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Business Cases:

Supporting PTD Solutions

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In 1970, the OSH Act was promulgated with the intent focus "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions" (29 U.S. Code 671). The question of how to accomplish that goal has been the subject of discussions throughout the SH&E community long before the act was passed. Over the years, practitioners and researchers have suggested that an effective way to prevent and control occupational injuries, illnesses and fatalities is to design out or minimize hazards and risks early in the design process (Lin, 2008; NIOSH, 2006, 2010; Schulte, Rinehart, Okun, et al., 2008).

Looking at early efforts beginning in the 1800s, this belief was typified by the widespread implementation of machine guards, boiler safety practices and controls for elevators, followed by more efforts such as lockout/tagout controls and improved ventilation.

Following passage of the OSH Act, many efforts, including the Safety and Health Awareness for Preventive Engineering (SHAPE) program (www.cdc.gov/niosh/topics/SHAPE), the issuance of the Process Safety Management of Highly Hazardous Chemicals Standard (29 CFR 1910.119), the OSHA Alliance Roundtable on Design for Construction Safety (www.designforconstructioninsafety.org), and NSC's Integrating Safety Through Design Symposium and its Institute for Safety Through Design were all undertaken to encourage prevention during the design process (Schulte, et al., 2008). Despite this level of activity, a need for a national comprehensive approach to address worker safety and health issues by designing out potential hazards at the beginning phases of a project remained.

In July 2007, NIOSH launched the Prevention Through Design (PTD) national initiative to establish such a comprehensive approach (NIOSH, 2012). The initiative's broad mission is "to prevent or reduce occupationally related injuries, illnesses, fatalities and exposures by including prevention considerations in all designs that affect individuals in the occupational environment" (NIOSH, 2010). With the assistance of diverse stakeholders spanning the industrial sectors and educational disciplines, PTD was defined as:

> The practice of anticipating and "designing out" potential occupational safety and health hazards and risks associated with new processes, structures, equipment or tools, and organizing work, such that it takes into consideration the construction, maintenance, decommissioning and disposal/recycling of waste material, and recognizing the business and social benefits of doing so. (NIOSH, 2010)

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PTD addresses SH&E needs by "eliminating hazards and minimizing risks to workers throughout the life cycle of work premises, tools, equipment, machinery, substances and work processes, including their construction, manufacture, use, maintenance, and ultimate disposal or reuse" (NIOSH, 2010).

As NIOSH moved forward, researchers found that too many promising control technologies (engineering design solutions)—those grounded in PTD—were not transferred from research into practice. Although proof of preventing occupational injury, illness or fatality alone often drives industry to change, the lack of adoption of these effective solutions demonstrated that there were others reasons behind SH&E business decisions. Understanding the reasons for businesses to use programs and practices grounded in PTD became the objective of a NIOSH study. Although the research team selected several controls to examine more closely, this article presents information on only three—safe patient lifting and handling, ergonomic wine grape picking tub and chemical substitution in professional garment cleaning.

The NIOSH team selected the business case as the method to determine why these three solutions were adopted. *Business case* is a term used frequently but often misunderstood. Querying Google returns several definitions or functions:

- Business case captures the reasoning for initiating a project or task.
- Business case is part of a project's mandate, produced before a project is initiated.
- Business case is a type of decision-making tool used to determine how a particular decision will affect profitability.
- Business case is a structured proposal for business improvement that functions as a decision package for decision makers.

In reality, the business case answers the question, What's in it for the company? Or in this instance, Why would the company implement practices grounded in PTD?

Many methods and tools are available to develop a business case based on economics, finance and business management. To determine the business case for the three PTD engineering controls in this study, the value strategy was selected. This method was initially designed by an ORC Networks and NIOSH team under the sponsorship of AIHA and American Board of Industrial Hygiene (AIHA, 2009; Biddle, Carande-Kulis, Woodhull, et al., 2011; Brandt, Doganier, Downs, et al., 2010). The seven-step strategy culminates with the financial and nonfinancial value of a program, activity or intervention (Table 1). For this study, the purpose of each step has been expanded beyond industrial hygiene to include all SH&E activities associated with the three engineering controls being studied.

Information for each step can be obtained directly from company records, through discussions with affected workers and management, from prior studies conducted on similar programs, activities or interventions, or a combination of all three. As shown in this study, the value strategy can also be used to create the business case using various assumptions and parameters.

