP	DCO
67	DR	R/P/SP	NL
68	SK	R	DCO
69	P	NL	NL
70	P	W	DCO
71	P	P/R/LY	DCO
72	J	W	DCO

Load 3: Light			
#	Garment	Fiber	Care Label
1	P	C	MW
2	SW	C	NL
3	SW	S	DC
4	SK	C	NL
5	P	R/P	NL
6	P	W	DC
7	BL	S	NL
8	P	P	DCO
9	J	W	DCO
10	S	R/P	NL
11	P	S/L	DCO

APPENDIX E – SILICONE DRY CLEANING

Load 3: Light			
#	**Garment**	**Fiber**	**Care Label**
12	BL	S	DCO
13	SW	S/N/SP	DC
14	P	C/SP	DCO
15	P	C/LY	DC
16	BL	R/SP	DCO
17	S	S	DC
18	BL	S	HW
19	S	R	HW
20	SW	R	DCO
21	SW	R	DCO
22	P	C/SP	DCO
23	S	S	MW
24	P	C	DCO
25	P	C/N/SP	MW
26	P	L	DCO
27	S	P	MW
28	SW	W	DCO
29	SW	C/N/SP	DCO
30	SK	L/R/SP	DCO
31	S	R/P	MW
32	S	R/P	MW
33	SK	C/N/SP	DCO
34	SK	P	DCO
35	BL	S	DCO
36	S	S	MW
37	P	C/LY	DCO
38	BL	R/P	DCO
39	P	NL	NL
40	SW	C/SP	DC
41	P	C	DCO
42	P	C/SP	MW
43	BL	ACE/C	MW
44	P	R/P	NL
45	S	P	NL

Appendix F

KEY TO GARMENT PROFILE ABBREVIATIONS

Fiber Type Terms	
ACE	Acetate
ACR	Acrylic
C	Cotton
CASH	Cashmere
L	Linen
LY	Lycra
N	Nylon
P	Polyester
R	Rayon
S	Silk
SP	Spandex
TEN	Tencil
W	Wool

Garment Type Terms	
BL	Blouse
DR	Dress
J	Jacket
P	Pants
S	Shirt
SH	Shorts
SK	Skirt
SW	Sweater

Care Label Terms	
DC	Dry Clean
DCO	Dry Clean Only
HW	Hand Wash
MW	Machine Wash
NL	No Label

Appendix G

PETROLEUM DRY CLEANING BETA SITE – GOLDEN HANGER CLEANERS

Description of Tests: 4/23, 4/30, 5/14

Three tests were run at Golden Hanger Cleaners using the same protocol. On each test day, four loads of between 28 and 33 lbs were processed. The same program (#41) was used for each load. Pressing was continuous (by two pressers) soon after the first load was finished.

Date	Total Lbs	Total Garments	Avg. Load Time	Total Press Time
4/23	124	161	60 min	3:36
4/30	123	162	65 min	3:57
5/14	126	138	53 min	3:02

