Consumers of Doubt: Engineers in Denial during the Ozone Crisis, 1974-1989

Abeer Saha
Charlottesville, VA

Bachelor of Science in Mechanical Engineering, University of Virginia, 2013

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At a large gathering of technologists in Washington D.C., engineers and managers of a multi-billion dollar American industry were reminded that "technology" faced a "severe challenge" from the environmental and consumer protection movements of the tumultuous 1960s.[1] But they were urged not to lose faith. Their critics had underestimated them, and the power of technological innovation and engineering excellence. "Abandonment of technology was not the answer." They were reminded that technology itself was not the cause of our problems, but rather, technology could "solve all of the ills of our present society."[2] Little did they suspect that the most serious threat to their faith in technology was soon going to make a dramatic appearance.

On June 28, 1974, *Nature* published an article by Mario Molina and Sherry Rowland which boldly declared that large amounts of chlorofluorocarbons (CFCs) may be reaching the stratosphere and leading to the "destruction of atmospheric ozone."[3] A fall in stratospheric ozone concentrations would allow harmful ultraviolet radiation to reach the surface of the earth, leading to increased instances of skin cancer, disruptions in agriculture, and global climate modification. An actual depletion of the ozone layer had not yet been detected, but these University of California scientists had issued an early warning of what could happen if millions of pounds of CFCs continued to be released into the atmosphere unchecked. More than two decades later Molina and Rowland would go on to receive the Nobel Prize in Chemistry for their work in bringing the ozone crisis to the attention of the world.

Rowland and Molina had singled out CFCs -11 and -12 (also known as Freons) as the most potent ozone depleters. These chemicals were used widely as refrigerants in air-

[1] David Morrison, "Engineering Excellence or Societal Regulation?" *ASHRAE Transactions* 77 (2) (1971): 14.
[2] Ibid., 18.
[3] Mario J. Molina and F. Sherry Rowland, "Stratospheric sink for chlorofluoromethanes: chlorine atoms catalyzed destruction of ozone," *Nature* 240 (June 28) 1974, 810-812.

conditioners and refrigerators, and aerosol propellants in spray cans, forming the backbone of two multi-billion dollar industries in the United States alone. The air-conditioning and refrigeration industry, in particular, perceived the charge against these, ostensibly innocuous, CFCs as a threat to their profits and their very existence. Despite their awareness of the alarming health and environmental implications of ozone depletion, this threat would be met with fifteen years of outright denial.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), a non-profit, research and standard-setting organization, had more than thirty thousand members when the news of the CFC-ozone depletion theory made national headlines. Its membership would grow to more than fifty thousand over the next decade. ASHRAE's stated purpose was to advance those arts and sciences that were related to heating, ventilation, air-conditioning, and refrigeration (together these fields were known by the acronym HVAC&R). The HVAC&R industry had been using CFCs for several applications since the 1930s. While ASHRAE prided itself as a research organization that was established "for the benefit of the general public" it nonetheless maintained a close alliance with the HVAC&R industry's trade organization and lobbying group the Air-conditioning and Refrigeration Institute (ARI). Soon, however, this alliance, and ARI's vested interest in maintaining the profitable CFC industry, would endanger ASHRAE's own constitutional commitment to "recognize the effects of its technology on the environment," and specifically on the ozone layer.[4]

From the very onset of the ozone crisis, the HVAC&R industry had the option of choosing from several CFC-alternatives, such as ammonia and non-ozone depleting halocarbons.

[4] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., "Bylaws," *ASHRAE Transactions* 80 (2) (1974): 543.

But instead they chose to deny that the threat was real. While a ban on CFCs would necessarily have shut down a production line for the chemical manufacturers such as Du Pont and Allied Chemical (giving rise to CFC-alternatives nonetheless), it would not have ended the air-conditioning and refrigeration industry or ASHRAE. For the HVAC&R industry, it was not a deny-or-die situation. But that is exactly the binary through which members of industry began to perceive the ozone issue. The engineers at ASHRAE who had dedicated their careers to developing technological solutions to industry's and society's problems, chose in this instance to deny the ozone problem.

Framing the ozone crisis as a deny-or-die predicament of existential magnitude was a perfect way to rally up industry-wide support for the diversionary tactics of the CFC manufacturers and their "merchants of doubt".[5] After all, had the HVAC&R industry decided to engineer their way out of the crisis at considerable expense (as they were later forced to do by regulation), the multi-billion dollar CFC business would have all but disappeared within the decade. Instead, the looming shadow of command-and-control industrial regulation by the government was framed as an assault on their livelihoods, their modes of production, and their very world-views. Their convictions dictated that technology and technologists were not to blame. But by presenting the ozone depletion theory to the members of ASHRAE as an attack on technology itself, those with a stake in the CFC-business were able to influence thousands of technologists and their sympathizers into the depths of denial.

A zealous faith in the promise of technology was invoked within these technologists in order to cast the ozone depletion hypothesis as a luddite conspiracy. Many within ASHRAE

[5] Naomi Orekes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*, (New York: Bloomsbury, 2010)

believed that technology was the solution and not the problem. They had an overriding faith in technology and its rightful place at the apex of America's drive toward world leadership. This belief allowed them to be thoroughly circumspect of any theory that threatened their deep convictions about the primacy of technology on the path to progress. Furthermore, they were so caught up in the "anti-technology" attacks of the 1960s and 70s, and the decline of American engineering and technical leadership on the global stage, that they fiercely guarded what remaining prestige and attractiveness their professions had in the eyes of the nation.[6] This powerful combination of technological optimism and inferiority complex rendered them susceptible to the rhetoric of ozone-depletion skeptics.

The rhetoric of scientific "uncertainty" was a crucial weapon in the skeptics' arsenal, but it rested on an untenable interpretation of certainty and proof. Industry members repeatedly invoked the language of the theory being "unproven." Members of ASHRAE were led to believe that it would only be reasonable to wait to act until the science was "certain" and therefore, "proven." But the history and philosophy of science have shown that there is no such thing as absolute certainty in science and no theory that is indisputable.[7] There is only the best possible explanation available at a given time, waiting to be supplanted by the next superior paradigm.[8] In other words, members of ASHRAE did not realize that what they were waiting for was in fact never going to arrive. Even when they finally caved into accepting the theory, some fifteen years after the Molina and Sherwood article, it had yet to live up to the impossible expectation of

[6] Matthew Wisnioski, *Engineers for Change: Competing Visions of Technology in 1960s America* (Cambridge, MA: MIT Press, 2012).
[7] Karl Popper, *The Logic of Scientific Discovery*, (London: Routledge Classics, 2002); Wendy Parker, "Environmental Science: Empirical Claims in Environmental Ethics," in Stephen M. Gardiner and Allen Thompson (eds.) *The Oxford Handbook of Environmental Ethics (Forthcoming)* (Online: Oxford Handbooks Online, Nov 2015); Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA: MIT Press, 2013).
[8] Thomas Kuhn, *The Structure of Scientific Revolutions,* (Chicago: University of Chicago Press, 1962);

"complete certainty," but was nonetheless branded as such by industry and media. By 1989 the original theory had withstood intense scientific debate but was no closer to being "uncontestably proven" than it had been in 1974.

In recent years, scholars of the ozone crisis, as well as of other anthropogenic environmental issues, have highlighted the strategy of denial and delay that corporations and their stakeholders have resorted to in order to hold on to their markets and their profits.[9] What has been studied less, or in many cases, ignored, have been the mechanics of denial as it plays out within the populations at whom the rhetoric of denial is being directed. In their landmark study, Naomi Oreskes and Erik M. Conway, for instance, have pointed to "merchants of doubt" of anti-communist, free-market persuasions who have been the driving force of denialism in the face of environmental issues since the 1950s.[10] Their research revolves around a few prominent and powerful men in the realms of science, policy, and industry, who skewed the science and fabricated doubt in order to obstruct and delay government regulation that could otherwise have helped save lives and protect the environment. This paper focuses instead on the "consumers of

[9] Naomi Orekes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*, (New York: Bloomsbury, 2010); Sharon Roan, *Ozone Crisis: The 15-year Evolution of a Sudden Global Emergency*, (New York: John Wiley & Sons, 1989); Lydia Dotto and Harold Schiff, *The Ozone War* (Garden City, NY: Doubleday & Company, 1978); James Maxwell and Forrest Briscoe, "There's Money in the Air: The CFC Ban and Dupont's Regulatory Strategy," *Business Strategy and the Environment,* Vol 6 (1997), 276-286; Richard Mullin, "What can be learned from DuPont and the Freon Ban: A Case Study," *Journal of Business Ethics*, Vol 40 (2002), 207-218; For studies of denial in other environmental crises see: Gerald Markowitz and David Rosner, *Deceit and Denial: The Deadly Politics of Industrial Pollution* (Berkeley: University of California Press, 2002); Nancy Langston, *Toxic Bodies: Endocrine Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010); Pete Daniel, *Toxic Drift: Pesticides and Health in the Post-World War II South* (Baton Rouge and Washington D.C.: Louisiana State University Press in association with the Smithsonian National Museum of American History, 2005); Gerald Markowitz and David Rosner, *Lead Wars: The Politics of Science and the Fate of America's Children* (Berkeley: University of California Press, 2013).

[10] Naomi Orekes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*, (New York: Bloomsbury, 2010), 36; For similar arguments made about industry in general, as it relates to neo-liberal ideological motivations for environmental inaction, see: Ulrich Brand, "Green Economy – The Next Oxymoron?: No Lessons Learned from Failures of Implementing Sustainable Development," *GAIA* 21 (1) (2012): 28-32; Stephen Gill (ed.), *Global Crisis and the Crisis of Global Leadership* (Cambridge: Cambridge University Press, 2012).

doubt," and in doing so attempts to fill a gap in the growing literature on science and denial in the Cold War era.

