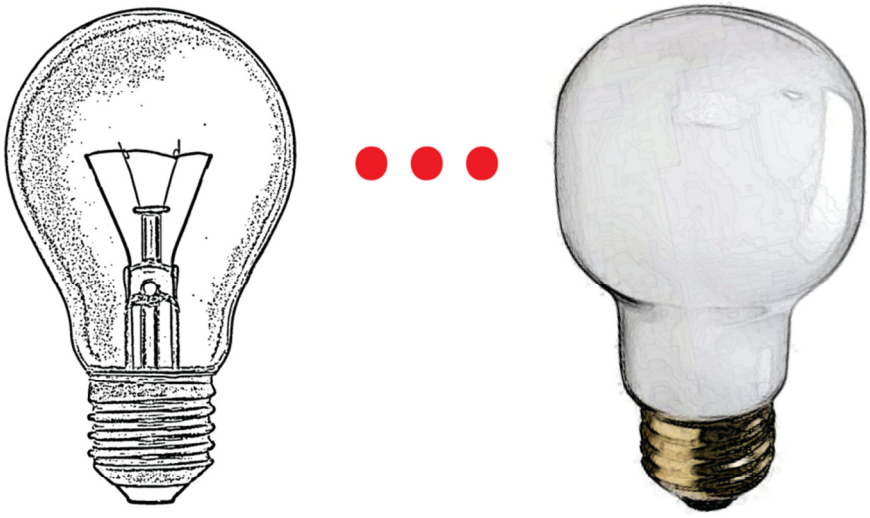
Regulation

The Unsung Hero in American Innovation

September 2011



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Acknowledgments
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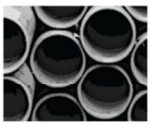
Contents

Regulations have a remarkable history of spurring innovation. This report looks at the regulatory attempts to address five serious problems: wasteful light bulbs, emissions of harmful sulfur dioxide from coal plants, workers' exposure to carcinogenic vinyl chloride, releases of ozone-destroying chlorofluorocarbons from aerosol cans, and inefficient home appliances.

Each case presented a challenge to industry: How to continue offering the same products while complying with the federal regulation? Industry officials fiercely resisted most of these regulations, often claiming that they would be put out of business if a rule under consideration was implemented. Yet, as each proposed rule covered in this report took effect, the industries met the standard—typically by developing better systems or products—and their doomsday scenarios were not realized in the least.

Regulations That Spurred Innovation

	Regulation		Innovation
Incandescent Light Bulb 	In 2007, the Energy Independence and Security Act increased the standard of efficiency for traditional incandescent light bulbs.	Politicians protested the regulation. but...	Philip's Lighting invented a new halogen incandescent that emits light that is almost indistinguishable from traditional bulbs, uses 30 percent less energy, and lasts three times longer.
Removal of CFCs 	After the scientific discovery that chlorofluorocarbons (CFCs) harm the ozone layer, government agencies implemented a ban on all non-essential CFC aerosol propellants.	Industry protested the regulation. but...	A day after the EPA officially implemented the regulation, the inventor of the original aerosol announced the invention of a cheaper aerosol propellant that didn't pose a threat to the ozone layer.
Vinyl Chloride 	In 1974, OSHA virtually banned emissions of carcinogenic vinyl chloride in the manufacturing of PVC.	Industry protested the regulation. but...	B.F. Goodrich, the largest PVC manufacturer, soon invented a process that both shielded workers from vinyl chloride exposure and was more efficient.
Removal of SO2 	Beginning with the 1970 Clean Air Act, the federal government began demanding that coal plants reduce emissions of sulfur dioxide, a major air pollutant that causes acid rain and smog.	Industry protested the regulation. but...	In response to the EPA's regulations, industry improved the efficiency of post-combustion sulfur dioxide removal technology, otherwise known as "scrubbing."
Appliance Standards 	During the energy crisis of the 1970s, Congress enacted efficiency standards for consumer appliances being used in residential and commerical buildings.	Industry protested the regulation. but...	The government standards prodded manufacturers to improve the efficiency of their products. These efficiency improvements are projected to save American consumers more than $240 billion by 2030.

I. Increasing Light Bulb Efficiency

The Problem

Traditional incandescent light bulbs are extremely inefficient. They are based on technology invented in 1879 by Thomas Edison. They waste 90 percent of their energy emitting heat, not light, and average just 750 to 2,500 hours of an operating life.[1] Lighting accounts for 30 percent of all electricity used in our country.[2] An average of 82 pounds of coal are burned to produce the amount of electricity that a traditional incandescent bulb consumes in its lifespan.[3]

The Regulatory Response

In 2007, the Energy Independence and Security Act was signed "to move the United States toward greater energy independence and security." The law established a series of efficiency standards for light bulbs. The first phase requires a 25 to 30 percent increase in efficiency over traditional light bulbs by 2012. The second stage requires a 60 percent improvement by 2020.