A single firm evaluated a lifting program calculating the return on investment (ROI) based on workers' compensation savings only. Collecting company records and conducting personal interviews was the method used to determine the costs and benefits associated with wine grape tubs. Finally, the business case for the garment wet-cleaning technology was created by using prior studies that covered multiple establishments using differing methods and parameters.

This study demonstrated that the business case developer should never lose sight of the need to capture information that is meaningful to the final investment decision maker. When important, explore the changes in health outcomes, SH&E risk management and in business processes. The developer should also consider the effects on achieving business objectives that cover a wide range of topics including sustainable business, SH&E excellence, employee retention, increased profits, increased market share and excellence in corporate social responsibility.

The following sections review the business cases developed for each of the three PTD controls.

Case One: Safe Patient Lifting & Handling

A best practices program was implemented in nursing home facilities within a healthcare corporation covering a total of 552 licensed beds with facilities that ranged from 60 to 120 beds (Collins & Bell, 2010; Collins, Wolf, Bell, et al., 2004). The process and methods of program implementation and, most importantly, the effect of the rate and severity of musculoskeletal injuries and the costs associated with these injuries among nursing staff in nursing homes were evaluated to determine the program's viability. Table 2 presents the injury and illness record prior to implementing the intervention.

The PTD control to mitigate the risk of musculo-skeletal injuries consisted of both engineering and administrative controls. The program encompassed using mechanical lifting equipment, implementing a zero-lift policy, and continuing a medical management program that encouraged quality health-care, rehabilitation and light-duty work for injured workers while they were reintegrated into the workforce. More specifically, the elements of this safe resident handling program included:

- ergonomic assessments of patient-care work;
- patient-care assessment protocols to prescribe the best patient transfer methods;
- mechanical patient lifting equipment and aids for repositioning patients;
- training on the proper use of patient handling equipment;
- peer leaders who encourage and maintain the program;
- written policies on safe patient lifting;
- management endorsement and support.

Two types of mechanical lifting equipment were adopted, and friction-reducing sheets were used as aids for repositioning patients in bed. A full-body lift was used to transfer patients from chair to toilet, bed to chair, lifting patients from the floor when they had fallen and weighing residents who did not have weight-bearing capability. A stand-up lift was used to help with high-risk tasks including toileting, bed-to-chair transfers, changing of incontinence briefs and ambulation for those residents who had partial weight-bearing capability. Staff were asked to evaluate and provide input on equipment selection to help ensure their buy-in to the program.

A written zero-lift policy provided guidelines for determining each resident's needs for transferring and the methods for safely handling and moving residents. Mechanical lifts were to be used when a patient could not be safely transferred or moved using other means. For patients who could be safely transferred or moved with limited manual assistance, mechanical lifts were not required. The charge nurse was given the responsibility for ensuring that all transfers were performed according to this guidance, with the nursing home administrator having final responsibility for enforcing the policy.

The program was implemented in six nursing home facilities ranging in size from 60 to 120 beds for a total of 552 licensed beds affecting 1,728 nursing employees. Table 3 lists the major costs of program implementation.

Was the Program Worth the Investment?

The effect of implementing this program was first measured by evaluating the changes in musculoskeletal injuries that occurred while lifting or moving a resident (Table 4). With the program in place, the number of nonfatal injuries or illnesses was reduced from an average of 47 incidents per year (Table 2) to only 16 over the next 6 years. The workers' compensation claims costs were also collected for this same period. Despite year three having high costs due to one particularly costly injury, the company spent $10,000 less in the 6 years with the safe patient handling program than the 3 years without the program.

With the cost of the new program determined and the evaluation of its effect on health outcomes, a financial analysis was conducted (Table 5). These measures demonstrated that it would be well worth investing in the safe patient handling program in other locations within the corporation. More importantly, the organization made this decision based on only analyzing the first component—health outcomes—of the value strategy.

Case Two: Ergonomic Wine Grape Picking Tub

An ergonomic picking tub to minimize injuries from lifting and carrying cut grapes among grape harvest workers was introduced to the wine grape industry in the Sonoma and Napa counties of northern California in the late 1990s. The tub was the result of University of California, Davis, Agricultural Ergonomics Research Center (UC Davis AERC) and AgSafe (a nonprofit organization) working in partnership with NIOSH "to demonstrably reduce or eliminate ergonomics risks factors for identified musculo-skeletal disorders." More than a decade later, AgSafe and NIOSH again partnered to determine the use and impact of this particular PTD engineering control.