Revisiting the results of the original scientific research that followed the Rowland-Molina hypothesis, the following analysis will trace the evolution of the CFC-ozone-depletion controversy from its beginnings in 1974 to its resolution in 1989. Using ASHRAE meeting transaction records and articles from their journal, this article will highlight ASHRAE's rhetoric and response to the science and politics of the ozone crisis. Congressional hearings and newspaper coverage, alongside secondary sources, will be used to describe the political, social, and cultural context of denial in the face of CFC-based ozone depletion. This article argues that faith in the promise of technology and the rhetoric of scientific uncertainty formed the double helix of the DNA of denial during the ozone crisis.

One Crisis after Another

"The solution lies with you, as individuals, as engineers, as industry representatives. With your knowledge and your ability…through the systems your technology can provide…This is your opportunity as patriotic citizens of this country and of the world," exhorted Senator Mike Gravel (D-AK), delivering a speech to thousands of members of the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) in early 1974.[11] Only a few months ago, an energy crisis had gripped the nation. Arab members of the Organization of Petroleum Exporting Countries (OPEC) had imposed an oil embargo against the United States. Inflation skyrocketed. The technological utopia of cheap, unlimited energy came under serious

[11] Mike Gravel, "The Real Energy Crisis," *ASHRAE Transactions* 80 (1) (1974): 21.

attack. And everyone was scurrying in search for a solution. ASHRAE was called on to contribute.

In response, the society's President David Rickelton called for "energy optimization through technology."[12] Over twenty-five percent of the total energy use in America was related to the HVAC&R domain. This meant that ASHRAE could have a huge impact on amending the crisis by preventing wasteful and inefficient energy use. Their plan was to contribute to energy conservation through more efficient heaters, air-conditioners, and refrigerators, as well as better insulation and ventilation in buildings and homes. Members were encouraged to review energy legislation and use their influence and expertise to ensure that "meaningful" regulations were adopted by the government instead of hasty rulemaking that would only "add to the bureaucracy" without any energy conservation impact.[13] While ASHRAE members were certainly wary of any overbearing governmental intervention in business matters, they recognized the need for some regulation, and were even appreciative of government efforts to promote solar energy and federal energy efficiency standards.

ASHRAE's involvement with the energy crisis continued through the years of the ozone issue, and their focus on conservation remained strong. The *ASHRAE Journal* published hundreds of articles on energy conservation in the years following the oil embargo. Their research committee funded scores of projects in areas pertinent to energy efficiency, conservation, and recycling. ASHRAE's technologists prided themselves on their technological expertise and ingenuity. They believed it was technology and innovation that would solve their energy problem and rescue the nation from the hardships of inflation. They were not opposed to

[12] David Rickelton, "New Horizons 1974-1975," *ASHRAE Transactions* 80 (2) (1974): 11.
[13] Paul C. Greiner, "Legislation Affecting Energy Conservation," *ASHRAE Journal* 16 (April, 1974): 34.

technological fixes, and neither were they opposed to regulation; they were simply concerned that whatever controls were adopted by government make a real difference in resolving the energy crisis.

But another crisis had arrived at the scene. As researchers around the world began investigating the Molina-Rowland hypothesis, American news media was not far behind. Over the next few weeks and months newspapers across the country called the public's attention to the ozone "threat" and "peril."[14] Congress and the National Research Council (NRC) of the National Academy of Sciences (NAS) took this threat seriously. A series of hearings and research efforts were initiated.

A few years prior to Molina and Rowland's discovery, the NAS had already been conducting research on the potential modification of the stratosphere from supersonic transport, such as Concorde aircrafts. Their primary concern, however, had not been CFCs but nitrogen oxide (NO_x) emissions. With the CFC hypothesis published in *Nature*, and gobbled up by the press, the National Research council (NRC) was quick to redirect its efforts. A panel by the name of Climate Impact Committee was established within a few short months and was charged with examining the effects of halogens on the ozone layer.[15]

In the meantime, moved by the widespread and urgent headlines implicating CFCs in ozone depletion, Representative Paul Rogers (D-FL), chairman of the Subcommittee on Public Health and Environment, introduced a bill in the House to amend the Clean Air Act in order to

[14] George Getze, "Effect on Atmosphere Told: Refrigerant, Aerosol Gas Called a Threat; Threat to Ozone," *Los Angeles Times*, June 28, 1974, A3; Walter Sullivan, "Tests Show Aerosol Gases May Pose Threat to Earth," *New York Times,* September 26, 1974, 1; Ronald Kotulak, "The aerosol can's threat is no joke," *Chicago Tribune*, September 29, 1974, A1; Thomas O'Toole, "Freon Called a Threat to Earth's Ozone Layer," *The Washington Post*, November 21, 1974, A1; Harold M. Schmeck, "Delay on Gas Ban Held Ozone Peril," *New York Times*, December 13, 1974, 15.

[15] Panel on Atmospheric Chemistry, National Research Council, *Halocarbons: Effects on Stratospheric Ozone* (Washington D.C.: National Academy of Sciences, 1976), vi.

provide the Environmental Protection Agency (EPA) regulatory powers to "control and possibly ban" the production and consumption of fluorocarbons.[16] Another supporting bill called for a ban on CFCs 11 and 12, "unless a study finds such substances innocuous."[17] Hearings on these bills were conducted in mid-December and included testimonies from both Rowland and Molina, as well as several other prominent researchers, representatives from environmental groups such as the Natural Resources Defense Council (NRDC), and those from the CFC-related industries.[18]

Raymond McCarthy, technical director of the highly profitable Freon Products Division at E. I. Du Pont De Nemours Company, was called on to represent the CFC-manufacturing industry at these early hearings. His testimony laid down the blueprint for much of the standard industry response that was to follow over the next decade and a half. Apart from detailing all the benefits of CFCs as refrigerants, and their obvious importance in residential refrigeration and air-conditioning, as well as other medical and commercial applications, McCarthy emphasized four main points: the economic impact of an outright ban on fluorocarbons would be financially destabilizing for the eight billion dollar industry resulting in a potential loss of jobs and inconvenience to consumers; if the CFC-ozone-depletion hypothesis were real it would be a global problem and because the U.S. produced "only" fifty percent of all CFCs worldwide, regulating industry in the U.S. alone would not solve the environmental issue; there was no experimental proof for the Rowland and Molina hypothesis; and, finally, more research was needed. Discounting the theory of ozone-depletion as "purely speculative" with "no concrete evidence," McCarthy assured the subcommittee that if "credible scientific data" was to come to

[16] United States Congress, House Subcommittee on Public Health and the Environment, Committee on Interstate and Foreign Commerce, *"*Fluorocarbons: Impact on Health and Environment*,"* Hearings, Dec.*11*-12, 1974, 93rd Congress 2nd session (Washington: GPO, 1974), *Proquest Congressional Publications.* Accessed Online: 9 March 2016.
[17] Ibid.
[18] Ibid.

light, then Du Pont would "stop production of these compounds."[19] But the kind of data that qualified as "credible" was heavily contested. McCarthy's was a promise with a lot of fine print.

At the opposite end of the spectrum were environmental groups such as the NRDC. What made CFC regulation so urgent in their eyes, was that these inert chemicals took decades to reach the stratosphere. So the effects of CFC release in the present would not be measureable for a long time to come, but once measured, would be too late to stop. In other words, waiting several years for experimental evidence of ozone depletion from CFCs, before taking steps toward remediation and regulation, would make the negative consequences of years-worth of ozone-depletion inevitable. With that in mind the NRDC recommended that aerosol products that contained ozone depleting propellants be banned, "prohibiting their manufacture and distribution."[20] Aerosols like spray paints, hair sprays, and deodorizers were considered frivolous uses, and therefore an easier target for regulation through a straightforward ban. Demands to control and substitute CFCs in more essential uses such as refrigeration would come once the smaller battles for a CFC-aerosol ban had been won.

In January 1975 a cohort of Federal agencies created the Federal Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS). By May of that very year IMOS released its results in a report titled, *Fluorocarbons and the Environment*. Its conclusion was unequivocal: "Unless new scientific evidence is found to remove the cause for concern, it would seem necessary to restrict uses of fluorocarbons-11 and -12."[21] However, because the NAS would soon be releasing its own report, the IMOS committee suggested that regulatory agencies

[19] Ibid., 380-381.
[20] Ibid., 426-427.
[21] Council on Environmental Quality, Federal Council for Science and Technology, *Fluorocarbons and the Environment: Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS)* (Washington D.C., June 1975).

wait until the NAS confirmed their results before initiating rulemaking procedures. When the NAS released its final report, in September, they concluded that regulation of CFCs was "almost certain" to be necessary in the future.[22] CFCs had been found to be reaching the stratosphere, and thereupon decreasing in concentration at the rate they would be expected to if the CFC-ozone-depletion hypothesis were right. Furthermore, the CFC-reaction that led to ozone depletion had also been confirmed in the laboratory. What remained to be measured was an actual decrease in stratospheric ozone concentrations. This had not been achieved yet because the ozone concentrations in the upper atmosphere varied up to five percent on a daily and seasonal basis, making it very hard to measure the smaller changes that the theory had predicted should have already occurred. Therefore, for an indication of how soon the regulations should be enacted, the NAS deferred to the results of forthcoming research in the next couple of years. They judged that waiting for two years would only fractionally impact the total amount of CFCs that were already on their way to the stratosphere, and in so doing, they implicitly accepted that they were already committed to the bulk of the depletion that was to come.