The Resistance

In 2011, the incandescent light bulb became the *cause celebre* of members of Congress playing to the Tea Party hostility over anything smacking of government regulation. Several bills—including the "Light Bulb Freedom of Choice Act" by Rep. Michele Bachmann (R-Minn.)—were introduced in Congress to eliminate the light bulb efficiency standard. Bachmann also incorporated an attack on the light bulb standards into her campaign for the White House, promising that "President Bachmann will allow you to buy any light bulb you want."[4]

Critics of the efficiency standard either imply or assert outright that it will ban the use of incandescent bulbs, forcing consumers to use compact fluorescent bulbs, which many dislike because they emit a bluish-white hue. For example, a June 2011 *Wall Street Journal* editorial opened by saying that in seven months, "Washington will effectively ban the sale of conventional 100 watt incandescent light bulbs that Americans have used nearly since the days of Thomas Edison. Instead we will all be required to buy compact fluorescent

[1] See, *e.g.*, "Energy Basics," U.S. Department of Energy. Available at http://www.eere.energy.gov/basics/buildings/incandescent.html.
[2] "The Real Deal on Compact Fluorescent Light Bulbs," National Audubon Society Facts Sheet, August 2009.
[3] *Ibid.*
[4] Andrew Restuccia, "President Bachmann Will Allow You to Buy Any Light Bulb You Want," *The Hill*, June 17, 2011.

lights."[5] Watchdog group Media Matters counted 40 times in which conservative news outlets have claimed that rules slated to take effect in 2012 will require consumers to use compact fluorescents.[6]

The Results

The law does not ban incandescent light bulbs.[7] It simply requires that light bulbs sold in 2012 be at least 30 percent more efficient than Edison's 1879 model. Ultimately, the law spurred companies to produce Edison's light with much less waste.

"There's a massive misperception that incandescents are going away quickly," Chris Calwell, a researcher with Ecos Consulting, an energy consulting firm said in 2009. "There have been more incandescent innovations in the last three years than in the last two decades."[8]

In anticipation of the first phase of requirements under the 2007 energy bill, manufacturers began investing in new bulbs that would both meet the new standards and still produce the soft light of incandescent light bulbs. By 2009, Philips Lighting, a Dutch electronics company, brought to market a new halogen incandescent that emits light that is almost indistinguishable from traditional bulbs, is 30 percent more efficient, and lasts three times longer.[9]

In contrast to old incandescents, Philips' halogen bulbs use a reflective coating that captures heat and transforms it into light.[10] Other manufacturers, including General Electric and Osram Sylvania, have also introduced energy-efficient halogen incandescents.

The new bulbs cost more than the traditional bulbs. For example, a Philips 100 watt-equivalent incandescent costs about $4, compared to 25 cents for traditional incandescent light bulbs.[11] But with their increased energy efficiency and longer lifespan, the new bulbs will save consumers money over time, according to the Department of Energy (DOE).[12]

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[5] "The Light Bulb Police: Americans Deserve Their Choice of Illumination," *Wall Street Journal* editorial, June 7, 2011.
[6] "Conservative Media Misled Light Bulb Consumers At Least 40 Times In 7 Months," Media Matters, July 18, 2011.
[7] See, *e.g.*, Kevin Drum, "Incandescent Bulbs Not Banned. Repeat: Not Banned," *Mother Jones*, July 15, 2011.
[8] Leora B. Vestel, "Incandescent Bulbs Return to Cutting Edge," *New York Times*, July 5, 2009
[9] *Ibid.*
[10] *Ibid.*
[11] *Ibid.*
[12] See, *e.g.*, "Frequently Asked Questions: Lighting Choices to Save You Money," U.S. Department of Energy Web site. Available at www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=11978?print.

Additional Innovations: LED Bulbs

Concern over energy efficiency and a government incentives program also have inspired the development of bulbs using light emitting diodes (LEDs)—the type of lights often seen on home electronics—that offer efficiency beyond halogen incandescents or even compact fluorescents.

A Philips LED bulb—which was awarded a $10 million prize by the DOE as the best replacement for a traditional 60-watt incandescent—emits light indistinguishable from that of traditional incandescents while using only one-sixth the energy.

If every 60-watt incandescent bulb in the U.S. were replaced with the prize winner, the United States would save about $3.9 billion worth of electricity annually, enough to power Washington, D.C., for three years.[13] LED bulbs still cost $25 or more, which most consumers would not readily pay even though the bulbs are purported to offer overall savings over their 20-year lives because of their increased energy efficiency. But if history is a guide, the cost of LED bulbs will steadily decline.

II. Reducing Sulfur Dioxide Emissions

The Problem

Sulfur Dioxide, SO2, is a major air pollutant that causes acid rain and smog, and has long been recognized as a serious health hazard. It contributes to thousands of premature deaths annually in the United States.[14] Most infamously, it caused the 1952 smog inversion in London that killed a staggering 4,000 people in one week.[15]

The Regulatory Response

About two-thirds of SO2 emissions come from coal-fired power plants.[16] The Clean Air Act of 1970 instructed the newly formed Environmental Protection Agency (EPA) to set maximum allowable emissions for stationary sources (most importantly, coal plants) and required states to develop federally approved pollution control plans. Nearly all of the resulting state plans called for ongoing reductions in SO2 emissions.[17] The effect

[13] "Department of Energy to Announce Philips Lighting North America Wins L Prize Competition," U.S. Department of Energy, Aug. 2, 2011.
[14] See, *e.g.*, Resignation letter Eric v. Schaeffer, EPA Director Office of Regulatory Enforcement, Feb. 27, 2002. Available at http://www.e2.org/ext/document.jsp?docId=1422.
[15] See, *e.g.*, "The Lethal London Smog Event 5th-9th December 1952." Available at http:/www.world-weather-travellers-guide.com/london-smog.html.
[16] Margaret R. Taylor, *et al.*, "Control of SO2 Emissions from Power Plants: A Case of Induced Technological Innovation in the U.S.," Technological Forecasting & Social Change, 2005, p. 354.
[17] *Ibid.*, p. 704.

of these plans was to require utilities operating coal-fired plants to implement "scrubbing" technologies to capture SO2 emissions before they reached the atmosphere.

Subsequently, amendments made in 1977 to the Clean Air Act required installation of scrubbers in new plants and in existing plants undergoing renovations. Additional Clean Air Act amendments passed in 1990 established a cap-and-trade system that required owners of coal-fired power plants that exceeded set amounts of emissions to purchase credits from companies whose emissions were below the established limits.

