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GRADE A+ to D

Promoting Green Innovation

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If the aim of environmental policy is to minimize society's environmental impacts wherever feasible, it would seem that environmental policy would be designed specifically to encourage the innovation and diffusion of greener, more environmentally benign, technology. Unfortunately, for the most part, our environmental laws which regulate pollution in air, water, on land, at workplaces, and from chemicals, have tended to do the opposite, that is, discourage innovation and the diffusion of green technology.

The problem is that environmental laws take the necessity of pollutants as a given, and attempt to manage the hazards that arise from their use. Aptly named as risk management, this model of regulation focuses on the pollutant itself (e.g. a hazardous chemical, an air pollutant, etc.) in order to set an acceptable risk level posed by the pollutant. For example, the Occupational Safety and Health Administration (OSHA) sets permissible exposure levels for workplace hazards. Other environmental statutes such as the Clean Air Act and Safe Drinking Water Act likewise set standards for permissible levels of pollutant.

By focusing on the pollutant, the risk management model does not require regulators to determine whether a safer, greener alternative exists which would eliminate the pollutant altogether as an output of a production process or as a hazard in a consumer product. A second regulatory model, known as alternatives analysis, is a method for identifying viable alternatives to polluting production processes or hazardous consumer products. Alternatives analysis consists of two separate yet related components. The first component, alternatives assessment, compares the technical, health, safety, environmental, and economic attributes of a chemical or product to alternatives. After the assessment is completed, the second component, alternatives evaluation, balances the respective attributes of the chemical or product and the alternatives (e.g., lower toxicity vs. higher cost) with the goal of selecting the option that best fits the decision criteria guiding the evaluator.

The risk management regulatory model does not require regulators to determine whether a safer, greener alternative exists which would eliminate the pollutant altogether.

While alternatives analysis was developed as a voluntary tool for industries to identify potentially safer alternatives, attention has begun to focus on integrating alternatives analysis into public policy. If regulators were required to phase out polluting industrial processes and consumer products when less polluting alternatives are identified, then presumably firms would be driven to invent safer products and processes because there would a clear market for their innovation.

REGULATORY INITIATIVES

There has been some movement towards integrating alternatives analysis into environmental policy. For example, in 1989, the United States Environmental Protection Agency (EPA) phased out asbestos based on its ongoing risk and the availability of safer alternatives. The EPA believed it had the authority to do this under the Toxic Substances Control Act (TSCA) but asbestos manufacturers challenged this ruling. The Fifth Circuit Court decided the EPA needed to retract its rule because the agency had not provided sufficient evidence that asbestos caused an unreasonable risk nor sufficiently took into account the costs associated with the alternatives. While the agency could have provided this evidence, they never did so. In addition, the court ruling halted EPAs use of alternatives analysis under TSCA to promote the phase out for any other toxic substance.

The Pollution Prevention Act (PPA) of 1990 created a new federal law designed to integrate alternatives analysis into environmental policy. The statute begins with the following words: “The Congress hereby declares that it is the national policy of the United States that pollution should be prevented or reduced at the source whenever feasible.” This suggests that alternatives analysis would become the dominant method used by federal agencies for determining feasible alternatives capable of preventing pollution at the source. While the PPA pushed the EPA to develop a number of major partnerships with polluting industries to develop safer alternatives, these efforts were voluntary and the agency never required the use of alternatives analysis in implementing any of the major environmental statutes regulating air, water or ground pollution, or toxic chemicals.

The 1990 amendments to the Clean Air Act appeared to come closer to requiring use of alternatives analysis in the regulation of hazardous air pollutants (HAPs). The statute lists 189 chemicals as HAPs, requires the EPA to identify the largest sources of emissions for each pollutant, and for each large source, set a National Emission Standard for the HAP (known as a NESHAP) based on what is technologically achievable, including zero emission. Every eight years, the agency is required to review technological innovation in order to potentially lower the limit.

A second regulatory model, known as alternatives analysis, is a method for identifying viable alternatives to polluting production processes or hazardous consumer products.