Not everyone was willing to wait. After the IMOS report itself, many consumers, influenced by media coverage of the unfolding issue, and inexpensive alternatives, had switched over to roll-on antiperspirants and pump sprays, avoiding the use of aerosols altogether.[23] Some large manufacturers of aerosol sprays had stopped using CFCs and others were actively searching for substitutes. A combination of popular politics and media frenzy enabled the state of Oregon to ban CFCs in aerosol sprays as early as June 1975. Similar legislation had been

[22] Committee on Impacts of Stratospheric Change, Assembly of Mathematical and Physical Sciences, National Research Council, *Halocarbons: Environmental Effects of Chlorofluoromethane Release* (Washington D.C.: National Academy of Sciences, 1976), 7.
[23] Steven Greenhouse, "Aerosol Feels the Ozone Effect," *New York Times*, June 22, 1975, 149.

introduced in thirteen other states.[24] The state of New York required companies to label aerosols products containing CFCs.[25] A comparable flurry of legislation occurred at the Federal level as well. Fresh bills proposing bans on CFC-based aerosols were introduced both in the Senate and the House.

ASHRAE's Early Reaction and Rhetoric

Since the announcement of the CFC-ozone-depletion hypothesis, ASHRAE, like the rest of the HVAC&R industry, had been watching the major CFC-producing companies call the theory into question at congressional hearings and wait for the interagency taskforce (IMOS) to release its findings on the inadvertent modification of the stratosphere. ASHRAE was painfully aware that air-conditioning and refrigeration accounted for thirty percent of the two billion pounds of fluorocarbons that were produced in the United States every year. A ban on the production of CFCs would have enormous repercussions for the multi-billion dollar HVAC&R industry. They were also aware that the effects of a depleted ozone layer included increased incidences of skin cancer, crop damage, and weather modification.[26] But for ASHRAE this was not a choice between treading the well-worn path of denial, on the one hand, or being proactive in their search for a technological fix—as it had done in the face of the energy crisis—on the other. ASHRAE was presented the ozone crisis as a deny-or-die predicament. And a choice between death and denial was no choice at all. The problem was not real. They were convinced.

"Any law or regulation which would ban or restrict the use of fluorocarbon compounds as refrigerants… would force us to attempt to revert to an ice-box economy," declared Herbert

[24] Ibid.
[25] James Maxwell and Forrest Briscoe, "There's Money in the Air: The CFC Ban and Dupont's Regulatory Strategy," *Business Strategy and the Environment,* Vol 6 (1997), 276-286.
[26] ASHRAE-NSPE Liaison Program, "Dateline Washington," *ASHRAE Journal* 17 (May 1975): 20-21.

Gilkey, in testimony before the IMOS committee in 1975.[27] Gilkey was a mechanical engineer who had served in U.S. Army Corps of Engineers during World War II. After the war he returned to pursue his PhD at the University of Illinois, Urbana-Champaign. There he established contacts in the air-conditioning industry and this led him to becoming a member of ASHRAE. His credentials and contacts also secured him the position of Government and Consumer Affairs Director at HVAC&R industry's trade organization, ARI.[28] He had imbibed the industry agenda to deny the science and was determined to delay any regulation of CFCs. His reference to an "ice-box" economy—the very antithesis of a technologically advanced society, every engineer's nightmare—although obviously hyperbole, conveyed the seriousness of the threat to their way of life, that not only industry leaders, but rank-and-file engineers, would see in the CFC-ozone issue.

In spite of the IMOS report results that upheld the ozone-depletion hypothesis, ASHRAE life member George C. Briley, the Vice President of a mid-sized refrigeration company, soon followed Gilkey's lead. In an article on trends in the refrigeration industry he remarked: "Anybody for a block-ice plant complete with horses?"[29] These technologists were afraid of what they perceived as a regressive turn of events. Briley's unabashed and colorful analysis blamed "uninformed" "highly emotional" politicians and masses for blowing the CFC-issue out of proportion and threatening "our economy, our business, and our personal lives."[30] An accomplished manager, a professional engineer registered in several states, a holder of four U.S. patents, and the author of numerous peer-reviewed papers and articles related to refrigeration,

[27] Ibid., 21.
[28] James W. Phillips, University of Illinois Urbana-Champaign, "Herbert Talbot Gilkey," *TAM Report No. 712, Arthur Newell Talbot: Proceedings of a conference to honor TAM's first department head and his family, April 1994*, Retrieved from: http://uihistories.library.illinois.edu/TAMHistory/Talbot/contents.html, Accessed on: March 26, 2016.
[29] George C. Briley, "Trends: Refrigeration Report 1975," *ASHRAE Journal* 17 (December 1975): 18.
[30] Ibid., 18.

Briley went on to make a statement that revealed the fallacy on which his denial, and that of many others, flourished.[31] "Extensive tests are being made to prove or disprove the effects of some halocarbons upon the ozone layer," he confidently asserted.[32] But this binary of "prove or disprove" set up an impossible criterion for atmospheric scientists to fulfill. Briley's expectations would not be met, not before a lot of damage had already been done.

In February of 1976, ASHRAE's Board of Directors issued its official statement on the ozone-fluorocarbon issue. Apart from pointing out that the science was uncertain, the statement emphasized that the government should consider the importance of the HVAC&R industry for the economy and quality of life of the American people, as well any potential regulation's financial and temporal feasibility for the industry.[33] The impact on the economy and quality of life in the case of ozone depletion could be much more severe than in the case of industry regulation, but this ASHRAE's statement did not concede.

The position statement was published in *ASHRAE Journal's* August run of 1976. Every article in this volume was dedicated to the "Ozone Fluorocarbon Issue." An engineer at the Carlyle Compressor Company went so far as to recommend holding off any regulation until there was "absolute proof" that CFC emissions were harmful.[34] He did not realize that his recommendation left no room for CFCs to ever be regulated. His "absolute proof" would always go wanting. Another engineer, was much more reasonable and straightforward in his conclusion. He recognized that replacing CFCs for industrial and low-temperature refrigeration was not a

[31] George C. Briley, "Resume," Retrieved from: http://www.retaaz.com/retaazphx/gcb/resume.htm, Accessed on: March 26, 2016.
[32] George C. Briley, "Trends: Refrigeration Report 1975," *ASHRAE Journal* 17 (December 1975): 18.
[33] ASHRAE Board of Directors, "Policy Statement on the Current Ozone-Fluorocarbon Issue," *ASHRAE Journal* 18 (August 1976): 39.
[34] Theodore G. Foster, "Impact of a Ban of R-11, R-12 and R-500 Refrigerants on Air-Conditioning," *ASHRAE Journal* 18 (August 1976): 27.

"technical problem, but rather an economic" one.[35] A scientist at General Electric's Physical Sciences Laboratory, contributed an article that emphasized the need for a "careful risk/benefit analysis," consistent with the industry party-line.[36] One author, speaking from the perspective of automotive air-conditioning, made the plea for an extended time frame of close to a decade to move away from CFCs.[37] With respect to CFC substitutions in domestic appliances, another contributor concluded, "a review of the technical consequences of a forced change from R12 to R22 does not provide any strong signals that this is either an outright unfeasible solution, [or] that it is a change one would embrace voluntarily." In other words, it *was* possible to replace the most harmful CFCs with substitutes, but only with the right kind of incentives: either mandated through regulation or from the imminent threat of severe environmental and health consequences, or both.

Hans J. Borchardt, of Du Pont's Freon (CFC) Division, pointed out in his article, that HVAC&R "technology would be set back to the detriment of the general public" if a prohibition was imposed on CFCs.[38] This would be in direct contradiction to ASHRAE's objective of public welfare, he implored. But that a depleted ozone layer would also be to the detriment of the general public, he left out. ASHRAE's goal of recognizing "the effects of its technology on the environment" was not mentioned at all in this special volume on the ozone issue.[39] ASHRAE Journal's editor reminded readers that, "on the basis of present knowledge and theory, a clear understanding of our atmosphere's chemistry is conjectural at best." He then went on to convey

[35] Sam P. Soling, "Impact on Industrial and Low Temperature Refrigeration," *ASHRAE Journal* 18 (August 1976): 29.
[36] H.O. Spauschus, "Technical Considerations for Refrigeration and Air-Conditioning," *ASHRAE Journal* 18 (August 1976): 24.
[37] Samuel F. Ciricillo, "Impact on Automotive Air Conditioning," *ASHRAE Journal* 18 (August 1976): 30-32.
[38] Hans J. Borchardt, "ASHRAE's Role," *ASHRAE Journal* 18 (August 1976): 38.
[39] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., "Bylaws," *ASHRAE Transactions* 80 (2) (1974): 543.

the fear with which much of the HVAC&R community had begun to perceive the CFC issue: "if a roof is leaking, you repair the room. You don't tear down the whole house."[40] The industry had framed the ozone crisis as a threat to their very existence: a deny-or-die situation.

The fear and defensiveness exhibited by many within the HVAC&R industry was fueled by their faith in technology. Their technological-optimism—a strong conviction in the positive potential of technology—was being shaken at its foundation. When keynote speaker, Robert E. Smylie, Deputy Associate Administrator of NASA, addressed a large ASHRAE audience in early 1976, he could not have confirmed this faith, and the threat to it, more directly: "There is the view that technology is the culprit, the cause of our problems rather than the means to overcome them…My real message to you is that advanced technology is the promise of the future."[41] In an effort to hold on to this conviction, many members of ASHRAE bought into denial. Participating in the rhetoric of scientific "uncertainty" was an easy way to salvage one's technological optimism in the face of shedding long-held beliefs.