The Resistance

Industry has fought the implementation of scrubbers all along. It challenged the initial regulations issued under the Clean Air Act of 1970 and lost before the Supreme Court in 1976.[18] Throughout the 1980s, industry opposed the standards that were eventually created by the Clean Air Act of 1990. "Utilities predicted a cost of $1,000 to $1,500 for every ton of sulfur dioxide removed. Some said it could not be done even at that exorbitant price," an op-ed writer recalled years later, noting that the eventual cost ended up being a tenth as much.[19] Meanwhile, coal-fired utilities ignored requirements in the 1977 Clean Air Act to install scrubbers in plants undergoing renovations. The Department of Justice sued nine utilities in 1999 and 2000 for flouting the law.[20]

The Results

There are many ways to reduce SO2 emissions from coal plants, including pre-combustion treatment (in which coal is prepared before its use to improve its burning efficiency) and the use of low-sulfur coal (which naturally emits less SO2). But when the Clean Air Act was passed in 1970, flue gas desulfurization (FGD)—commonly known as "scrubbing technology"—was thought to offer the greatest potential for a comprehensive solution.[21]

The emphasis was on "potential." Although scrubbers were first implemented in London in 1926, they had never worked well. The first scrubbers were not installed in the United States until 1965.[22]

[18] *Ibid.*
[19] Jessica Matthews, "Clean Sweeps: Two Success Stories for the Environment," *Washington Post*, Dec. 18, 1995.
[20] See, *e.g.*, "EPA's Smoke Screen: How Congress Was Given False Information While Campaign Contributions and Political Connections Gutted a Key Clean Air Rule," Public Citizen, October 2003.
[21] Margaret R. Taylor, *et al.*, "Control of SO2 Emissions from Power Plants: A Case of Induced Technological Innovation in the U.S.," Technological Forecasting & Social Change, 2005, p. 704.
[22] Margaret R. Taylor, *et al.*, "Regulation as the Mother of Innovation: The Case of SO2 Control," Environmental Technology, April 2005, p. 371.

In the 1960s, scrubbers caused serious plugging in boilers and air heaters.[23] In 1970, a National Research Council panel on SO2 found that commercially proven technologies for control of sulfur oxides from combustion processes did not exist.[24] But the panel predicted that a feasible solution could be developed in one-to-three years.

The stringency of rules instituted in response to the 1970 Clean Air Act "provided an important incentive for the development of FGD technology," researchers Margaret Taylor and others wrote in 2005.[25]

In other words, the law prompted innovation. Although fewer than 100 patents for SO2 pollution control were issued before 1967 (and none since the mid-1930s), more than 2,500 patents were issued from 1967 through 1997.[26] During the 1970s, the number of scrubber vendors increased from 1 to 16.[27]

In the wake of the Clean Air Act, scrubbers became significantly more effective at capturing SO2 and less costly to install.

- The percentage of SO2 that scrubbers were able to prevent from reaching the atmosphere increased from about 75 percent in the mid-1970s to 95 percent by the mid-1990s.[28]

- Capital costs for scrubber technology were cut in half.[29]

- Costs to maintain plants with scrubbers declined, as operators learned to prevent corrosion and other problems that had previously required plants to be shut down for repairs.[30]

[23] *Ibid.*, p. 367.
[24] "Environmental Regulation and Technology Innovation: Controlling Mercury Emissions from Coal-Fired Boilers," Northeast States for Coordinated Air Use Management, September 2000.
[25] Margaret R. Taylor, *et al.*, "Regulation as the Mother of Innovation: The Case of SO2 Control," *Environmental Technology*, April 2005.
[26] Margaret R. Taylor, *et al.*, "Control of SO2 Emissions from Power Plants: A Case of Induced Technological Innovation in the U.S.," *Technological Forecasting & Social Change*, 2005, p. 709.
[27] Margaret R. Taylor, *et al.*, "Regulation as the Mother of Innovation: The Case of SO2 Control," *Environmental Technology*, April 2005, p. 356.
[28] Margaret Taylor, *et al.*, "The Effect of Government Actions on Technological Innovation for SO2 Control," Carnegie Institute of Technology, Aug. 1, 2001, p. 2.
[29] *Ibid.*
[30] Margaret R. Taylor, *et al.*, "Control of SO2 Emissions from Power Plants: A Case of Induced Technological Innovation in the U.S.," Technological Forecasting & Social Change, 2005, p. 713.

Meanwhile, the amount of SO2 emitted into the atmosphere decreased significantly. Between 1980 and 2008, the amount of SO2 in the air declined by 71 percent, even though electricity production from coal plants grew by 26 percent.[31]

In 2003, President George W. Bush's Office of Management and Budget determined that the 1990 Clean Air Act program to reduce emissions of SO2 and NOX (another coal plant pollutant) had the largest quantified human health benefits of any federal regulatory program in the previous 10 years—over $70 billion annually. OMB pegged the ratio of benefits to costs at more than 40-to-1.[32]

SO2 emissions remain a major health scourge, not because of the inadequacy of scrubber technology but because of industry's intransigence in implementing it. Even today, the EPA regards SO2 and NOX (which also comes largely from coal plants) as so dangerous that it estimated that the reductions in emissions resulting from just from one new set of standards (issued in 2010) will prevent up to 36,000 premature deaths a year.[33]

III. Protecting Workers from Poisonous Vinyl Chloride

The Problem

In January 1974, a public health emergency crisis arose over the discovery that exposure to vinyl chloride, a substance used to produce polyvinyl chloride (PVC), caused a rare but usually fatal form of liver cancer called angiosarcoma.[34]