Hand harvesting wine grapes is a multistep process involving bending, reaching, pushing and lifting (Meyers, Miles, Tejada, et al., 2002). Workers begin by moving down a row of grape vines, bending over and reaching into the grape clusters to cut the grapes free using a small curved knife. The workers remain bent over while putting the grapes into a tub or bin. As the worker fills the tub, s/he moves it down the row with sideways leg thrusts.

When the tub is full, the worker locates the gondola in an adjacent row, lifts the tub over his/her head, above and beyond the grape vines, and empties the grapes into that gondola. The worker then returns with the empty tub to the next location on the vine row and repeats this process. At the time of the initial study, filled tubs had documented weights of up to 80 lb.

This harvesting process is physically demanding, exposes workers to various ergonomics risk factors and results in a large number of injuries. AgSafe (1992) reported that between 1981 and 1990, an average of 3,654 nonfatal disabling injuries occurred in vineyard work in California. Of those, 42% were sprains and strains, of which 41% were reported as back injuries.

In the early stages of the original study, UC Davis AERC researchers identified the ergonomics risk factors in the manual handling of cut grapes during the harvesting process (Duraj, Miles, Meyers, et al., 2000). Those risk factors included:

- highly repetitive gripping, using a knife to make 25 to 50 cuts per minute;
- sustained trunk flexion (forward bend) of 20° to 45° for about 30 seconds at a time while cutting;
- severe trunk flexion (forward bend) of up to 90° for several seconds several times during each cycle when stooping to move the tub, remove leaves or gather grapes;
- manually lifting and carrying an average of 20 tubs per hour, averaging 57 lb (26 kg) each;
- contact stresses on hands from knife handle and from tub handles;
- high metabolic demands (average working heart rate of 125 beats per minute, with average energy expenditure of 47.7% aerobic capacity).

This analysis, along with the number of work-related injuries experienced in the industry, suggested that the process could benefit from a design intervention that addressed lifting and carrying much lighter loads (Meyers, Miles, Faucett, et al., 2006). The picking tub or bin selected by the original research project reduced the capacity by 13%. The original larger capacity tub is shown on the left in Photo 1 while the smaller capacity intervention tub is shown on the right.

As a result, the average weight load for a worker to lift and carry was reduced by 11 lb, from 57 to 46 lb. The smaller tub measures 24 in. deep × 14 in. wide × 8 in. high compared to 25 in. deep × 16 in. wide × 8 in. high—2 in. narrower from front to back, 1 in. narrower side to side.

Is This Engineering Control Beneficial?

In the follow-up study, management from companies that participated in the original study were interviewed about the costs of using the smaller tubs, changes in worker injuries or illnesses, changes in productivity associated with use of the smaller tub and any other changes deemed important. Those interviewed did not know (or care) about the cost of the tubs as the amount was viewed as inconsequential. After further discussion, it was determined that these employers averaged 500 tubs per harvest and the smaller tub was approximately $2 more than the larger tub—a total additional expense of $1,000 annually.

Several improvements in ergonomic risk factors were identified, suggesting that the number of injuries, or at least pain and discomfort, would be reduced. For example, because the replacement tub is narrower from front to back, the load center of gravity is closer to the body, resulting in a 29% improvement in the NIOSH lifting index, which is an estimate of the level of physical stress associated with a manual lifting task. The higher the lifting index, the fewer number of workers are available who can safely sustain that level of activity. Table 6 (p. 59) lists additional improvements.

However, those managers interviewed did not know whether the number of injuries or illnesses had been changed by the use of the smaller tubs. What they did know was that the workers liked the smaller tubs. This was more important to these companies as they wanted to keep the workers they knew and trusted to complete the harvest in the current and future years.

These companies did not consider whether productivity changed as a result of using the smaller tubs. As long as the harvest was completed on time and without adding substantial costs to complete, they were pleased. They were more concerned about worker happiness and grape quality. They felt that the tubs accomplished both.