In 1993, EPA issued the first NESHAP, for perchloroethylene (PCE) used in dry cleaning. In developing the initial NESHAP, EPA focused their assessment on the viability of advanced pollution control equipment. While EPA had begun studying technology changes which eliminated the use of PCE in dry cleaning, the regulation made no mention of these alternatives. In this article we use PCE and the dry cleaning process as a case study to demonstrate the importance, challenges and rewards of green innovation.

GREEN INNOVATION FOR TOXIC DRY CLEANING

Perchloroethylene dry cleaning appears to be a particularly good case study to examine the role that green innovation and alternatives analysis can play in promoting the development and/or diffusion of safer alternatives. The Clean Air Act gives the EPA authority to use alternatives analysis as a regulatory decision-making tool, the agency is required to periodically review technology changes, and cleaner garment care technologies have been under development.

Up to the 1930s dry cleaning machines primarily used highly combustible petroleum solvents and therefore were located in the industrial core of cities. During World War II, when petroleum supply was rationed, cleaners turned to non-petroleum chlorine-based compounds, primarily PCE. Because PCE did not pose a fire hazard, soon PCE dry cleaners were able to move into commercial neighborhoods, closer to where their customers worked and lived. As a consequence, the number of dry cleaning plants increased rapidly through the second half of the 20th century. By 2005, there were an estimated 32,000 dry cleaners operating in the United States, of which 3,000 were in southern California.

As dry cleaners became ubiquitous in cities and even small towns, increasing evidence began to emerge in the 1970s of the adverse health and environmental impacts associated with PCE use in dry cleaning. Effects of chronic exposure to PCE include dizziness, impaired judgment and perception, damage to the liver and kidneys, and respiratory disease. Other risks include neurotoxicity and reproductive and developmental toxicity as well as various forms of cancer such as bladder, stomach, esophageal, intestinal, and pancreatic. Knowledge of the adverse effects of PCE came precisely at a time when significant new national environmental and occupational regulations were being developed. By 1990, PCE was listed in the Clean Air Act as a hazardous air pollutant.

The first clearly identifiable green technology to emerge in the garment care industry was a water-based alternative known as professional wet cleaning.

As regulation of PCE dry cleaning intensified in the 1990s, so did interest in the development of alternatives to PCE, including reformulated petroleum solvents, silicone-based solvents, liquid carbon dioxide (CO_2), and water-based alternatives. While it was clear that some alternatives (water-based professional wet cleaning and CO_2) appeared to be relatively benign, other alternatives (petroleum and silicone) pose their own set of environmental and occupational problems. Petroleum dry clean emissions are classified as volatile organic compounds (VOCs), which are both smog-forming and are classified as a greenhouse gas. The silicone-based dry cleaning solvent (decamethylpentacyclosiloxane) has been identified as a potential carcinogen. In addition, both petroleum and silicone-based solvents are combustible and produce a substantial amount of hazardous waste.

The first clearly identifiable green technology to emerge in the garment care industry was a water-based alternative known as professional wet cleaning. Wet cleaning, a process of hand-laundering delicate garments, has long been practiced by cleaners. Professional wet cleaning industrialized this practice by using computer-controlled washers and dryers, specially formulated detergents, and specialized finishing equipment to create a cost-effective alternative to dry cleaning. The essential technological innovation of professional wet cleaning was to mechanically simulate hand-washing by using a computer to control the rotation of the drum in order to minimize agitation while providing sufficient movement for effective cleaning of delicate garments.

Wet clean washers are also equipped with a computer programmed detergent injection system, which allows the cleaner to specify the precise amount and type of wet clean detergents and sizing agents used for each load. Soft water is mixed with these detergents and agents prior to coming into contact with any garments. Biodegradable cleaning agents have been formulated for wet cleaning by detergent manufacturers to maximize cleaning power while minimizing color change and shrinkage. Wet clean dryers are equipped with moisture sensors to ensure garments retain the appropriate amount of moisture after the dry cycle is complete. Specialized tensioning pressing machines are used to enhance the restoration of constructed garments, such as suit jackets, suit pants, and tailored items.

Cleaners who switched to professional wet cleaning were able to maintain their level of service and customer base while increasing their profits.