Results

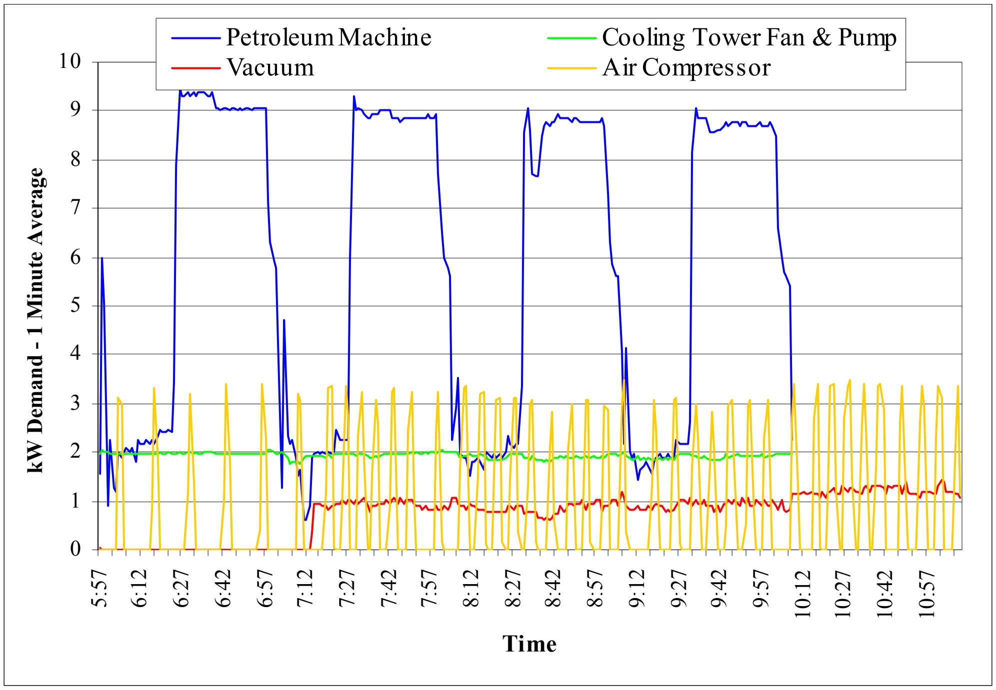
Electricity

	4/23/04		4/28/04		5/14/04	
Equipment	**kWh**	**Lbs**	**kWh**	**Lbs**	**kWh**	**Lbs**
Petroleum Mach.	24.35	124	24.96	123	18.10	126
Cooling Tower[16]	8.13		8.69		7.85	
Air Compressor	4.88		4.94		3.39	
Vacuum	3.87		3.96		2.86	
Total	41.23	124	42.55	123	32.20	126
Per 100 Lbs	33.10		34.59		25.53	
					Average kWh per 100 Lbs	**31.07**

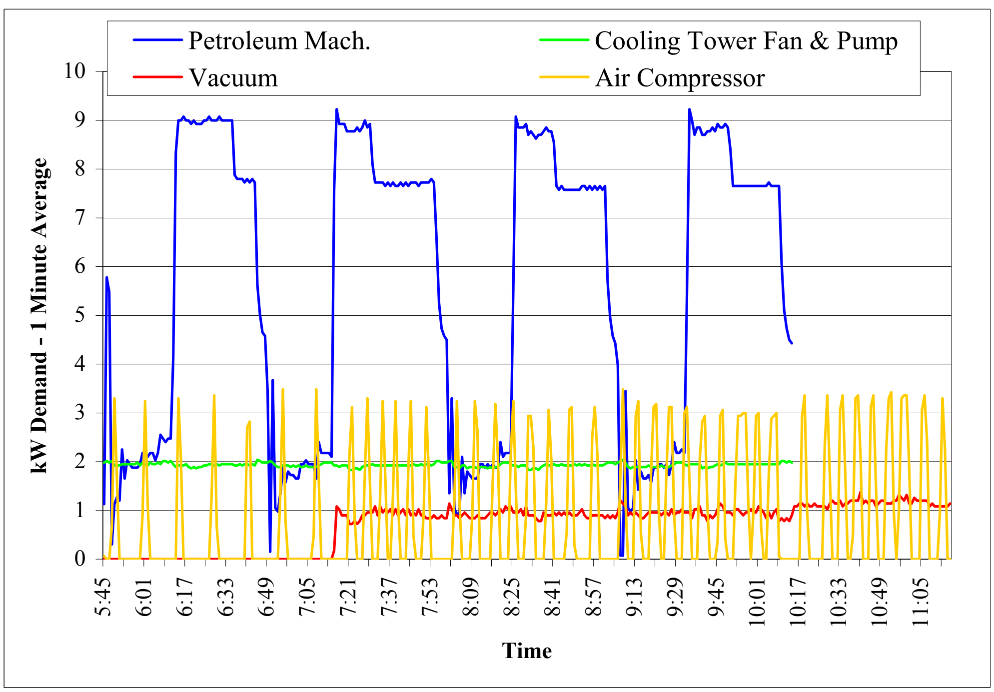
[16] Includes cooling tower fan and pump.