The harvest workers stated that sometimes they had to work a little longer, but they left the fields without the aches and pains that were common when they used the larger tubs. They also indicated that they did not experience a loss in production, which would have meant a loss in wages.

In addition to the interviews, AgSafe sent a questionnaire to other wine grape harvest companies throughout California about their use and opinions of the smaller tubs. Of the companies answering, nearly one half indicated that they currently use the smaller tubs. The majority (80%) began providing the tubs because they were a safer option for employees, while only 5% provided them to increase productivity. Similarly, when asked why they would continue to provide the smaller tubs, 60% said because this option was safer for the employee, 28% because the workers liked them better and only 6% because of productivity.

Based on questionnaire results and the interviews, it was determined that the PTD engineering control was beneficial as it had positive effects on these companies' business objectives (see "Intervention" sidebar). For this group of businesses, the decision to use smaller tubs rested more on meeting business objectives, especially maintaining their workforce in place and happy, than on determining the financial benefits.

Case Three: Professional Garment Cleaning

Tetrachloroethylene or perchloroethylene (perc) has long been recognized as an effective cleaning solvent and for the past 60 years has been the most commonly used solvent in the garment cleaning industry. As a volatile organic solvent, perc poses serious health hazards if worker and environmental exposures are not properly controlled.

Perc can affect the body through respiratory and dermal exposure. Chronic exposure can cause dizziness, impaired judgment and perception, dermatitis, damage to the liver and kidneys, depression of the central nervous system and respiratory disease (NIOSH, 1997). Furthermore, International Agency for Research on Cancer (IARC) classified perc in group 2A, meaning that it is probably carcinogenic to humans, including esophageal cancer, lymphoma, and cervical and bladder cancer (Earnest, Spencer, Smith, et al., 1997; IARC, 1995). In 2012, EPA posted its final health assessment for perc indicating that the substancec is a “toxic chemical with both human health and environmental concerns” and is a “likely human carcinogen” (EPA, 2012a, 2012b).

Regulations restricting the use of perc in the U.S. have been increasing since the 1990s, but remain principally focused on reducing or eliminating its ozone depletion properties and environmental pollution contributions. Under the 1990 revisions of the Clean Air Act, in 1993 EPA issued technology-based national emission standards for hazardous air pollutants (NESHAP) that required operators to control perc emissions at individual dry cleaners. As part of the EPA process, these standards underwent review that led to revisions accounting for the new developments in production practices, processes and control technologies, with final standards going into effect in 2006.

The regulations include a phase-out of perc use by Dec. 21, 2020, at dry cleaners located in residential buildings, along with requirements that have already reduced perc emissions at other dry cleaners. EPA’s 2007 air toxics standards for the halogenated solvent cleaning industry also address perc by setting limits for a group of toxics that include this solvent. EPA also set the maximum contaminant level for perc under the Safe Drinking Water Act.

OSHA established mandatory permissible workplace exposure limits and provides guidance to reduce worker exposure, which includes recommendations for PPE. Although not specifically addressing perc, OSHA standards that may apply when workers are exposed to perc include: HazCom (29 CFR 1910.1200); PPE (29 CFR 1910.132); and Respiratory Protection (29 CFR 1910.134).

As a result of the increasing attention to the health and environmental concerns surrounding perc, including more stringent impending regulations, extensive research and development have led to acceptable perc alternatives to the garment cleaning market. Principle alternatives include petroleum solvents, silicone-based solvents, liquid carbon dioxide and wet cleaning (Sinsheimer, Grout, Namkoong, et al., 2007). Each alternative has different physical properties that affect their SH&E hazards. These alternatives positioned the U.S. garment cleaning industry of more than 37,000 establishments (U.S. Census Bureau, 2012) to make decisions about which solvent substitutes and processes.

Over the past 2 decades, numerous efforts by EPA, Center for Neighborhood Technology (CNT), Pollution Prevention Center and Toxics Use Reduction Institute (TURI) have been undertaken to assist garment cleaning industry in the decision-making process. EPA and TURI performed evaluations of alternative chemicals and processes focusing on their cost and performance, including the SH&E effects (Ellenbecker & Geiser, 2011; EPA, 1993; TURI, 1996). CNT explored alternatives "in which cleaners can use new processes that not only are environmentally friendly to workers, garments and communities, but also allow the small 'mom and pop' cleaner to continue to operate profitably" (Star & Ewing, 2000). Pollution Prevention Center focused on determining the viability of professional wet cleaning in California (Sinsheimer, Grout, Namkoong, et al., 2004; Sinsheimer, et al., 2007). This article presents a compilation of the results from these sources to provide insight into the business case for implementing wet cleaning.