Computer-Controlled Washing

- Microprocessor controls automatic detergent dispensing, drum speed and rotation.
- Low water level and temperature.
- Water and detergent mixes prior to entering the cleaning drum.

Cleaning Agents

- Detergents remove stains/soils.
- Conditioners add smoothness and softness.
- Sizing adds body and helps with finishing.
- Automatic dispensing system injects cleaning agents to washer.

Moisture Sensor Dryer

- Precise moisture control.
- Moisture levels of garments is continually monitored.
- Reverse rotating tumbling.
- Automatic shut off at specified residual moisture level.

Finishing Tensioning Equipment

- Enhances restoration of constructed garments.
- Uses steam to relax fibers and tension to reshape garments.
- Uses air to dry.
- Shortened pressing times.

Figure 1: Professional wet cleaning technology

VIABILITY OF PROFESSIONAL WET CLEANING

From a green innovation perspective, the question was whether professional wet cleaning represented a viable substitute for PCE dry cleaning. The opportunity for a robust comparison of PCE dry cleaning with professional wet cleaning came in 2000, when the South Coast Air Quality Management District (SCAQMD) funded a large-scale demonstration project focused on converting a series of PCE dry cleaners to professional wet cleaning. The Professional Wet Cleaning Demonstration Project provided the opportunity to conduct before and after evaluations of seven cleaners switching from PCE dry cleaning to professional wet cleaning under real world operating conditions.

Three general criteria were used to determine viability of professional wet cleaning as an alternative to PCE dry cleaning. Technical performance measures were used to evaluate whether each cleaner was able to maintain his or her quality of cleaning and level of service after switching to professional wet cleaning. A financial assessment evaluated the relative profitability of each cleaner before and after switching to professional wet cleaning. Resource use analysis compared electricity, natural gas, and water use before and after switching to professional wet cleaning.

Performance Evaluation The performance assessment measured the ability of cleaners to successfully wet clean garments they had previously dry cleaned. A summary of the results showed:

- Problem garments (i.e. items returned for additional work, ruined, or sent out) occurred at a similar rate in wet cleaning and dry cleaning (Fig. 2).

- Customer retention rates were over 97% for all cleaners (Fig. 3).
- Cleaners rated the quality of their cleaning service and the level of customer satisfaction to be equal to or higher in wet cleaning compared to dry cleaning in all but one case.
- Negative reactions from customers of cleaners who switched were minimal.

Once a green innovation, such as professional wet cleaning, has been established, one would think that public policy would be in place to encourage its rapid diffusion.

Figure 2: Percentage of problem garments (Source: [1]).

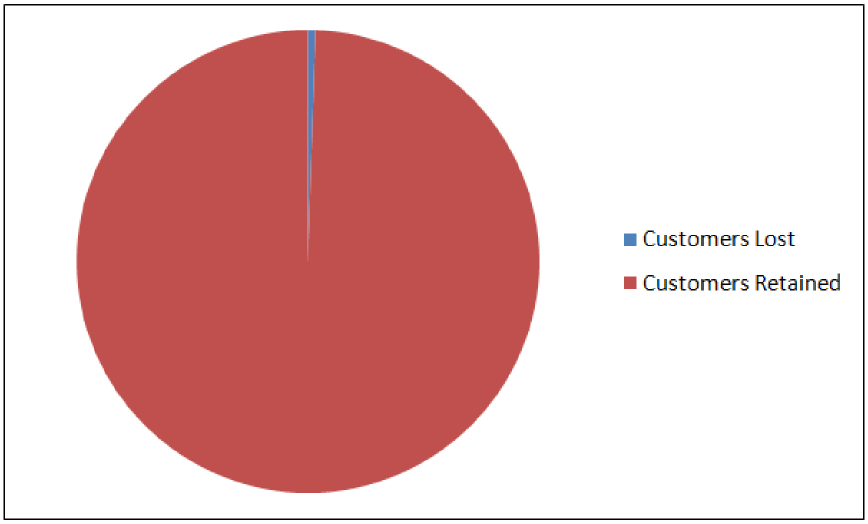

Figure 3: Customer retention rate after cleaners switched to professional wet cleaning (Source: [1]).