At that 1976 semi-annual meeting, ASHRAE co-hosted a seminar with ARI, titled, "Fluorocarbon/Ozone Impact on Air Conditioning and Refrigeration." Dr. Ralph J. Cicerone, who had worked with Rowland and Molina to implicate CFCs in ozone depletion, testified for the accuracy of the hypothesis in front of Congress, and understood the science of ozone depletion as well as anyone, also made a presentation at the seminar.[42] In order to give policymakers an appreciation for the difficulties involved in making predictions of ozone

[40] W. Edmond Gutman, "Editor's Comment," *ASHRAE Journal* 18 (August 1976): 5.
[41] Robert E. Smylie, "Technical Leadership: Commitment in a Changing World," *ASHRAE Transactions* 82 (1) (1976): 4-6.
[42] United States Congress, Senate Subcommittee on Upper Atmosphere, Committee on Aeronautical and Space Sciences, "Stratospheric Ozone Depletion, Part 2," Hearings, Sep.18-19, 23, 1975, 94th Congress 1st session (Washington: GPO, 1975), *Proquest Congressional Publications.* Accessed Online: 26 March 2016.

depletion, at one congressional hearing Cicerone had compared it to predicting the weather.[43] Implied was the understanding that there would always be some level of uncertainty. But his speech at ASHRAE did not dissuade the chairs of the event from repeating and reinforcing the industry's untenable expectations off of atmospheric science. More research "to prove or disprove" the ozone depletion hypothesis, was needed, they echoed, urging members to "answer this challenge with facts, not emotions."[44] Such an interpretation of scientific uncertainty bolstered their technological optimism while exacerbating their skepticism of the CFC-ozone-depletion hypothesis.

Denial spurred ASHRAE members to pit one issue, namely the energy crisis, against another—the ozone threat. Many would argue that reducing or replacing CFCs would deter the energy conservation efforts that ASHRAE was so proactively pursuing. While the CFC issue was mired in controversy, the energy crisis was palpable, and did not rely on atmospheric chemistry for proof. It was easy to deny the former on grounds of uncertainty, while the latter was a matter of economic realities. Most importantly, the way ASHRAE had framed the two problems, accepting the ozone depletion hypothesis would call their technology and industry seriously into question, but accepting the energy crisis was an opportunity to rescue the nation from dire straits and glorify the reputation of the engineering profession. Put like that, it was an easy choice.

[43] United States Congress, House of Representatives Subcommittee on the Environment and the Atmosphere, Committee on Science and Technology, "Inadvertent Modification of the Upper Atmosphere: Research and Development Relating to Halocarbons and Ozone Depletion," Hearings, May 20-22, July 31, 1975, 94th Congress 1st session (Washington: GPO, 1975), 23, *Proquest Congressional Publications.* Accessed Online: 26 April 2016.
[44] Stewart L. Segerstrom and Julius C. Olsen, "Fluorocarbon/Ozone Impact on Air Conditioning and Refrigeration," *ASHRAE Transactions* 82 (1) (1976): 15.

From Unilateral Regulation to a Multilateral Approach

By the 1970s hazardous wastes at Love Canal and PCBs in the Hudson River, among other highly publicized toxic episodes, opened the door to expansive regulatory measures aimed at controlling all toxic chemicals. The focus was on prevention as opposed to remediation. In October 1976, President Gerald Ford signed the Toxic Substances Control Act, which empowered the EPA to conduct a screening of chemicals before they were released into the environment and prohibit the manufacture of those substances that were found to be harmful.[45] This opened up CFCs to regulation by the EPA. With this new authority the EPA and the Food and Drug Administration (FDA), proposed a phase out of all "non-essential" uses of CFCs. Making good on the proposal, in May, 1977, the EPA, along with other federal agencies, announced a timetable that would phase-out the use and manufacture of CFCs for non-essential products by the end of 1978. The aerosol industry toward whom the phase-out was directed, was already well on its way to CFC alternatives but even though the refrigeration and air-conditioning industries were deemed "essential," they were more anxious for the future of their CFC refrigerants than ever before.[46]

Responding to the proposed phase-out of the non-essential uses of CFCs, President of ASHRAE, Bruno P. Morabito, a manager at Carrier Corporation, addressed an official statement to the EPA. Consistent with the strategy exhibited by the industry so far, Morabito cherry picked those points that suited their agenda of denial, ignoring the evidence that underscored the need for regulation. He warned that "any disruption" in the supply of insulating materials that contained CFCs "could have a serious impact on our ability to conserve energy—" pitting one

[45] Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York: Cambridge University Press, 1987), 188-194.
[46] Sharon Roan, *Ozone Crisis: The 15-year Evolution of a Sudden Global Emergency*, (New York: John Wiley & Sons, 1989), 71-86.

crisis against another.[47] Morabito insisted that "the problem—if it exists—is not immediate."[48] While this may have sounded fine on the surface, it flew directly in the face of what scientists were saying about the lag between ozone depletion and detection. Detection was not possible in the "immediate" present, but ozone depletion was. If the problem existed—as many scientists had been insisting—the longer that CFC reductions were delayed, the more CFCs would be released to the atmosphere, and that much more depletion of the ozone layer would occur in the long run.

Morabito thought it important to remind the EPA that "without air-conditioning" New Orleans, Houston, and Dallas, among other centers of trade, "would be mere shadows of what they are today." [49] But no one was considering dismantling every pre-existing air-conditioning and refrigeration unit in the country; Or, for that matter, banning CFCs without a plan to replace them with alternatives. Morabito's paranoia was an indication of the extent to which the ozone crisis was seen as a deny-or-die situation.

Despite his protestations of uncertain science, Morabito initiated the formation of an ASHRAE Task Group on halocarbon emission control and justified it by stating that ASHRAE "should prepare—within reason—for the eventuality that regulation is necessary."[50] Some part of Morabito may have realized that the scientists and environmentalists might be right, and that there was truth in the ozone-depletion theory. Nonetheless, that doubting voice of reason was drowned out by the call of faith. At a forum on reducing CFC refrigerant emissions, that soon followed, ASHRAE members were reminded, that the CFC-ozone-depletion hypothesis was an

[47] Bruno P. Morabito, "Morabito Backs Voluntary EPA-Industry Regulation of Fluorocarbon Emissions: Warns Reduction in Air Conditioning and Refrigeration Could Have Serious Consequences," *ASHRAE Journal* 19 (December 1977): 16.
[48] Ibid., 15.
[49] Ibid., 16.
[50] Ibid., 16.

"unproven theory."[51] It was ironic that a forum dedicated to brainstorming ways of reducing CFC emissions was not convinced that there was really a problem. This contradiction was a demonstration of ASHRAE's faith in technology coming into tension with their denial of CFC-ozone-depletion.

On August 7th, 1977, President Jimmy Carter signed amendments to the Clean Air Act, which mandated that the EPA conduct studies in coordination with other agencies in order to establish the impact of human activities on the stratosphere. The EPA was required to submit an interim report by the end of the year, and a final report by 1979, along with a proposal for regulating those substances and activities that harmed the ozone layer.[52] While most previous studies had estimated a seven percent depletion in the ozone layer if CFC production continued at current levels, both these latest EPA-commissioned-reports more than doubled that estimate to sixteen percent ozone depletion, despite the CFC-aerosol ban in place.[53]

The estimate of sixteen percent ozone depletion spurred the EPA into action. When the EPA had proposed its ban on CFC-aerosol products in 1977, only a few countries had followed suit. Urged by industry to recognize that the U.S. contributed to "only" half of the worldwide CFC production, the EPA saw the need for international regulations. Since CFC-emissions anywhere, meant ozone depletion everywhere, it was in the United States' interest to establish global consensus on CFC-emission reductions. Although the HVAC&R industry continued to deny the science of ozone depletion, they were eager to support the need for international or

[51] J. Hoffman, "Forum: How can Chlorofluorocarbon Refrigerant Emissions be Reduced?" *ASHRAE Transactions* 84 (1)(1978): 19.
[52] *Clean Air Act Amendments of 1977,* Public Law 95-95, 91 Statute 685 (1977).
[53] Committee on the Impacts of Stratospheric Change, Assembly of Mathematical and Physical Sciences, National Research Council, *Response to the Ozone protection Sections of the Clean Air Act Amendments of 1977: An Interim Report* (Washington D.C.: National Academy of Sciences, 1977); Committee on the Impacts of Stratospheric Change, Assembly of Mathematical and Physical Sciences, National Research Council, *Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons* (Washington D.C.: National Academy of Sciences, 1979);

multilateral negotiations instead of national or unilateral controls. ARI spokesmen and ASHRAE members were both, denying the legitimacy of the CFC-ozone-depletion hypothesis and supporting the need for global action, in the same breath.[54] This was because global negotiations would take longer to crystallize, buying the industry time, and would also prevent the U.S. industry from losing market share to foreign CFC producers.