Which Is the Best Alternative Cleaning Method?

This evaluation began with investigating the financial advantage of each garment cleaning process. Table 7 presents a comparison of the initial cost of equipment and installation for five of the more common processes. Interestingly, these costs confirmed that professional wet cleaning was a viable option for exploration by these organizations who were interested in reducing the exposure to perc in the 1990s.

The differences in operational costs between wet and dry cleaning processes were collected in nine case studies. Funding and technical assistance to California companies willing to replace their existing dry-cleaning process with wet cleaning began in 1995. Tables 8, 9 and 10 (p. 62, 63) provide the results from that work, led by the Pollution Prevention Center at Occidental College.

Operational costs coupled with the machine and installation costs were used to develop financial measures that help business owners make decisions about selecting and adopting chemical substitution and redesigned equipment. Using data collected by the State of California's Air Resources Board (Fong, Chowdhury, Houghton, et al., 2006) over a 5-year period, the difference between the benefits and costs of changing to an alternative cleaning process (i.e., net present value) was determined by comparing each process to the wet cleaning and perc dry-cleaning processes (Table 11).

The results demonstrate that the wet-cleaning process is the best option from a financial perspective, even without the probable reduction in occupational injury and illnesses or improvements in productivity that are typically included in net present value calculations.

However, the effect on the environment was considered in nearly every study, regardless of the other issues considered. Furthermore, public presentation often referred to the wet-cleaning process as being a "green" solution—pointing to the associated positive corporate social responsibility of making the change. Publication titles such as "Fashioning a Greener Shade of Clean: Commercialization of Professional Wet Cleaning in the Garment Care Industry" and "The Viability of Professional Wet Cleaning as a Pollution Prevention Alternative to Perchloroethylene Dry Cleaning," clearly demonstrate the link to environmental emphasis. The article, "Being Green While Staying Clean in Malibu"

(Colony Cleaners), was published in *Malibu Times* to publicize the conversion of one local cleaner to the wet-cleaning process. In “Leading the Green Cleaning Wave,” Hesperian Cleaners was praised as the first in Alameda County to be a Bay Area Green Business following its decision to “go green” by changing to wet cleaning. The concept of informing customers of the company commitment to being “green” transcends to naming the company —The Greener Cleaner, a professional garment cleaning shop in Chicago. A critical reason for adopting this PTD engineering control was improving the environment and the connection of that improvement to the company reputation.

Conclusions

What started as a determination of the business case for selected PTD engineering controls, resulted in highlighting the different ways that a business case can be developed and used in SH&E. Why a company adopts (or might adopt) any PTD design solution is a precursor for determining the value that is highlighted in a business case. Table 12 provides the reasons implementing those controls examined in this study.

This study also highlighted the differing ways that business case results can be used by an SH&E professional (Table 13, p. 64). This is only the beginning of work needed to fully understand the many reasons that companies adopt PTD design solutions. It is also only the beginning of learning how to develop the business case for use in making these decisions for all types and sizes of employers.

Biography

Elyce Biddle, Ph.D., is a senior research economist at NIOSH and an adjunct professor at West Virginia University. She focuses on occupational injury and fatality cost modeling, including drafting CDC guidelines on constructing business cases for health promotion and prevention. Biddle was coordinator of the NIOSH Economic Evaluation of Occupational Health and Safety Interventions at the Company Level Task Force.

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Intervention Effect on Business Objectives

Human Resources Objectives

- Reduced worker turnover
- Improved worker morale
- Decreased worker aches, pain and injury

Production Objectives

- Met harvest schedules
- Maintained or improved quality of grape
- Maintained or improved production levels

The Value of Simple Solutions

- **Problem:** An equipment manufacturing facility had 27 mechanical pump presses, 16 injection mold machines and 7 assembly lines for boxing plastic interiors and safety switches. Products were also painted at the facility, using powder coat paint. The hazard identified to mitigate involved noise exposure to employees working on the assembly line.
- **Risk:** Approximately 130 to 150 employees worked in the assembly line area where there was borderline overexposure to noise. Employees working in the fabrication group were exposed to a time-weighted average of 89 decibels (dBA) over 8 working hours.
- **Solution:** The company instituted a noise abatement program to eliminate or mitigate noise hazards in the production process. This intiative included hiring consultants to conduct noise surveys, develop a noise map and make recommendations to improve working conditions in the equipment manufacturing facility. In the first year, the consultants focused on the fabrication area and completed their tasks within the assembly line area in three days. As a result, employees working in the assembly area were rotated and only worked a maximum of 1 hour per day.