In December 2002, the SCAQMD ruled to phase out PCE dry cleaning based on ongoing risk and the viability of non-PCE alternatives.

Financial Analysis A financial assessment evaluated the relative profitability of each cleaner before and after switching to professional wet cleaning. A summary of results showed:

- Monthly operating costs were significantly lower with professional wet cleaning. (Fig. 4)
- After switching to professional wet cleaning, each operator no longer paid operating expenses associated with the operation of a PCE dry cleaning machine, including the cost of solvent, filters, hazardous waste, and regulatory fees.
- Costs that were consistently higher when operating a PCE dry cleaning machine included equipment depreciation, maintenance, and electricity. The costs of cleaning agents were higher when operating professional wet cleaning equipment.
- Labor costs were equivalent or lower in professional wet cleaning.

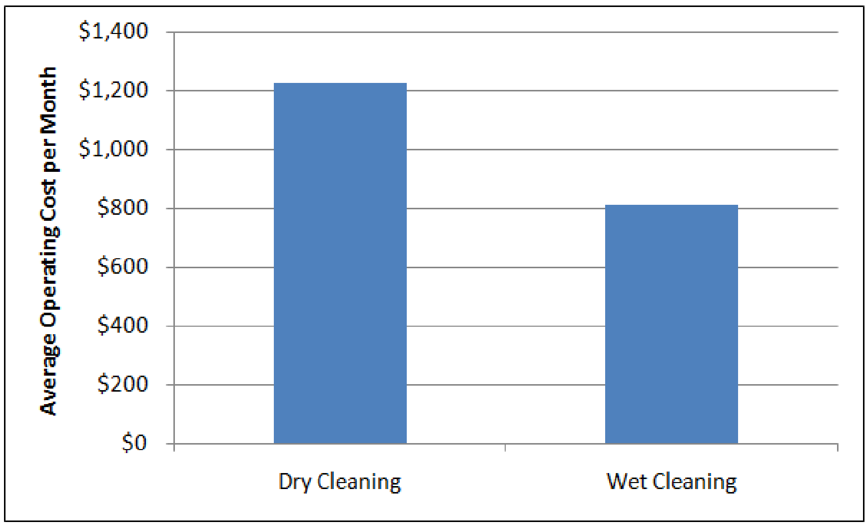

Figure 4: Process-dependent operating costs: Dry Cleaning vs. Professional Wet Cleaning (Source: [1]).

Resource Use Evaluation An assessment of electricity, natural gas, and water use was undertaken to compare the resource demands of cleaners switching from dry cleaning to professional wet cleaning. Data were based on monthly billing records obtained from the cleaners or their utility providers.

- Electricity use was significantly lower in professional wet cleaning.
- Natural gas use was lower at three quarters of the facilities.
- Water use was comparable.

Summary of Viability Evaluation The technical evaluation of cleaners switching from PCE dry cleaning to professional wet cleaning showed professional wet cleaning to be a viable alternative to traditional dry cleaning. Environmentally, professional wet cleaning proved to be an energy efficient, non-toxic technology that eliminates hazardous air emissions, hazardous waste production, and the potential for soil and groundwater contamination. From a performance standpoint, the cleaners who switched to professional wet cleaning were able to maintain their level of service and customer base while increasing their profits. These research findings were subsequently replicated in studies in the San Francisco Bay Area, San Diego, and Sacramento.

Once a green innovation, such as professional wet cleaning, has been established, one would think that public policy would be in place to encourage its rapid diffusion. However, as discussed in the following sections, widespread adoption of this new technology has faced formidable obstacles.

This case study of promoting the innovation and diffusion of environmentally benign alternatives in the garment care industry is instructive for developing a new approach to chemical policy in which the identification of safer substitutes becomes the driver for phasing out more hazardous consumer products and industrial processes.