Over the course of the seventies, the United Nations Environment Programme (UNEP) had been holding international conferences to bring attention to transnational environmental issues. An international panel met in Washington D.C. in March, 1977, to initiate a conversation around the environmental concerns of ozone layer depletion. At a follow-up meeting in Oslo, April of 1980, several Nordic nations, as well as Canada, Germany, and the United States agreed that the wait-and-see approach could be dangerous and that all nations should begin reducing CFCs. Spurred by the dramatic increase in ozone depletion predicted by the 1979 NAS report, the U.S. EPA went the furthest by announcing that it would propose a cap on CFC production at 1979 levels which would be followed by further cutbacks of fifty to seventy percent in the long run.[55]

Identifying this as the most serious threat so far, the CFC industry in America responded within the next few months by forming the Alliance for Responsible CFC Policy, consisting of over two hundred representatives from one hundred and fifty different companies and organizations, with the explicit intention "to further delay planned EPA regulations" on CFCs.[56] In formal comments to the EPA, the ARI cautioned that the proposed restriction on CFC

[54] Charles F. Sepsy, "Continuing Growth Through Professional Development," *ASHRAE Journal* 22 (August 1980): 22; ASHRAE-NSPE Liaison Program, "Dateline Washington," *ASHRAE Journal* 22 (September 1980): 19.
[55] Wall Street Journal Staff Reporter, "EPA to Propose a Ceiling, Then Cutback, on the U.S. Production of Fluorocarbons," *Wall Street Journal*, April 16, 1980, 8.
[56] ASHRAE-NSPE Liaison Program, "Dateline Washington," *ASHRAE Journal* 22 (September 1980), 18-19.

production was based on a "hypothesis, not fact," and that it was "unproven," and would "adversely affect some 230 million Americans."[57] The problem with the "hypothesis, not fact" dichotomy was that in the time it may take for a hypothesis to turn into a fact, the ozone layer would already be severely depleted. And, to the extent that the word "fact" suggested one hundred percent certainty, the CFC-ozone-depletion theory would always remain a hypothesis. Further, in the long run a depleted ozone layer would have adverse consequences for the entire planet, far outweighing the implications of regulating CFCs.

ASHRAE too felt the need to better represent its interests to the government. In April 1981, ASHRAE named Jim E. Cox their Washington Representative—ASHRAE's own liaison to the Capitol. Cox had obtained his PhD in Mechanical Engineering from Oklahoma State University and went on to become a Professor at the University of Houston. In 1975 the American Society of Mechanical Engineers (ASME) had selected Cox to represent them as a Congressional Fellow. He served on the House Science and Technology Committee and advised the ASME on issues of policy.[58] This background made him an ideal candidate to help ASHRAE navigate the ozone crisis. Cox was responsible for maintaining "personal contacts and channels of communication with the Federal Government," providing "counsel to the Federal Government on pertinent engineering matters," and identifying, analyzing, and disseminating information about any "governmental issues" and "actions" that impacted the ASHRAE community.[59] As a part of fulfilling these responsibilities, Cox would soon be writing a "Washington Report" for the *ASHRAE Journal*, reaching thousands of members every month.

[57] Priscille F. Trias, "Industry News," *ASHRAE Journal* 23 (April 1981): 19.
[58] ASHRAE, "Jim Cox Named Washington Representative," *ASHRAE Journal* 23 (April 1981): 60.
[59] James E. Cox, "Washington Report," *ASHRAE Journal* 24 (January 1982): 88

Fortunately for ASHRAE and ARI, the HVAC&R industry already had allies in government. Senator Lloyd Bensten (D-TX) and Representative Thomas A. Luken (D-OH) each introduced bills in the Senate and House, respectively, which sought to stall the EPA's proposed regulations.[60] Representative John Dingell (D-MI), the chairman of the House Committee on Energy and Commerce, cosponsored the House bill along with Luken.[61] Senator Robert Stafford (R-VT) and Representative Henry Waxman (D-CA), among others, would also support the same legislations in the near future.[62] With quite a few Democrats opposing environmental controls, it is clear that the ozone issue was not split along traditional partisan lines of progressive versus conservative politics, and neither was ASHRAE.

In the meantime, ASHRAE also adopted a new official position on CFC regulation, which stated, that despite its "concern [for] environmental damage" further regulation of CFCs in essential purposes like heating, refrigeration, and air-conditioning was "not warranted."[63] ASHRAE's president echoed this sentiment at their 1981 semi-annual meeting, saying, "federal regulation is premature."[64] Its Board of Directors approved a report reacting to the proposed limitations on CFCs, calling the state of the science "at best quite limited and at worst…erroneous." The report repeated the standard argument for "severe" economic repercussions and the need for "international consensus" and action. It also invoked competing findings and theories without considering the strong evidence which supported the real

[60] ASHRAE-NSPE Liaison Program, "Dateline Washington," *ASHRAE Journal* 23 (April 1981): 12-13.
[61] Jim E. Cox, "Washington Report," *ASHRAE Journal* 24 (April 1982): 14.
[62] Jim E. Cox, "Washington Report," *ASHRAE Journal* 24 (May 1982): 14; Jim E. Cox, "Washington Report," *ASHRAE Journal* 25 (August 1983): 12.
[63] ASHRAE Board of Directors, "ASHRAE Position Statements," *ASHRAE Journal* 23 (August 1981): 54.
[64] Charles F. Sepsy, "State of the Society 1980-1981," *ASHRAE Journal* 23 (August 1981): 53.

possibility of CFC induced ozone-depletion.[65] Alternative theories reinforced their sense of an uncertain scientific picture and the underlying catalyst of uncertainty was about to be reinforced.

A Change of Pace

1981 brought a change in administrations that stopped the EPA in its tracks. The Reagan administration had set out on an agenda to cut government spending, deregulate industries, and appoint like-minded ideologues to regulatory agencies.[66] ASHRAE viewed the "less-government" philosophy of the Reagan administration with "mixed emotions." Some praised the removal of mandated regulations but others were less enthusiastic about the massive budget cuts in research and development, especially when it came to the federal solar and energy programs that ASHRAE was heavily invested in.[67] By May, when Anne Gorsuch was nominated by President Ronald Reagan to head the EPA, "there was an almost audible sigh of relief" on the part of the CFC industry.[68] Under Gorsuch the EPA faltered under massive budget cuts and made no progress on its promise of implementing a national freeze on CFC output—but it continued to elicit more research from the NRC. Mary Hughes of the State Department, involved in the multilateral conferences with UNEP, picked a leaf out of the industry's own playbook and confirmed that "not enough is currently known to identify with certainty those chemicals which may be a threat to the global ozone."[69] This reassured the HVAC&R industry that the United States' position at the international negotiations would be more moderate than the goals that the EPA had earlier proposed.

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[65] ASHRAE, "ASHRAE takes position on CFC Regulation," *ASHRAE Journal* 23 (April 1981): 59.
[66] Sean Wilentz, *The Age of Reagan: A History 1974-2008* (New York: HarperCollins, 2008); Phillip J. Cooper, *The War Against Regulation: From Jimmy Carter to George W. Bush* (Lawrence, KS: University of Kansas Press, 2009).
[67] Jim E. Cox, "Washington Report," *ASHRAE Journal* 24 (March 1982): 47.
[68] Sharon Roan, *Ozone Crisis: The 15-year Evolution of a Sudden Global Emergency*, (New York: John Wiley & Sons, 1989), 104.
[69] Jim E. Cox, "Washington Report," *ASHRAE Journal* 24 (November 1982): 51.

Even the latest research results seemed to favor the industry. Predicted ozone depletion reduced from the 1979 value of sixteen percent back to seven percent in the 1982 NAS report, and down further to about three percent in the 1984 NAS report. While the total amount of ozone depletion seemed to be reducing, models predicted a simultaneous redistribution of ozone concentrations occurring between the upper and lower layers of the atmosphere. Ozone levels were supposed to be decreasing in the upper atmosphere, but increasing in the lower. So the total ozone column was not going to be diminished as much as earlier models had indicated. While the industry took this as a vindication of their position to oppose CFC regulation, the irony remained that the uncertainties in the latest reports were just as great as they had been when the industry had rejected the earlier predictions of greater depletion on the grounds of uncertainty. The scientific claim that CFCs were depleting the ozone layer, locally if not totally, persisted.[70] Furthermore, that CFCs, among other gases, were redistributing the balance of ozone in the atmosphere, continued to disturb concerned scientists and environmentalists.

ASHRAE's members were neither anti-science nor were they anti-environment per say. But they were extremely sensitive to the "anti-technology" sentiment that had been on the rise since the 1960s. It began in 1962 with Rachel Carson's famous attack on the indiscriminate use of chemical pesticides.[71] Jacques Ellul's *Technological Society*, published in English in 1964, drew attention to the threat of technology to human autonomy. Four years later, Rene Dubos' Pulitzer Prize winning *So Human an Animal* urged to "make technology once more the servant

[70] Committee on Chemistry and Physics of Ozone Depletion and the Committee on Biological Effects of Increased Solar Ultraviolet Radiation, Environmental Studies Board, Commission on Natural Resources, National Research Council, *Causes and Effects of Stratospheric Ozone Reduction: An Update* (Washington D.C.: National Academy Press, 1982); Committee on Causes and Effects of Changes in Stratospheric Ozone: Update 1983, Environmental Studies Board, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, *Causes and Effects of Changes in Stratospheric Ozone: Update 1983* (Washington D.C.: National Academy Press, 1984);
[71] Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin, 1962).

of man."[72] John Kenneth Galbraith's *The New Industrial State*, like Ellul, invoked images of men becoming the servants of technology, warning of an oppressive "technostructure" in a new industrial age.[73] Lewis Mumford drew attention to the power-complex of science, technology, and politics, and questioned the totalitarian, technocratic directions in which this "megamachine" was headed.[74] Alvin Toffler's *Future Shock*, was published in 1970 and went on to become a bestseller. Toffler was critical of technology and traced many of society's ills to the rapid pace of technological change.[75] This so-called "anti-technology" vision remained vibrant through the seventies with the release of influential books such as E.F. Schumacher's *Small is Beautiful* that championed small-scale and locally suited technological systems as opposed to the large-scale technology transfer being advocated by most economists and technologists around the world.[76]