Value of the Solution

As a result of this simple solution, employees were healthier, happier and more comfortable in the workplace. Health-related absenteeism declined drastically. Employee morale increased significantly, improving the quality of work. The intervention resulted in a net present value of $47,249 and a net present value for future hearing loss of $198,015. The internal rate of return was 161%, while the return on investment was 98%. The discounted payback period was 0.6 years.

Note. From www.aiha.org/votp_NEW/study/casestudies.html

Photo 1.
The redesigned bin (left) decreased injuries related to the original design (right).

Table 1

Value Strategy

Step	Task	Purpose
1	Identify key business objectives and hazards	Inventory work processes and operations, associated hazards and business objectives.
2	Prioritize value opportunities	Evaluate how ESH program, activity or intervention under consideration influences business objectives.
3	Assess risk	Identify actual or predicted risk reduction(s) associated with ESH program, activity or intervention.
4	Identify changes	Identify real or anticipated changes resulting from implementation of ESH program, activity or intervention.
5	Assess impacts	Measure impacts associated with changes in health status, the ESH risk management process and business processes.
6	Determine value	Determine value of ESH program, activity or intervention (savings, cost avoidance, new revenue and other benefits).
7	Present value proposition	Prepare executive summary presentation describing financial and nonfinancial value of ESH program, activity or intervention.

Table 2

OSH Experience Before Intervention

	Year 1	Year 2	Year 3	Total
Fatalities	0	0	0	0
Nonfatal injuries or illnesses	51	57	33	141
Workers' compensation claim costs	$183,012	$161,337	$111,837	$456,186

Table 3

Cost of Best Practices Program Implementation

Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Equipment	$143,556	0	0	0	0	0
Training	$15,000	$12,000	$10,000	$10,000	$10,000	$10,000
Total	$158,556	$12,000	$10,000	$10,000	$10,000	$10,000

Table 4

OSH Experience After Intervention

Experience	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Fatalities	0	0	0	0	0	0	0
Nonfatal injuries/illnesses	28	20	19	13	13	5	98
Workers' compensation claim costs	$61,020	$31,716	$249,706	$20,820	$68,623	$14,228	$446,113

Table 5

Financial Measures of Implementing Best Practices Program

Net present value (NPV)	$437,395.17
Internal rate of return (IRR)	106%
Return on investment (ROI)	129%
Payback period	1.03 years

Table 6

Comparative Ergonomics Risk Factors

	Large tubs	**Small tubs**
Lifting force	57 lb (season average)	46 lb (season average)
Sliding force	19–22 lb (terrain differences)	13–16 lb (terrain differences)
NIOSH lifting index	3.4	2.4
Energy expenditure	47.7% of aerobic capacity	45.0% of aerobic capacity
Back injury probability	0.64	0.060

Note. From “Final report of the California vineyard ergonomics partnership project: Ergonomics prevention of musculoskeletal disorders in winegrape vineyards,” by Agricultural Ergonomics Research Center (NIOSH in Continuing Agreement PHSCCU912911-01), 2000, Davis, CA: Author.

Table 7

Professional Garment Cleaning Machine Cost Comparison

Process	Machine	Installation
Perc dry cleaning	$43,900	$2,500 to $5,000
Hydrocarbon	$61,000	$5,000 to $6,000
GreenEarth (liquid silicone)	$63,000	$5,000 $6,000
CO_2	$140,000	$50,000
Wet cleaning	$40,000	$2,000 to $2,500

Note. From "California dry cleaning industry technical assessment report," by M. Fong, H.R. Chowdhury, M. Houghton, et al., 2006, Sacramento, CA: California EPA, Air Resources Board, Stationary Source Division, Emissions Assessment Branch.