Industry had been aware for years of troubling evidence of health risks from workers' exposure to vinyl chloride, in large part because of research it funded. But the general public did not learn about the hazards until January 1974, when B.F. Goodrich, the largest PVC manufacturer, informed the National Institute for Occupational Safety and Health (NIOSH) that three employees at one of its plants had died of angiosarcoma.[35]

Investigations over the next few months revealed additional cases of angiosarcoma among vinyl chloride workers, leaving little doubt over the substance's culpability. Other evidence

[31] David M. Hart and Kadri Kallas, "Alignment and Misalignment of Technology Push and Regulatory Pull: Federal RD&D Support for SO2 and NOX Emissions Control Technology for Coal-Fired Power Plants, 1970-2000," MIT-IPC-Energy Innovation Working Paper 10-002, April 2010, p. 2.
[32] "Cap and Trade: Acid Rain Program Results," Environmental Protection Agency Fact Sheet. (Undated.) Available at http://www.epa.gov/capandtrade/documents/ctresults.pdf.
[33] "Proposed Transport Rule Would Reduce Interstate Transport of Ozone and Fine Particle Pollution," Environmental Protection Agency fact sheet, undated. Available at http://epa.gov/airtransport/pdfs/FactsheetTR7-6-10.pdf.
[34] Paul H. Weaver, "On the Horns of the Vinyl Chloride Dilemma," *Fortune*, October 1974.
[35] *Ibid.*

implicated vinyl chloride in a range of other conditions, including gastrointestinal complications and chromosome damage. But as the health risks became increasingly clear, industry officials expressed doubt over the feasibility of reducing vinyl chloride exposures to assuredly safe levels in a PVC manufacturing environment.

That set up what *Fortune* dubbed "the vinyl chloride dilemma," which the magazine summarized with this chilling subtitle: "If government allows workers to be exposed to [vinyl chloride], some of them may die. If it eliminates all exposure, a valuable industry may disappear."[36]

By 1974, PVC had become ubiquitous in American society. Pipes, floor tile, house siding, wire, cables, packaging materials, furniture, bottles, rain coats, shower curtains, medical tubing, auto upholstery, credit cards, Saran Wrap, and phonograph records were among the products being fashioned from white PVC pellets.[37]

The Regulatory Response

The Occupational Safety and Health Administration (OSHA) responded quickly to the crisis. Less than three months after the health risk was revealed, the agency issued an emergency temporary standard that lowered permissible ambient levels from 500 parts per million (ppm) to 50 ppm. The next month, the agency issued a proposed rule calling for "no detectable level" of vinyl chloride in workplaces—0 ppm.[38]

The Resistance

PVC manufacturers and industries that relied on PVC howled, arguing that the proposed standard could not be met and that they would be put out of business it were enacted.

"If the proposed 'no-detectable-level' standard is adopted, the vinyl chloride and polyvinyl chloride resin producing industries will be forced to close down immediately," said Ralph Harding Jr., president of the Society of the Plastics Industry, the industry's trade association.

A report commissioned by the plastics industry warned that the proposed rule would cause "severe economic dislocation," eliminating 1.7 million to 2.2 million jobs and preventing $65 billion to $90 billion in products from reaching the market. Among the casualties of the

[36] *Ibid.*
[37] Various sources.
[38] *Ibid.*

proposed rule would be the entire automobile industry, which, the report said, "would, in fact, have to shut down."[39]

Firestone, a major PVC manufacturer, said it would be forced out of the plastics business and that it would sue on the basis that the rule was infeasible. To the extent the standard might have been achievable, Firestone said it would have to double its capital costs to meet it.[40]

In written comments submitted to OSHA, MCA Records said if PVC production were halted, "our industry would be forced out of business." The National Association of Home Builders said the proposed rule threatened to put "sorely needed housing . . . beyond the reach of an increasingly large segment of the public."[41]

A company that produced medical tubing warned that curbing supplies of PVC would jeopardize the availability critical equipment used for kidney dialysis and heart surgery.[42]

There were widespread calls for compromise, such as setting the standard at 25 parts per million, which scientists could not affirm to be safe. To the author of *Fortune*'s debate-framing article, the answer was clear: OSHA should compromise, not only to protect the viability of the industry but also to ensure society's continued access to the bounty of PVC products.

"It is clear that [OSHA regulators'] task should be to find the right 'trade offs'—to devise regulations in which the benefit of increased health for workers is balanced against the increased cost to the plastic industry and society as a whole," *Fortune* wrote.[43]

In the end, OSHA barely compromised. Fewer than nine months after news had broken of hazards posed by vinyl chloride, OSHA issued a final rule calling for exposures of no more than 1 part per million, except in sealed-off areas in which workers would be required to wear respirators to ensure that they did not inhale any fumes.[44]

OSHA's small concession did not placate industry. The plastics industry trade association said the standard was unrealistic and would likely be impossible for most to meet.

[39] David T. Cook, "Plastics—Jobs vs. Worker Safety," *Christian Science Monitor*, July 15, 1974.
[40] Paul H. Weaver, "On the Horns of the Vinyl Chloride Dilemma," *Fortune*, October 1974.
[41] Walter Mossburg, "Debating Health vs. Jobs: Plastics Industry Mobilizes To Thwart Tough Rules On Handling Vinyl Chloride," *The Wall Street Journal*, June 25, 1974.
[42] *Ibid.*
[43] Paul H. Weaver, "On the Horns of the Vinyl Chloride Dilemma," *Fortune*, October 1974.
[44] "New Rules Set to Reduce Vinyl Chloride Risk," *The Washington Post*, Oct. 2, 1974.