POLICY CHOICES

In December 2002, the SCAQMD ruled to phase out PCE dry cleaning based on ongoing risk and the viability of non-PCE alternatives. Opponents to the phase out, primarily dry cleaning association representatives and PCE manufacturers, systematically challenged the viability of non-PCE alternatives throughout the rulemaking process. Criticism of professional wet cleaning focused primarily on whether cleaners could successfully process the full range of garments typically dry cleaned. Since the agency has co-sponsored the Professional Wet Cleaning Demonstration Project, they were able to respond to this challenge. Criticism of petroleum dry cleaning focused primarily on the issue that the marginal increase in VOC emissions outweighed the marginal decrease in PCE emissions. SCAQMD addressed this issue through an incentive program for non-PCE alternatives; they provided twice the incentive ($10,000) for professional wet cleaning and CO_2 than for petroleum and silicone ($5,000).

In May 2006, the ARB voted to phase out PCE dry cleaning throughout California. This unanimous ruling overturned their staffs recommendation to continue the use of PCE dry cleaning. The staff believed that the reduction of PCE emissions was outweighed by the projected increase in VOC emissions. Staff also presented to their Board the option of phasing out both PCE and VOC dry cleaning, which they rejected based on cost; staff believed most cleaners would shift primarily to silicone dry cleaning, which according to ARB staff, would create an unacceptable increase in cost. During the Governing Boards deliberation, the Board acknowledged the concern with the shift to VOC dry cleaning, stating they would likely need to limit the use of this sub-optimal alternative in the future.

The policy options table (Table 1) illustrates the benefits of an alternatives analysis approach in which a series of policy options are presented along with critical trade-offs. One glaring omission from Option 3, phasing out PCE and VOC, was that while silicone did represent a more expensive alternative, cleaners could also choose to switch to the less expensive professional wet cleaning. This being the case, the cost analysis for Option 3 should have been based on the less expensive alternative (professional wet cleaning) making this option the preferred choice eliminating both the target toxic use (PCE dry cleaning) as well as a sub-optimal VOC-emitting alternative (petroleum dry cleaning).

California voters continue to support policies aimed towards greater improvements in environmental quality and the protection of natural capital. However, less is known about Californians as consumers. Put simply, how many of us are living a "green" day-to-day life?

Table 1: Air Resources Board Policy Options for Regulating PCE Dry Cleaning (Source: [2]).

POLICY OPTIONS	CONTENT	ANALYSIS
Staff Recommendation	No PCE phase out engineering controls	Engineering controls sufficient to create acceptable risk
Option 1	No PCE phase out take no action	Continues to be a potential public health risk from PCE emissions
Option 2	PCE phase out	Most of market would go to petroleum and create unacceptable increase in VOC
Option 3	PCE and VOC phase out	Most of market would go to silicone and create unacceptable increase in cost

SCAQMD and ARB were the first regional and state agencies to phase out PCE dry cleaning. EPA was now in the position to move towards a national phase out of PCE dry cleaning. Yet in July 2006, two months after the ARB decision, EPA ruled to allow the continued use of PCE dry cleaning. The Sierra Club sued EPA claiming the agency incorrectly used risk assessment for determining the continued use of PCE dry cleaning was safe, while the Clean Air Act requires that the agency base the new rule on changes in practice, including technological innovation, specifically citing professional wet cleaning. In 2009, the Obama EPA agreed to temporarily suspend the suit in order to reevaluate their position.

Additional Policies to Further the Diffusion of Environmental Benign Alternatives While the phase out of PCE dry cleaning in California has created a market for environmentally benign professional garment care alternatives, sub-optimal technologies (e.g. petroleum and silicone) have begun to dominate the sector. In 2000 there were only a handful of professional wet cleaners and petroleum dry cleaners in California. By 2010, while the number of dedicated wet cleaners increased to over 150, petroleum dry cleaning increased to over 1,500. One factor explaining this preference for the sub-optimal technology is the fact that petroleum dry clean represents a simple chemical substitution while professional wet cleaning is a process change requiring technical training to learn the new process.