Table 8

Monthly Operating Expenses for Dry Cleaning Processes

Monthly expense	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8	Firm 9
Solvent	$50	$100	$90	$56	$66	$133	$929	$200	$113
Detergent	$53	$16	$21	$39	$50	$5	$133	$13	$83
Water	$44	$20	–	–	–	–	$73	–	$111
Electricity	$89	$143	$187	$93	$300	$244	$156	$642	$364
Gas	$278	$466	$221	$267	$488	$552	$438	$488	$435
Filters	$60	$25	$11	$23	–	$40	$882	$40	$7
Hazardous waste	$100	$54	$40	$54	$35	$100	$100	$117	$50
Machine upkeep	$147	$239	$83	$132	$172	$111	$158	$298	$119
Equipment	$430	$299	$270	$299	$375	$375	$375	$375	$375
Regulatory fees	$108	$108	$81	$108	$91	$48	$119	$74	$65
Total	**$1,359**	**$1,470**	**$1,004**	**$1,071**	**$1,577**	**$1,608**	**$3,363**	**$2,247**	**$1,722**

Note. From “Fashioning a greener shade of clean: Commercialization of professional wet cleaning in the garment care industry,” by P.J. Sinsheimer, C. Grout, A. Namkoong, et al., 2004, Los Angeles, CA: Pollution Prevention Education and Research Center.

Table 9

Monthly Operating Expenses for Wet Cleaning Processes

Monthly expense	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8	Firm 9
Solvent	$0	$0	$0	$0	$0	$0	$0	$0	$0
Detergent	$121	$246	$82	$167	$63	$60	$0	$300	$400
Water	$34	$30	–	–	–	–	$540	–	$91
Electricity	$50	$115	$132	$75	$120	$144	$140	$324	$292
Gas	$266	$510	$144	$255	$353	$387	$334	$353	$408
Filters	$0	$0	$0	$0	–	$0	$762	$0	$0
Hazardous waste	$0	$0	$0	$0	$0	$0	$0	$0	$0
Machine upkeep	$24	$24	$24	$24	$83	$24	$0	$24	$24
Equipment	$208	$208	$208	$280	$193	$379	$379	$379	$379
Regulatory fees	$0	$0	$0	$0	$0	$0	$24	$0	$0
Total	**$703**	**$1,133**	**$590**	**$801**	**$812**	**$994**	**$2,179**	**$1,380**	**$1,594**

Note. From “Fashioning a greener shade of clean: Commercialization of professional wet cleaning in the garment care industry,” by P.J. Sinsheimer, C. Grout, A. Namkoong, et al., 2004, Los Angeles, CA: Pollution Prevention Education and Research Center.

Table 10

Cost Reductions in Operating Expenses Using Wet- Versus Dry-Cleaning Processes

	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8	Firm 9
Cost reduction	$656	$337	$414	$270	$765	$614	$1,185	$867	$130

Average savings: $582 monthly

Note. From “Demonstrating the viability of professional wet cleaning: California and beyond,” by P.J. Sinsheimer, 2008. Presented at a meeting of the North East Waste Management Officer’s Association.

Table 11

Net Present Value of Alternative Garment Cleaning Processes

Base versus comparison	Net present value
Perc versus wet clean	$29,061
Hydrocarbon versus wet clean	$31,924
GreenEarth versus wet clean	$53,099
CO2 versus wet clean	$170,911
Perc versus hydrocarbon	($2,863)
Perc versus GreenEarth	($24,038)
Perc versus CO_2	($141,850)

Table 12

Case Study Examples of Motivators to Adopt Wet Cleaning

Adoption reason	Case study example
Financial value	Mechanical lifting program
Worker satisfaction	Wine grape harvesting tubs
Worker safety and health	Mechanical lifting program Wine grape harvesting tubs
Meet business objectives	Wine grape harvesting tubs Wet garment cleaning
Environmental benefits	Wet garment cleaning
Corporate social responsibility	Wet garment cleaning

Table 13

Reasons to Develop a Business Case

Business case results use	Case study example
Justify resources and capital investment	Mechanical lifting program
Demonstrate nonfinancial value of design solution	Wine grape harvesting tubs
Select among alternative solutions	Wet garment cleaning
Demonstrate the value of doing the "right thing"	Mechanical lifting program Wine grape harvesting tubs Wet garment cleaning