Firestone said the rule "puts the vinyl plastics industry on a collision course with economic disaster"[45] and would "throw 2 million jobs down the drain."[46]

The Results

What happened next was wholly unexpected.

In August 1975, just 10 months after final rule was issued, B.F. Goodrich announced that it had developed a process that would meet the OSHA standards without requiring respirator use. Its system captured residual vinyl chloride in the manufacturing process without allowing it to come into contact with workers.[47] A few months later, Goodrich touted its new technology in a *Wall Street Journal* display ad in which it said the new system "will be simple to operate [and] will increase raw material efficiency."[48]

In April 1976, Goodrich announced that it had signed licensing agreements for its containment technology with six corporations and that it planned to expand its own vinyl chloride manufacturing capacity at several plants that year.[49] By August, at least three other companies announced they were licensing safety technology or soon intended to.[50]

Shortly thereafter, demand for PVC boomed, prompting the industry to embark on an enormous expansion in manufacturing capacity. "PVC Rolls out of Jeopardy, into Jubilation," headlined a *Chemical Week* article published just 22 months after the final rule was announced.[51]

In addition to Goodrich's expansion plans, *Chemical Week* reported, Borden was building a PVC plant; Diamond Plastics planned to build a very large plant and a small plant; Dow Chemical was building a large plant; Stauffer Chemical was adding capacity to an existing plant; Robintech was increasing an existing plant's capacity by two-thirds; Shintech was expanding a plant by 50 percent; Tenneco was building a mid-size plant; and Continental Oil was adding on to an existing plant.[52]

[45] "Safety Rules Issued for Vinyl Chloride,: *The New York Times*, Oct. 2, 1974.
[46] "New Rules Set to Reduce Vinyl Chloride Risk," *The Washington Post*, Oct. 2, 1974.
[47] "B.F. Goodrich Says New System Reduces PVC Resin Hazards," *The Wall Street Journal*, Aug. 27, 1975.
[48] B.F. Goodrich display ad, *The Wall Street Journal*, Dec. 9, 1975.
[49] "Off To a Good Start," *Chemical Week,* April 28, 1976.
[50] "Getting Out the Last Traces of VCM," *Chemical Week*, Aug. 11, 1976.
[51] "PVC Rolls Out of Jeopardy, Into Jubilation," *Chemical Week*, Sept. 15, 1976.
[52] *Ibid.*

Even Firestone, which less than two years earlier had said the OSHA rule would force it out of the plastics industry, announced plans to bring a new PVC plant online by mid-1979, tripling its overall capacity."[53]

"Clearly, those actions signify U.S. vinyl producers' confidence that they have solved the 'OSHA problem' that threatened the viability of their industry less than two years ago," *Chemical Week* wrote.[54]

The planned increases in capacity would supplement an already booming business. PVC shipments in the first half of 1976 were up nearly 52 percent over the previous year, according to the plastic industry's trade association.[55]

Even in the late-1970s, as a recession loomed, the PVC industry continued to roar. "Producers of polyvinyl chloride are so convinced of the plastic resin's potential that they're scurrying with expansion plans, at the onset of a recession," began an August 1979 *Wall Street Journal* article.[56]

The *Journal* article ticked off a series of recently announced expansion plans, including industry-leader B.F. Goodrich's announcement of plans to double its company-wide 7 billion lbs./year PVC capacity over the ensuing six years. As demand for PVC was leveling off in some markets, new uses for the product were being developed, such as making window frames and creating automobile coatings.[57]

A 1995 report on OSHA rules by Congress's Office of Technology Management found that actual costs to implement the vinyl chloride rule were at most $278 million, compared to OSHA's $1 billion forecast. But, OTA wrote, the technological advances the rule inspired "enhanced manufacturing productivity, allowed better rationalization of material inputs, largely eliminated the need for manual reactor cleaning (a prime source of high exposures for the workforce), and provided a new source of income to the technology's developers through licensing arrangements."[58]

[53] *Ibid.*
[54] *Ibid.*
[55] *Ibid.*
[56] Margaret Yao, "Producers of Vinyl Chloride Scurry With Expansion At the Onset of Recession," *Wall Street Journal*, Aug. 15, 1979.
[57] *Ibid.*
[58] Office of Technology Management, Gauging Control Technology and Regulatory Impacts in Occupational Safety and Health: An Appraisal of OSHA's Analytic Approach," September 1995, p. 67-68.

In 1997, the Centers for Disease control reported that the 1 ppm standard for exposure to vinyl chloride in the workplace was "readily achieved" and that "new cases of hepatic angiosarcoma in vinyl chloride polymerization workers have been virtually eliminated."[59]

IV. Preventing Ozone-Destroying CFC Emissions from Aerosols

The Problem

First developed in the 1920s by the U.S Department of Agriculture for use as a refrigerant, chlorofluorocarbons (CFCs) became the preferred substance for use in aerosol cans due to their ability to convert easily between liquid and gas states.[60]

But a groundbreaking 1974 study demonstrated the ability of CFCs to break down ozone. Evidence showed that CFCs were diffusing slowly into the stratosphere and depleting the ozone layer, exposing people to more ultra-violet (UV) radiation, increasing the risk of skin cancer. Excessive UV radiation also contributes to the greenhouse effect and harms the earth's vegetation and animal life.[61] About half of CFC emissions in the United States in the early 1970s came from aerosols.[62]

The Regulatory Response

In 1977, the EPA, the Consumer Product Safety Commission (CPSC) and the Food and Drug Administration called for phasing out almost all use of CFCs in aerosol propellants.[62]