APPENDIX G – BETA SITE, PETROLEUM DRY CLEANING

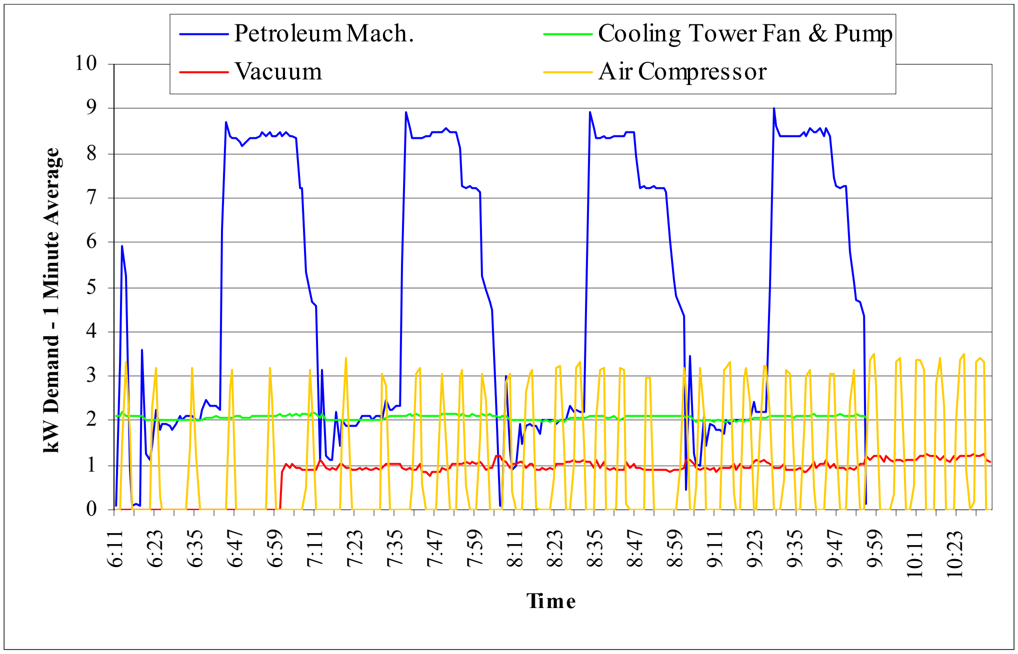
Electricity Sub Meter Data - Beta Petroleum Test 1



Electricity Sub Meter Data – Beta Petroleum Test 2



Electricity Sub Meter Data – Beta Petroleum Test 3



Natural Gas

Date	Therms	Per 100 Lbs	Therms 1st Load
4/23/04	15.1	12.2	2.9
4/30/04	14.8	12.0	3.0
5/14/04	12.5	9.9	2.9
	Average	11.4	2.9

Water

Date	Boiler	Cooling Tower	Total	Per 100 Lbs
4/23/04	10	-	39	31
4/30/04	6	29	35	28
5/14/04	6	30	36	29
Average	11	29.5	37	30

The amount of water used by the cooling tower increased as the morning wore on and temperatures rose. On 4/30, testing started at 5:48 am; on 5/14, testing started at 6:16 am.

Cooling Tower Water Use by Load				
Date	**Load 1**	**Load 2**	**Load 3**	**Load 4**
4/30/04	3	4	6	16
5/14/04	5	7	8	10

Appendix H

PROFESSIONAL WET CLEANING BETA SITE – NATURES BEST CLEANERS

Three field tests were completed at Natures Best Cleaners. This summary is only going to look at the third test because it is the only test that uses the final protocol agreed upon, and is therefore most representative of operations at this facility.

Description of Testing on 5-17-04

Three "wet clean" loads and one "wet wash" load were processed, including two dark and two light loads. The "wet clean" garments were dried for three minutes then hung, and the "wet wash" garments were dried to 16% residual moisture then hung. Virtually all of the washing and drying was completed before pressing began (pressing started at 8:28 and washing finished at 8:33). A total of 175 garments weighing 128 lbs were processed.

Wash Loads					Dry Loads	
Load	**Color**	**Lbs**	**Program**	**Length**	**Setting**	**Length**
1	Dark	29	1 – WC[17]	16 min	3 min	3 min
2	Dark	42	5 – WW	35 min	16 %	11 min
3	Light	29	3 – WC	16 min	3 min	9 min
4	Light	28	3 – WC	16 min	3 min	8 min