Jack Chaddock, the President of ASHRAE when the Reagan administration came to power, clearly expressed his disagreements and disappointment with the anti-technology rhetoric of the previous decades. He was a World War II veteran who went on to earn his PhD from MIT and become a Professor of Mechanical Engineering at Duke University, and eventually the chair of the department.[77] In his State-of-the-Society address to a large audience of ASHRAE members gathered for their semi-annual meeting in Houston, Chaddock admonished the anti-technologists, "who decry any new advances in technology" and call for "the moral reformation of engineers."[78] Citing Samuel Florman, an engineer and apologist for technology, Chaddock

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[72]Quoted from: Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought* (Cambridge: MIT Press, 1977), 14.
[73] Ibid., 16.
[74] Lewis Mumford, *The Myth of the Machine: Technics and Human Development* (1967); Lewis Mumford, *The Myth of the Machine:The Pentagon of Power* (1970).
[75] Alvin Toffler, *Future Shock* (1970).
[76] E.F. Schumacher, *Small is Beautiful* (1973).
[77] Duke University, "Duke Flags Lowered: Engineering Professor Jack Chaddock Dies," *Duke Today* (May 27, 2015), Retrieved from: https://today.duke.edu/2015/05/chaddock, Accessed on: March 29, 2016.
[78] Jack B. Chaddock, "The State-of-the-Society," *ASHRAE Journal* 24 (April 1982): 51-53.

reminded his audience that the public's fear and suspicion of technology was coming from unrealistic expectations of progress and a disillusionment with society at large, not just technological failures. Anti-technologists were unreasonable to expect technology without risks. In order to divorce the social, moral, and environmental externalities of technology from the engineering profession, Chaddock clarified that "engineers are creators, not guardians."[79] He concluded that the "solution of the world's technological problems can not be done in terms of public debate or ethical rhetoric," to those problems "we must apply sound engineering principles," "technical leadership," and "the highest levels of technological achievement." [80] In other words, only technologists could save the world from the evils of technology.

In enunciating his unambiguously technocratic vision for resolving the problems of the world, Chaddock did not acknowledge their deny-or-die response to the ozone crisis. If ASHRAE had applied their technical initiative to the CFC-issue early on, then the problem of emissions reduction and alternative refrigerants would likely have seen a far swifter and easier resolution. But their faith in technology and commitment to the rhetoric of scientific uncertainty had closed them to the real possibility of environmental damage from CFC emissions. Chaddock's vision would only solve those problems that engineers believed existed. The CFC problem, however, would pass unnoticed for many years; one too many to prevent a severe depletion of the ozone layer.

The Hole in the Ozone Layer

Anne Gorsuch, who had championed the deregulation agenda at the EPA, resigned in 1984 over a scandal concerning the mismanagement of the $1.6 billion Superfund program to

[79] Ibid., 53.
[80] Ibid., 53.

clean up hazardous waste. After her departure the EPA began working diligently with the State Department and UNEP to negotiate an international, multilateral treaty on CFC control. In the meantime, domestic and worldwide CFC production had returned to the same levels as before the aerosol ban; effectively nullifying the impact of the previous legislation within six years. This spurred the NRDC to sue the EPA for failing to issue a second round of CFC regulations as the Clean Air Act had suggested.[81] With the growing use of CFCs around the world, and a more proactive EPA administration that was being pressed to act by the NRDC, ASHRAE sensed that CFC-regulation was rearing its ugly head once again.[82]

Aware that UNEP was planning to draft an international agreement to protect the ozone layer, ASHRAE nonetheless remained defiant in its denial. Washington Representative Jim Cox, responded to the UNEP's 1983 meeting in Geneva by challenging the threat of regulation with statements, such as: "a significant hazard to the ozone layer…has yet to be proven."[83] In the run-up to UNEP's Vienna Convention, Cox drew ASHRAE's attention to the reducing trend in ozone depletion predicted by NAS models since 1979. He also pointed out that some models predicted an increase in "total" ozone levels, failing to mention that these same models nonetheless recognized that depletion would occur in the upper atmosphere and redistribute the total ozone layer.[84] Cox correctly stated that scientists agreed on the "need for more research" on the ozone issue.[85] But the desire for more research and the general acceptance of the CFC-ozone depletion hypothesis, were not mutually exclusive. His unspoken assumption was that science would reach a point where all uncertainties would be removed and no further research would be

[81] Sharon Roan, *Ozone Crisis: The 15-year Evolution of a Sudden Global Emergency*, (New York: John Wiley & Sons, 1989), 113.
[82] Jim E. Cox, "Washington Report," *ASHRAE Journal* 26 (January 1984): 14.
[83] Jim E. Cox, "Washington Report," *ASHRAE Journal* 26 (January 1984): 14.
[84] Jim E. Cox, "Washington Report," *ASHRAE Journal* 26 (July 1984): 8.
[85] Jim E. Cox, "Washington Report," *ASHRAE Journal* 27 (March 1985): 10.

needed—a highly unrealistic expectation given that atmospheric scientists have continued to research the dynamics of the ozone layer to the present day.

On March 22, 1985, the United States adopted the Vienna Convention for the Protection of the Ozone Layer, along with twenty-eight other countries. Although the treaty made no immediate commitments to reduce CFC production or consumption, it established the need for worldwide cooperation in the scientific and economic assessment of the CFC issue. It also urged the parties to independently regulate CFCs if the latest research found them liable in the modification of the ozone layer.[86] Any multilateral regulations, however, would have to wait for follow-up agreements, called protocols, under the Vienna Convention. The industrial coalition, Alliance for Responsible CFC Policy, believed that it was "premature to adopt a protocol" for the further regulation of CFCs because such action was not "scientifically justified."[87] Even though the Vienna convention did not mandate regulation, it did resuscitate the CFC-issue back to life. Little did anyone expect that within a few months, the ozone issue would be making headlines once again.[88]

Joe Farman, a British geophysicist, and his team at the British Antarctic Survey published a paper in *Nature* announcing that they had measured close to forty percent losses in ozone concentrations over the Antarctic during the austral spring season of 1984. Additionally, they had a decade's worth of data showing a steep downward trend.[89] Their instruments also measured CFCs and showed a positive correlation between ozone concentrations and the presence of CFCs 11 and 12, confirming the Rowland-Molina hypothesis of 1974. Within a few

[86] Ozone Secretariat, United Nations Environment Programme, *The Vienna Convention for the Protection of the Ozone Layer* (Nairobi: United Nations Environment Programme, 2001)
[87] Jim E. Cox, "Washington Report," *ASHRAE Journal* 27 (August 1985): 6.
[88] Walter Sullivan, "Low Ozone Level Found Above Antarctica," *New York Times,* November 7, 1985. B21.
[89] J. C. Farman, B.G. Gardiner, and J.D. Shanklin, "Large losses of total ozone in Antarctica reveal seasonal ClO_x/NO_x interaction," *Nature* 315 (May 16) 1985, 207-210.

months, NASA's recalibrated Nimbus 7 satellite also detected a severe depletion of ozone above Antarctica, confirming Farman's results.[90]

But for the industry, even these astonishing findings did not settle the controversy. There were differences between the overall ozone depletion levels detected by the satellite and the ground-based measuring units around the world. This perpetuated the confusion and doubt. Yet, for the first time, with direct experimental data, as opposed to theories, computer models, and laboratory experiments, ozone depletion had been measured in the stratosphere. Industry denialists then turned to alternatives to the CFC-hypothesis as their last hope. Two other explanations for the ozone hole, besides the CFC thesis, had been posited. One predicted that the ozone hole was solely a result of special atmospheric conditions prevalent in the Antarctic, and the other proposed that reactions of nitrogen oxides, as a result of solar blasts, were depleting the ozone over the South Pole.[91] To hypothesize alternative explanations for phenomena is commonplace in science. New theories are proposed and tested to see if they can carry the weight of the old ones and more. But for many this multiplicity of explanations simply perpetuated the "uncertainty" of the CFC-ozone depletion theory, when in fact the data supporting the hypothesis had never been stronger.

In 1986, with images of the "ozone hole" circulating on national television and the release of a major international report predicting significant ozone depletion from CFC production at 1980 levels, some kind of government intervention seemed imminent.[92] The EPA announced its Stratospheric Ozone Protection Plan that called for new studies and strongly

[90] Walter Sullivan, "Low Ozone Level Found Above Antarctica," *New York Times*, November 7, 1985, B21.
[91] Sharon Roan, *Ozone Crisis: The 15-year Evolution of a Sudden Global Emergency*, (New York: John Wiley & Sons, 1989), 139-40.
[92] Global Ozone Research and Monitoring Project, World Meteorological Organization, *Atmospheric Ozone 1985: Assessment of our Understanding of the Processes Controlling its Present Distribution and Change*, Volume 1 (Washington D.C.: NASA, 1986).

suggested a second round of CFC regulation by the end of 1987. This resulted from an out-of-court settlement between the EPA and the NRDC. The CFC Alliance, channeling the sentiment of the HVAC&R industry, was supportive of the call for additional research—anything to delay regulation.[93] Not necessarily because they were against regulation per say, but because accepting regulation would mean that their vision for the promise of technology would come under attack and their professional integrity would be implicated.