The Resistance

Industry preferred to use CFC aerosol propellants because they were non-flammable and produced a fine spray.[62] After 1974, with public concern growing over CFCs and industry anticipating a CFC ban, aerosol manufacturers began looking for alternatives.[63] Still, industry denied the scientific premise for the CFC ban. DuPont Corp., the world's largest manufacturer of CFCs, spent an average of nearly $1 million a year from 1972 to 1982, to challenge the findings that CFCs were depleting the ozone layer.[64]

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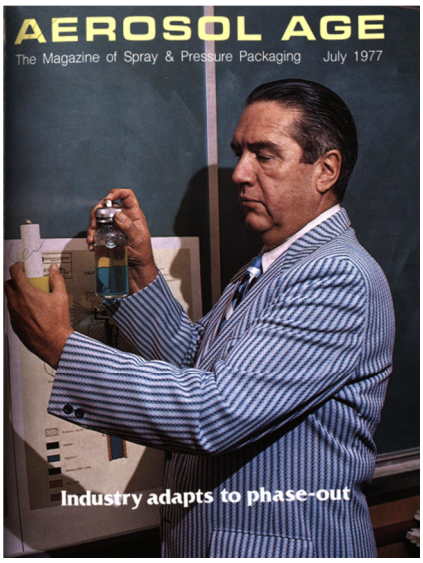
[59] "Epidemiologic Notes And Reports Angiosarcoma Of The Liver Among Polyvinyl Chloride Workers – Kentucky," Centers for Disease Control, Feb. 7, 1997.
[60] "F. Sherwood Rowland on Origin and Uses of Chlorofluorocarbons," See interview with Sherwood. Available at: http://www.youtube.com/watch?v=1xfJHukUQKE.
[61] "Are Aerosols Environmentally Friendly Now That CFC's Have Been Banned?" NHPR. Available at http://www.nhpr.org/node/17307.
[62] EPA Final Rule, See "Chapter 1: Environmental Protection Agency , Subchapter: Toxic Substances Control Act: Parts 712, 762, Fully Halogenated Chlorofluorocarbons," March 17, 1978.
[63] "Are Aerosols Environmentally Friendly Now That CFC's Have Been Banned?" NHPR. Available at http://www.nhpr.org/node/17307.
[64] Bridgette Smith, "Ethics of Du Pont CFC Strategy 1975-1995," *Journal of Business Ethics*, 1998.



DuPont, with funding from the Chemical Manufacturers Association (CMA), also created the Fluorocarbon Program Panel and, later, the Alliance for Responsible CFC Policy to dispute theories that CFCs harmed the environment. A separate industry group hired Dr. Joyce Brothers, a well-known psychologist, to lead a campaign against anti-CFC news.[65] *Aerosol Age*, an industry trade publication, argued "the chlorine-ozone hypothesis is purely speculative at this time with no concrete evidence having been developed to support it."[66]

Industry also criticized the EPA's proposed timeline for phasing out aerosols. "Finding a substitute for chlorofluorocarbons has not been easy," *Newsweek* wrote in summary of industry's comments. "No single alternative possesses their combination of chemical inertness, non-flammability, fast-drying spray and efficiency in ejecting the entire contents of a can,"[67].

In 1976, *Chemical Week* asked, "will consumers abandon the aerosol package completely, or will alternative propellant systems be acceptable?"

The Results

On May 14, 1977, just one day after the issuance of a federal regulation declaring CFC propellants an environment hazard and ordering them to be phased out, the inventor of the original aerosol valve announced that he had the solved the problem. Robert H. Abplanalp said he had developed an aerosol system with a non-CFC propellant that worked better than existing systems.

"Had the controversy not arisen, and this development had come along, it would have wiped out fluorocarbons anyway," said Abplanalp.[68]

While the new system "was perhaps developed in response to government regulation," said Abplanalp, a skeptic of the allegations surrounding CFCs, "this is one of the few times that consumers won't have to foot the bill." Abplanalp's innovation was advantageous because it used a 6:1 product-to-propellant ratio, in contrast to the 1:1 ratio in conventional aerosol

[65] John H. Sheridan, "Hydrocarbons Spur Aerosols' Comeback," *Industry Week*, September 1978, p. 140.
[66] "Ozone Controversy Reaches Congress," *Aerosol Age*, January 1975, p. 6.
[67] Peter Gwynne & Henry McGee, "Psst! Aerosol Alternatives," *Newsweek*, May 9, 1977.
[68] *Ibid.*

applications.[69] It also included a new valve that did not clog as easily and permitted users to fine-tune the spray.

Within two years of the announcement of the rule to ban CFCs in aerosols, CFCs were being used in less than 3 percent of all aerosols.[70] The industry, having suffered from a wave of bad publicity in the middle of the decade, experienced a resurgence.

"Doomsayers were ready to write their obituary, and many consumers think they have been banned. But far from being dead or banned, aerosols are making a comeback," *Chemical Week* wrote.[71]

"Marketers are talking about new-product introductions," said the aerosols development director at Phillips Chemicals. "Aerosols in the homes are no longer hidden under the sink. People do not feel guilty when they buy aerosols."[72]

The crackdown on CFCs, both worldwide and in the United States, continued with increasing urgency, especially with the discovery in the mid-1980s of a substantial hole in ozone layer over Antarctica, for which CFCs were blamed. Eventually, a worldwide ban was imposed against CFC use in air conditioners, refrigerators, and electrical cleaning supplies. By 2005, scientists reported that the ozone layer was recovering.[73]

V. Improving Home Appliance Efficiency

The Problem

Residential buildings account for more than 20 percent of the nation's energy consumption.[74] Historically, the refrigerators, air conditioners, furnaces and other appliances that burn all of that energy were not nearly as efficient as possible. Their waste has cost consumers billions of dollars in increased energy bills, while saddling the atmosphere was extra pollution from unnecessary energy generation.