Additional policy changes have the potential to tip this balance. The policy options include incentive and demonstration programs targeting environmentally benign technologies as well as additional regulatory and legislative action. In 2003, a CA state law was enacted (AB998) which imposed a fee on PCE used in dry cleaning to create an incentive ($10,000) for PCE cleaners switching to non-toxic and non-VOC alternatives as well as a demonstration program educating cleaners about approved technologies. Professional wet cleaning and CO_2 dry cleaning were approved while petroleum dry cleaning and silicone dry cleaning were excluded. In addition, most energy utilities in California have developed education and incentive programs for professional wet cleaning based on proven energy savings. For example, Southern California Edison has established a permanent professional wet cleaning demonstration center and hosts periodic workshops. Los Angeles Department of Water and Power provides a $4,000 incentive to cleaners switching to professional wet cleaning.

Additional regulatory action is also feasible. ARB's Governing Board signaled that they would be willing to revisit the issue of additional regulation limiting petroleum dry cleaning depending on the future diffusion of this sub-optimal technology. Municipalities and counties have the authority to develop ordinances to phase in the most environmentally benign alternatives and phase out less optimal alternatives

LESSONS LEARNED

This case study of promoting the innovation and diffusion of environmentally benign alternatives in the garment care industry is instructive for developing a new approach to chemical policy in which the identification of safer substitutes becomes the driver for phasing out of more hazardous consumer products and industrial processes. The case study shows that 1) it is possible to use alternatives analysis as a basis for identifying safer technologies and phasing out hazardous substances; 2) alternatives analysis can be used to differentiate more environmentally benign alternatives from sub-optimal choices; 3) sub-optimal alternatives, due to their chemical characteristics, may still be preferred over more environmentally benign alternatives; and 4) additional policy options may be necessary to drive the diffusion of the safest, cleanest, greenest alternatives.

New approaches to chemical policy designed to phase out hazardous substances and phase in the safest substitutes are beginning to emerge. The key policy question is: what will best drive industry to innovate safer alternatives? The simple answer is financial gain. If there is a clear public policy signal that the identification of a safer substitute will automatically trigger the phase out of more hazardous products or industrial processes, then firms will see a market for the safer substitute. Investment in safer, cleaner, greener substitutes would soon follow.

In California, a new statute (AB1879), dubbed Safer Alternatives Act, became law in 2008 which focuses on identifying and promoting safer substitutes to consumer products which use chemicals of concern. The statute explicitly states that alternatives analysis be used to identify potentially safer substitutes. While successful implementation of the Safer Alternatives Act has the potential of driving innovation of safer substitutes, the statute faces many significant challenges including: no funding to implement the regulations, uncertainty about who is to conduct the alternatives analysis, lack of methods developed to conduct the alternatives analysis, and lack of technical expertise in state government to assure efficient and effective implementation.

If done correctly, AB 1879 has the potential to significantly drive innovation of safer substitutes. If done poorly, AB 1879 could become a significant setback for the integration of lternatives analysis into public policy as a means of creating safer, cleaner, green substitutes. Much hangs in the balance.

GRADES

South Coast Air Quality Management District

A+: For supporting research establishing the viability of professional wet cleaning.

A: For being the first government agency to phase out the use of the toxic chemical PCE in dry cleaning.

D: For establishing an incentive program for non-PCE alternatives.

California Air Resources Board

B+: For phasing out PCE dry cleaning through all of California (though they have been reluctant to phase out petroleum dry cleaning).

Energy Utilities

A: For sponsoring research verifying the energy efficiency of professional wet cleaning and for developing professional wet cleaning demonstration programs and/or incentive programs.

California Legislature

A: For establishing AB 998 the incentive program for environmentally benign garment care alternatives, and for establishing AB 1879 the law promoting safer alternatives in consumer products.

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Dr. Peter Sinsheimer is the Executive Director of the UCLA Law and Environmental Health Sustainable Technology & Policy Program. The Program aims to clear the path for effective, balanced chemical policies, and to assist in the use of safer chemicals and alternative manufacturing processes in the marketplace. Prior to his current position, Dr. Sinsheimer served for twelve years as the Director of the Pollution Prevention Center at Occidental Colleges Urban and Environmental Policy Institute. Since 1998, Dr. Sinsheimer has been the principle investigator for the Environmental Garment Care Commercialization Project. Through this work, Dr. Sinsheimer has become a leading voice in the movement to establish alternatives analysis as a necessary science/policy tool to promote the innovation and diffusion of safer technologies.

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