For instance, when the Reagan administration had dismantled the Department of Energy's minimum energy efficiency standards, the HVAC&R industry was far from celebrating. Speaking at an ASHRAE semiannual meeting in Kansas City, ARI Chairman, Joseph H. Hoff, called on ASHRAE to establish "reasonable, responsible, [and] voluntary energy standards" in its place.[94] This was not just because in the absence of federal regulations the HVAC&R industry would now have to meet fifty different state standards, but also because ASHRAE and ARI were genuinely concerned about energy conservation. Hoff spoke of their responsibility toward creating a secure energy future for the nation and raising "the energy consciousness" of their management and clients.[95] Hoff ended his speech with an unmistakable plea for environmental stewardship. "We still live on a finite planet…we truly are 'children of the universe,' hanging here delicately in the vastness of space, protected from catastrophe."[96] Hoff's words indicate that he was not simply driven by the profit motive. He recognized that federal regulation could be valuable and that it was important to conserve resources and protect the delicate balance of the natural world. But this attitude did not translate into a concern for the ozone layer.

[93] ASHRAE, "Industry News," *ASHRAE Journal* 28 (February 1986): 7.
[94] Joseph H. Hoff, "Conservation through Teamwork," *ASHRAE Transactions* 90 (2A) (1984): xv.
[95] Ibid., xiv.
[96] Ibid., xvi.

Many within ASHRAE believed that America's high standard of living and industrial and economic leadership were a result of superior technological advancement. This contributed to their faith in technology. This also meant that a threat to technology—as the CFC-issue had come to be perceived—was also a threat to American power and the American way of life. So in order to uphold their nation's prestige the HVAC&R industry believed it was necessary to defend technological advancement, even at the cost of depleting the ozone layer.

Since the early 1970s, ASHRAE had become keenly aware of the need to internationalize its membership. By the 1980s, however, this drive to expand ASHRAE beyond the borders of North America became grounded in a growing sense of insecurity. "We are falling behind," announced Richard Perry of ASHRAE.[97] He was concerned that in order to stay at the cutting edge of technological advancement, American engineers needed to reach out to experts in other leading nations as well. Assistant director of the National Science Foundation (NSF), Nam P. Suh, in charge of the NSF's engineering program, was invited to speak at ASHRAE's semiannual meeting in 1986.[98] "The U.S. is facing major economic challenges from abroad," he admitted.[99] At the time he was most concerned with the increased export of engineering jobs to places such as Japan. He believed that the long-term solution to America's "industrial competitiveness problem must be found in technology."[100] Once again ASHRAE's engineers were called on to advance technology to protect American leadership. Such patriotic competitiveness reinforced ASHRAE's denial toward the harmful impact of CFCs. CFC regulation threatened American global power.

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[97] Richard P. Perry, "State of the Society," *ASHRAE Transactions* 89 (2A) (1983): viii.
[98] John Walsh, "Nam P. Suh Named to Head NSF Engineering Program," *Science* 225 (4667), September 14, 1984: 1134. Retrieved from: http://science.sciencemag.org/content/225/4667/1134.1, Accessed on: March 31, 2016.
[99] Nam P. Suh, "A Strategy for Staying Ahead in Technology," *ASHRAE Transactions* 92 (1A) (1986): xi.
[100] Ibid., xiii.

The End of an Industry

In June of 1986, Senator John H. Chaffee (R-RI) oversaw two days of congressional hearings, in front of the Subcommittee on Environmental Pollution, in order to examine the status and findings of the latest research. The hearing focused on the ozone issue as well as climate change; Senator Al Gore (D-TN) was one among the panel of witnesses called on by the committee. In the 1980s some Republicans, like Chaffee, shared the environmental ethos that Al Gore would later champion in his 2000 election campaign.

The mood of the committee and many of its witnesses was exhibited in Senator Chaffee's opening remarks. Quoting Russell Peterson, former chairman of the President's Council on Environmental Quality, who had worked as a chemist for 26 years, Chaffee stated, ""we cannot afford to give chemicals the same constitutional rights that we enjoy under the law, chemicals are not innocent until proven guilty." By not making policy choices today, by sticking to a "wait and see" approach, we may in fact be making a passive choice."[101] This was a perfect explication of the difference between a long-term precautionary approach and a short-term cost-benefit approach to risk assessment.

Chlorofluorocarbons turned out to be double trouble: ozone-depleting substances with a high global warming potential. The June hearings confirmed that CFCs were not only held responsible for leading to an increased risk of non-fatal skin cancers, but also for fatal melanoma skin cancers. Apart from more evidence of reduction in crop yields, loss of essential phytoplankton and other aquatic and terrestrial organisms, changes in the human immune

[101] United States Congress, Senate Subcommittee on Environmental Pollution, Committee on Environment and Public Works, "Ozone Depletion, the Greenhouse Effect, and Climate Change," Hearings, June 10-11, 1986, 99th Congress 2nd session (Washington: GPO, 1986), *Proquest Congressional Publication,* Accessed Online: 14 March 2016.

system, and damage to the cornea in human eyes, CFCs were also implicated in sea level rise, and a host of other threats that came from global climate modification. HVAC&R industry members and many within the Reagan administration, however, were satisfied with their worn-out call for further research to remove uncertainties, and multilateral international negotiations delaying any unilateral regulation that could hurt the national industry.[102] The White House would eventually go as far as to suggest a personal protection plan involving the use of sunglasses and skin lotion, as well as hats to shield the public from harmful radiation, as an alternative to regulation.[103]

In the meantime, the National Ozone Expedition, a NASA team of thirteen American scientists, were preparing to fly to the South Pole in order to determine the cause of the ozone hole over the Antarctic. Their preliminary results from the first year of measurements had ruled out the nitrogen-solar-blast theory, and were leaning toward a chemical explanation of ozone-depletion that implicated CFCs. But another theory that proposed purely atmospheric causes for ozone reduction in the Antarctic was still a viable alternative for those hoping not to have to regulate the chemicals. Thus, even as the EPA began to discuss different regulatory options, ranging from total production limits and product-specific restrictions, to emission fees and technological controls such as substitution and recycling of CFCs, Jim Cox of ASHRAE adamantly proclaimed, "the scientific picture has changed little," but "the emotional and political clouds surrounding the issue continue to escalate."[104] His assessment of the scientific picture was misleading, but his perception of the public's reaction was spot on. The states of Connecticut and

[102] Eddie Beres, "CFC's: A Technical Issue in a Political Arena," *ASHRAE Journal* 28 (December 1986): 34-36.
[103] Cass Peterson, "Administration Ozone Policy May Favor Sunglasses, Hats: Support for Chemical Cutbacks Reconsidered," *The Washington Post,* May 29, 1987: A1.
[104] Jim E. Cox, "Washington Report," *ASHRAE Journal* 28 (November 1986): 6-8; Jim E. Cox, "Washington Report," *ASHRAE Journal* 29 (February 1987): 17.

Oregon were taking steps toward a complete phase out of CFCs while bills introduced in the Senate proposed a ninety-five percent cut.[105]

Acutely aware of an impending CFC-cutback, the HVAC&R industry was now scrambling in search for CFC substitutes. Their go-to options were those halocarbons that were not "fully halogenated"— those CFCs that contained one or more hydrogen atoms in place of chlorine or fluorine. These were preferred because while they behaved somewhat like the fully halogenated CFCs that the industry had so far relied on, they were less stable and more likely to breakdown in the lower atmosphere before reaching the ozone layer. This made them less dangerous to the ozone layer. ARI demanded that "at least eleven years" be allowed before the use of substitutes can begin. During that time, the "current production supply must be maintained."[106] They argued that the testing of these new alternative CFCs, as well as the necessary product redesign and the retooling of manufacturing equipment, would take more than a decade to achieve.

Anxious for the future of the HVAC&R industry and its technology, ASHRAE members were reminded by President H.E. Barney Burroughs that "engineering and technology have suffered major death blows in recent times."[107] He was referring to the Three Mile Island disaster of 1979, the Bhopal-Union Carbide catastrophe of 1984, the Challenger spaceship explosion of early 1986, and the most recent, the Chernobyl calamity in April of the same year. But these did not shake his faith in technology. Instead he suggested that the technological challenges of the future "will be solved by more engineers, better trained engineers, and better engineering—not

[105] Jim E. Cox, "Washington Report," *ASHRAE Journal* 29 (May 1987): 16-18.
[106] ASHRAE, "Industry News," *ASHRAE Journal* 29 (July 1987): 5.
[107] H.E. Burroughs, "The Presidential Address: ASHRAE Technology and Human Destiny," *ASHRAE Transactions* 29 (August 1987): 20.

by more MBAs, financiers and lawyers."[108] He was suggesting that the problem was that engineers were not heard over the "financial guys in management."[109] And in order to do so, he called upon ASHRAE members to "speak out," "communicate the risk," and "be accountable."[110] Yet, many engineers, and Burroughs himself, were blind to the risk of CFCs and were quick to cite financial concerns as a reason not to regulate them.

In Burroughs' opinion the "technologically ignorant public" believed that, "engineering and technology" had "failed to protect them," and "that [the] risks of technology" were "not worth it."[111] He was deeply concerned about America's lack of faith in engineers. A falling trend in engineering program enrollments around the country since 1984 confirmed these suspicions.[112] In previous years, ASHRAE members had expressed similar apprehensions. One President had, with unease, cited statistics that suggested that half of the PhD recipients in American colleges were foreign nationals.[113] His successor, added to this anxiety for the education system. Citing a Carnegie Foundation study, it was pointed out that "the education system is far from meeting the full challenge of preparing people" and so emphasized that ASHRAE "must make a concentrated effort to advance engineering education."[114] These engineers were worried about the reputation and attractiveness of their professions. This added to their bias against anything that further endangered the engineer's reputation in the eye of the public. After all, for many at ASHRAE, engineers were the "trustees of the great American dream," and a "benign" chemical was not going to stop them from "keeping [that] dream

[108] Ibid., 18.
[109] Ibid., 20.
[110] Ibid., 20.
[111] Ibid., 20.
[112] National Science Board, National Science Foundation, "Higher Education in Science and Engineering," *Science and Engineering Indicators 2004* (May 2004), Retrieved from: http://www.nsf.gov/statistics/seind04/c2/c2s2.htm, Accessed on: March 31, 2016.
[113] Richard P. Perry, "State of the Society," *ASHRAE Transactions* 89 (2A) (1983): viii.
[114] Robert O. McDonald, "State of the Society," *ASHRAE Transactions* 90 (2A) (1984): x.

alive."[115] In the light of their faith in technology and anxiety for their professions, ASHRAE's denial of the CFC-ozone-depletion hypothesis persisted.