The Regulatory Response

The Energy Policy and Conservation Act of 1975 established test procedures, targets and labeling requirements for household appliances. The National Energy Act of 1978 instructed the DOE to set efficiency standards for 13 appliances. But President Reagan

[69] "Aerosol Spray Without Fluorocarbons," *Popular Science*, September 1977.
[70] "Aerosols Stage Comeback After Several Lean Years," *Chemical Week*, May 23, 1979.
[71] *Ibid.*
[72] *Ibid.*
[73] See, *e.g.*, Marsha Walton, "Ozone Layer Making a Recovery," CNN, Sept. 2, 2005.
[74] "Multi-Year Program Plan: Building Regulatory Programs," U.S. Department of Energy Efficiency and Renewable Energy Building Technologies Program, October 2010, p. 28.

halted the drafting of regulations shortly after his inauguration in 1981,[75] putting the federal appliance efficiency program on hold for the better part of a decade.

Amid the Reagan administration's hands-off approach to efficiency standards, many states issued their own rules. This eventually convinced industry to lobby for uniform federal standards.[76]

After being rebuffed by a presidential veto in 1986, Congress in 1987 assembled a veto-proof majority to pass a law setting deadlines to enact efficiency standards for most new home appliances.[77] Subsequent energy laws required creation of standards for commercial and industrial products. The energy efficiency program now covers products responsible for 82 percent of residential building energy use, 67 percent of commercial building energy use, and about of half of industrial energy use.[78]

The Resistance

When the first standards were being drafted in the late 1970s and early 1980s, small businesses predicted that they would suffer dire consequences. "What our competitors have been unable to do—namely, put us out of business—it now appears that our government will do," the president of air conditioner maker Marvair Co. said in 1981. One early 1980s report estimated that requirements to verify that appliances met the standards would put 65 percent of small-businesses manufacturers at risk of bankruptcy.[79]

Meanwhile, larger manufacturers and their trade associations expressed general opposition to the program and warned that instituting efficiency standards might spell the end of familiar products such as self-cleaning ovens, automatically defrosting refrigerators and portable air conditioners.[80] But the manufacturers' opposition began to wane by the mid-1980s.

Much of the strident opposition to federal efficiency standards came from the political sector. For example the Reagan administration said the initial wave of proposed standards "would impose massive regulatory burdens on the private sector."[81] Later, in a statement

[75] "U.S. to Ease Some Energy-Saving Rules," *The New York Times*, Feb. 19, 1981.
[76] See, *e.g.*, Martin Tolchin, "An Industry Asks for Regulation," *The New York Times*, Feb. 17, 1987.
[77] Sandy Johnson, "Reagan Expected to Sign Energy Efficiency Bill He Once Vetoed," Associated Press, March 4, 1987. (Only two House members opposed the bill, future House Majority Leader Tom DeLay (R-Texas) and future House Energy and Commerce Committee Joe Barton (R-Texas).)
[78] "Multi-Year Program Plan: Building Regulatory Programs," U.S. Department of Energy Efficiency and Renewable Energy Building Technologies Program, October 2010, p. 6-7.
[79] Michael Reese and Jerry Buckley, "A Tale of Regulation," *Newsweek*, March 2, 1981.
[80] "Appliance Makers Predict Problems for Energy Saving Standards," *The Washington Post*, May 17, 1980.
[81] "U.S. to Ease Some Energy-Saving Rules," *The New York Times*, Feb. 19, 1981.

accompanying his veto of the 1986 standards-setting bill, Reagan said the "bill intrudes unduly on the free market, limits the freedom of choice available to consumers who would be denied the opportunity to purchase low-cost appliances and constitutes a substantial intrusion into traditional state responsibilities and prerogatives."[82]

In the mid-1990s, the newly elected Republican Congress targeted efficiency standards as part of an overall assault of federal regulations.[83] President George W. Bush's administration also slowed the issuance of new standards, prompting a lawsuit from 14 states and other parties. The DOE settled the case in 2006 by entering into a consent decree in which it agreed to publish standards for 22 product categories.[84]

The Results

Despite the halting progress of the program, federal energy efficiency standards have been a success by almost any measure. Appliances have become dramatically more efficient, their costs have steadily dropped, and industry now stands in alliance with the DOE and consumer environmental groups in touting the accomplishments of the standards—and in pressing for new ones.

Consider refrigerators, which consume about one-sixth of the electricity in a typical house, more than any other item.[85] An averaged-sized refrigerator from the 1980s would cost about $190 a year to run at today's electricity prices. Refrigerators purchased today—which employ high efficiency motors and compressors, and improved heat exchangers—cost about $75 a year to operate. Standards slated to take effect in 2014 will improve refrigerator efficiency by additional 15 percent.[86]

If refrigerator energy use had continued on the trajectory it was on when the first efficiency standards were implemented, the nation would be consuming an extra 160 gigawatts a year just to keep its refrigerators running, according to David Goldstein, who in 2002 received a MacArthur fellowship for spearheading the effort to develop super-efficient

[82] Elizabeth Tucker, "Energy-Standard Veto: No One Won, Groups Say; Business, Consumer Advocates, Utilities Upset," *Washington Post*, Nov. 5, 1986.
[83] Dan Morgan, "House Conservatives Step Up Assault on Regulations," *Washington Post*, July 19, 1995.
[84] Memorandum from President Obama to Energy Secretary Chu, "Appliance Efficiency Standards," Feb. 5, 2009.
[85] See, *e.g.*, California Energy Commission, Consumer Energy Center. Available at www.consumerenergycenter.org/home/appliances/refrigerators.html.
[86] "DOE Standards Will Cut Energy Usage by 25 Percent," American Council for an Energy-Efficient Economy, Aug. 26, 2011.