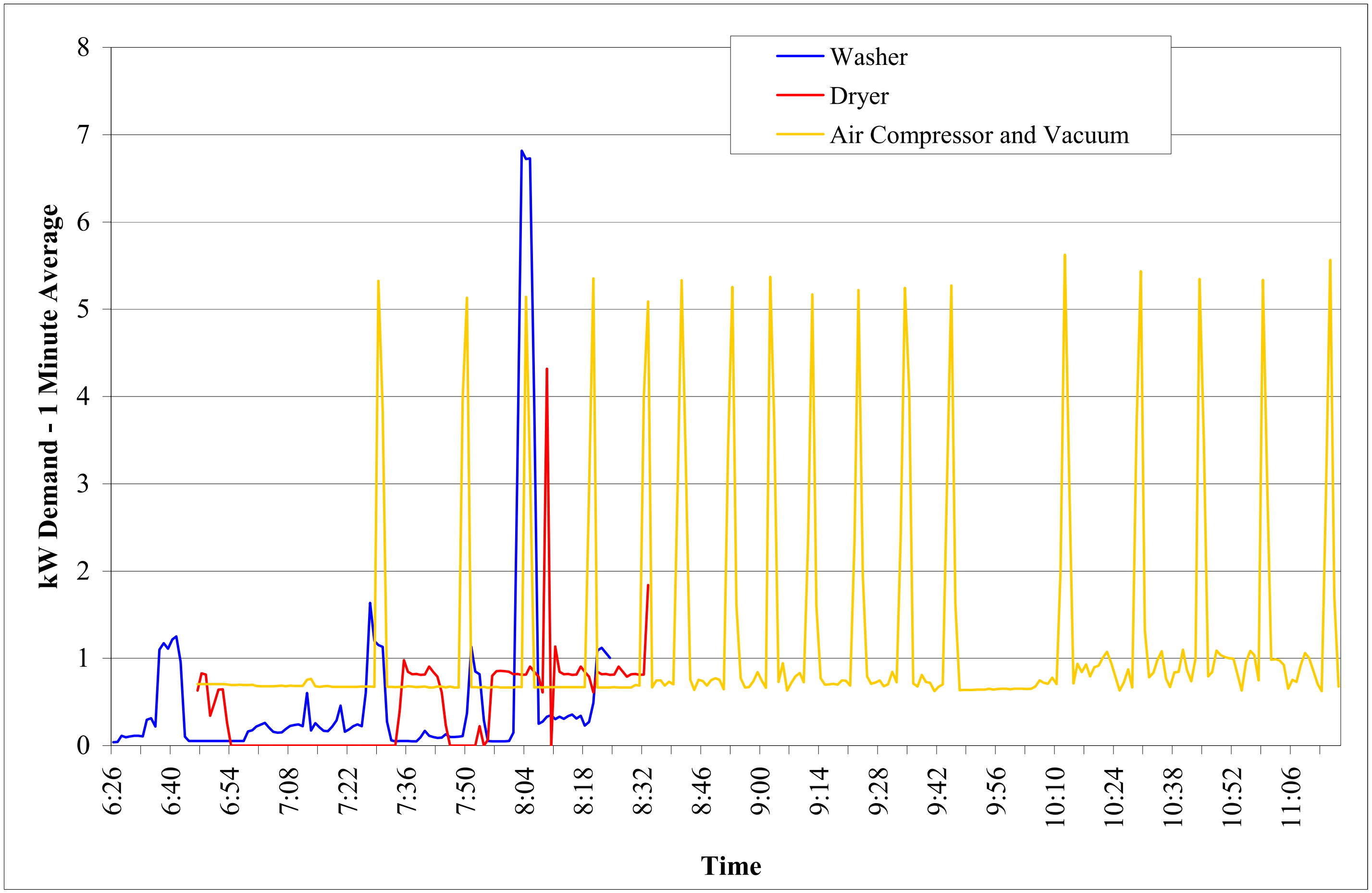
Pressing was completed in 2 hrs, 52 min, between 8:28 and 11:16 by 3 pressers. Hans noted that the garments processed that day required a lot of hand pressing and were more difficult. There were also a lot of lightweight garments, which would probably result in increased pressing time per lb.

Summary Results

Equipment	kWh	Therms	Gallons	Minutes	Lbs
Wet Clean Washer	1.053		110	119	
Wet Clean Dryer	0.815			108	
Air Compressor & Vacuum	5.530			272	
Pants Tensioning	4.832			164	
Form Finisher	0.043			174	
Pressing Board	1.538			174	
Boiler	1.400	10.02[18]	30[19]	272	
TOTAL	15.211	10.02	140		128
Per 100 Lbs	11.865	7.81	109		

[17] WC refers to wet clean, which is a more delicate load. WW refers to Wet Wash, which denotes a less delicate load.
[18] Approximately 6.6 therms were used during pressing, and 3.4 therms during washing and drying.
[19] Based on the water meter we initially estimated 60 gallons of water use by the boiler. This value was much higher than expected and may have been due to consumption by the other boiler, which was feeding the shirt press.

Electricity Sub Meter Data – Beta Professional Wet Cleaner Test, 5/17/04[20]



[20] The peak in kW demand by the washer at 8:05 was due to washers electric water heater. Methods for heating water vary: washers can use steam heat from the boiler, their electric heat, or hot water from a water heater. The washer at Del Rey Cleaners uses a water heater.