refrigerators. The annual savings from efficient refrigerators alone exceeds the entire amount of electricity generated by the United States' nuclear power plants.[87]

But the tremendous advances in refrigerator efficiency have not driven up prices. In January 1987, before standards took effect, an 18 cubic foot Kenmore refrigerator cost just under $500,[88] or $994 in 2011 dollars.[89] In August 2011, Sears was selling an 18.2 cubic foot Kenmore refrigerator for $424, less than half the inflation-adjusted cost of a comparable model from the pre-standards era.[90]

Likewise, clothes washers' energy consumption declined 63 percent from just 2000 to 2006, while dishwashers' water and electricity consumption were both down by about 30 percent over the same time period, according to the Association of Home Appliance Manufactures.[91] The DOE reports that central air conditioners are 30 percent to 50 percent more efficient than in the mid-1970s, and 20 to 40 percent more efficient than models sold just 10 years ago.[92] Window-unit air conditioners use only half as much energy as those made in the 1970s.[93]

As with refrigerators, most appliances regulated by federal standards cost much less than they did when before the standards were implemented. For example, a 2005 study published by the DOE's Lawrence Berkeley National Laboratories found that the inflation-adjusted prices of freezers, room air conditioners and clothes washers all dropped by well over 40 percent between 1985 and 2002.[94]

More advances are on the way. Appliance manufacturers have agreed to standards to reduce front-loading washers' water and energy use by about 50 percent by 2015; room air

[87] David Goldstein, "Some Dilemma: Efficient Appliances Use Less Energy, Produce the Same Level of Service with Less Pollution and Provide Consumers with Greater Savings. What's Not to Like?" NRDC Switchboard Blog, Dec. 17, 2010.
[88] Sears Ad, *Chicago Tribune*, Section 1, p. 16, Jan. 2, 1987.
[89] Bureau of Labor Statistics CPI Inflation Calculator. Available at www.bls.gov/data/inflation_calculator.htm.
[90] Sears Web site. Viewed on Aug. 29, 2011.
[91] "Home Appliance Energy Savings Quantified," press release of the Association of Home Appliance Manufacturers (AHAM), June 4, 2008.
[92] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Central Air Conditioners" Web site. Available at www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440.
[93] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Room Air Conditioners" Web site. Available at www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12420.
[94] Stephen Meyers, James McMahon, Michael McNeil, "Realized And Prospective Impacts Of U.S. Energy Efficiency Standards For Residential Appliances: 2004 Update," Lawrence Berkeley National Laboratory, June 24, 2005, p. 24.

conditioners will be at least 10 percent more efficient by 2014; and dishwashers will use nearly 15 percent less electricity and 25 percent less water by 2015.[95]

Standards do not deserve all of the credit for improving efficiency. Product performance generally improves over time, and the energy crisis of the 1970s enhanced demand for more efficient products. Complimentary government programs—such as research and development investments, the mandatory placement of energy consumption labels on appliances, and the incentives in the DOE's voluntary Energy Star program—all have contributed to improving the efficiency of appliances.

But standards have played a key role, both in prodding manufacturers to continue to improve the efficiency of their products and in ensuring that developers install highly efficient products in new buildings. For example, air conditioner maker Carrier Corp. once pointed out that contractors usually choose to install cheaper, less energy-efficient systems, leaving the buyer with the high utility bills.[96] Federal regulation ensures that inefficient products are not available for sale—to consumers or contractors.

The DOE's Lawrence Berkeley National Laboratories, which estimates the share of efficiency improvements resulting specifically from standards (as opposed to other baseline trends), credits efficiency standards with saving American consumers $64 billion from 1987 to 2005, and forecasts that the standards will save consumers $241 billion through 2030.[97]

Meanwhile, Marvair Co., the air conditioner maker that once claimed federal energy standards would push it out of business, proudly boasts on the front page of its Web site that the U.S. Patent and Trademark Office has accepted its patent application for an air conditioning system that achieves "substantial energy savings."

[95] "Major Home Appliance Efficiency Gains to Deliver Huge National Energy and Water Savings and Help to Jump Start the Smart Grid," joint press release of American Council for an Energy-Efficient Economy and Association of Home Appliance Manufacturers, Aug. 3, 2010.
[96] Michael Reese and Jerry Buckley, "A Tale of Regulation," *Newsweek*, March 2, 1981.
[97] Stephen Meyers, James McMahon, Barbara Atkinson, "Realized and Projected Impacts of U.S. Energy Efficiency Standards for Residential and Commercial Appliances," Lawrence Berkeley National Laboratory, March 2008, p. 26.

VI. Conclusion

This report illustrates a common cycle surrounding regulation. Industry typically first says that proposed solutions to generally recognized problems are too expensive—or even impossible—to meet. After the regulation takes effect, industry invariably develops a solution at far less cost than expected. By then, the once-heated controversy is all but forgotten, the public enjoys better protection, and, often, industry enjoys improved products or processes.

The cycle is instructive in light of the philosophical debate over regulations that permeates American politics today. If today's anti-regulatory ideologues prevailed when the issues in this report were being discussed, industries would not have been pushed to develop the solutions that they eventually achieved.

The promise of innovation should not be viewed as a requirement to justify necessary rules to protect workers, the public and the environment any more than football referees should be expected to help drive up television ratings. What the case studies in this report indicate is that regulations often bring out the best and the worst from the leaders of American industry: A reflexive opposition to public sector demands to solve problems and an unparalleled ability to develop solutions when they put their minds to it.