One thing most scientists agreed upon was that the detection of chlorine monoxide in the atmosphere above the South Pole would be uncontroversial confirmation of the CFC-hypothesis. It would not remove all uncertainties, and neither would it prove the Rowland-Molina hypothesis in any absolute sense, but it would serve as the most credible evidence in support of the CFC-ozone depletion theory obtained thus far. Chlorine monoxide was detected in the stratosphere during the second expedition to Antarctica. The official results were released at a press conference in September 1987.[116] But by then, the international community had already made up their minds.

At a UNEP meeting in Geneva, the United States had proposed freezing CFC production at current levels and phasing them out by ninety-five percent over the next decade. This was met with stiff resistance by several nations who considered such a large reduction too severe and the time-frame too short. Over the course of two meetings that followed, the phase-out was negotiated down to a fifty percent cut of 1986 production-levels. The breakthrough agreement was finally signed on Wednesday, September 16th, 1987. Representatives from forty-nine countries agreed to freeze CFC production and consumption (of specific ozone-depleting CFCs) at 1986 levels by the year 1990. They also agreed to a further twenty percent reduction by 1994 and an additional thirty percent cut by 1999. This meant that within twelve years the signatory nations would cut CFC input and output by fifty percent of 1986 levels. The Montreal Protocol, as it came to be known, would require that nations representing at least two-thirds of world CFC

[115] H.E. Burroughs, "The Presidential Address: ASHRAE Technology and Human Destiny," *ASHRAE Transactions* 29 (August 1987): 21.
[116] Michael Weisskopf, "Ozone Depletion Worsens, Is Linked to Man-Made Gas: Antarctic Data Bolsters Effort Against CFCs," *The Washington Post*, October 1, 1987, A23.

production would have to ratify the treaty for it to take effect. Moreover, it stipulated that all nations meet periodically to update the terms of the agreement based on the latest scientific understanding.[117] This last clause would ensure the end of the multi-billion dollar CFC industry.

Responding to the Montreal Protocol, ASHRAE published a special edition of its journal, entitled, "CFCs: Is the Sky Falling?" The HVAC&R industry was clearly defensive and continued to advocate minimal regulation. The editor insisted that each step that the industry had taken along the way to the recent agreement had "not been a matter of crying wolf." "Who knows how much damage might have been done" had the industry not "cried out" when the CFC issue came to fore, he asked rhetorically.[118] This was not just propaganda, it was denial at its best. He believed that the industry's resistance to CFC controls had rescued the nation from technological obscurity.

By 1987, refrigerants constituted almost half of the CFCs used in the United States. Kent Anderson, an ASHRAE member, called CFCs the "life blood" of modern refrigeration.[119] It was no surprise that ASHRAE was so unwilling to see them implicated in a global environmental threat. "It is hard to believe and difficult to accept that the safe and effective refrigerants that we have used for more than 50 years could have reached such a point," lamented Anderson. His statement perfectly captured his organization's predicament: ASHRAE's members genuinely believed that the science was "far from conclusive."[120] Their denial of CFC-induced ozone depletion was a symptom of their technological optimism.

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[117] Philip Shabecoff, "Dozens of Nations reach Agreement to Protect Ozone," *New York Times,* September 17, 1987, A1.
[118] Victor Petchul, "Commentary," *ASHRAE Journal* 29 (November 1987): 5.
[119] Kent Anderson, "CFCs: Is the Sky Falling?" *ASHRAE Journal* 29 (November 1987): 22.
[120] Ibid., 22.

The CFC Alliance, while admitting that the controls on fully halogenated CFCs were "inevitable," continued to oppose the proposed fifty percent cutback, stating that such drastic measures were "unwarranted."[121] On the other hand they were also confident in asserting, "the industry can be proud" of being a "part of the solution."[122] "It is your stratosphere. It is your business. Only you can protect them both," opined Chairman Richard C. Barnett.[123] But so far the industry had done little for the protection of the stratosphere and much to oppose it.

ASHRAE's and ARI's official positions continued to use the rhetoric of "uncertainty." They sought to remind their members and the government that unilateral regulation would hurt the national industry and standard of living without eliminating the ozone threat. They also argued that commercially viable substitutes for those CFCs identified by the Montreal Protocol would take decades to become available, and that the CFC-threat to the ozone layer was a technical issue that should not be dictated by "emotional feelings."[124] ARI additionally demanded that the global treaty incorporate the needs of "the less developed nations."[125] This would allow US manufacturers of CFCs and related products to expand markets overseas even as the national market was phased-down. Clearly much of the HVAC&R industry was still not convinced that CFCs were harmful for the ozone layer. This was despite Jim Cox, now ASHRAE's Director of Government Affairs, pointing out that "it is significant that all this scientific investigation to date has not disproved the theory."[126] This statement would have had much more impact had Cox and others understood that in modern science not disproving a theory is as close to proof as most theories ever get.

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[121] Richard C. Barnett, "The Alliance Position," *ASHRAE Journal* 29 (November 1987): 35.
[122] Ibid., 35.
[123] Ibid., 35.
[124] Jim Cox, "The ASHRAE Position," *ASHRAE Journal* 29 (November 1987): 38-39; Joseph M. McGuire, "The ARI Position," *ASHRAE Journal* 29 (November 1987): 36-37.
[125] Joseph M. McGuire, "The ARI Position," *ASHRAE Journal* 29 (November 1987): 37.
[126] Jim Cox, "The ASHRAE Position," *ASHRAE Journal* 29 (November 1987): 39.

It was the Ozone Trends Panel that finally put the CFC-issue to rest. The panel was a joint international effort by NASA, the National Oceanic and Atmospheric Administration (NOAA), the World Meteorological Organization (WMO), UNEP, and other prominent scientific bodies. They concluded that much of the global ozone layer depletion, that earlier studies had suggested would occur in the coming decades, had already taken place. 1.7 to 3 percent depletion between the 30 and 64 degree latitudes in the Northern Hemisphere, reaching 2.3 to 6.2 percent during the winter months, had been recorded from 1969 to 1986. CFCs were implicated for this destruction, and more was on its way. This 1988 report was shocking to some, but a confirmation of what others had been saying for years. [127]

The U.S. Senate ratified the Montreal protocol by a unanimous vote the same day that the Ozone Trend Panel released its findings. Within weeks Du Pont, the world's leading CFC producer, having already begun testing HFC-134a—a CFC alternative, announced that it would be completely phasing out its CFC business.[128] In this Du Pont anticipated UNEP's 1989 meeting in Helsinki where eighty-one nations pledged to completely ban those CFCs that were most harmful to the ozone layer by the year 2000.[129] Periodic adjustments to the Montreal protocol would continue to be made into the twenty-first century. The protocol was hailed as the first successful multilateral environmental treaty in the history of the United Nations and set a precedent for the Global Warming negotiations that followed in its wake.

The irony of it all is that the findings continued, in a strictly scientific sense, to retain uncertainties. The Ozone Trends Panel reported that "the weight of evidence strongly *indicates*

[127] United Nations Environment Program, et al, *Report of the International Ozone Trends Panel – 1988*, (Nairobi: UNEP, 1988) Volume I.
[128] From The Washington Post, "Du Pont Will Stop Making Ozone Killers," *Los Angeles Times*, March 25, 1988, B1; ASHRAE, "Industry News," *ASHRAE Journal* 30 (March 1988): 19.
[129] From Associated Press, "U.N. Meeting Vows to Ban ozone-Killing Chemicals," *Los Angeles Times*, May 6, 1989, 13.

th[at] manmade chlorine species are primarily responsible for the observed decrease in ozone (emphasis is mine)."[130] Note the careful use of the word "indicates" instead of "proves." The panel did not conclude that the evidence "proved" that CFCs were the cause of ozone depletion, because atmospheric science, with its sophisticated yet limited theories and instrumentation, inevitably cannot "prove" most hypotheses in any way that would require complete certainty. This does not mean that scientific theories cannot provide an accurate description of the world. But when it comes to uncertainty, science can, at best, only continue to refine confidence intervals and reduce theoretical ambiguities. Yet, it was in search of these impossible accuracies, "proven" theories, and "certain" predictions that industry, media, and policy-makers waited fifteen years to ban ozone-depleting substances for good.

Moving Past Denial

Given the results of the Ozone Trends Panel and Du Pont's consequent announcement to phase out CFCs, the HVAC&R industry finally moved past its denial by distinguishing between "old" and "new" science—a semantic sleight of hand.[131] The old science had uncertainties, whereas the new science was conclusive, they proffered. This was a false dichotomy, but nonetheless crucial for the industry in accepting the reality of CFC induced ozone depletion. A member of the HVAC Committee of the National Association of Plumbing-Heating-Cooling Contractors, echoed the HVAC&R community's new perspective: "a change in technology does not have to be bad; instead it can be an opportunity to do things better."[132] It is astonishing that it took an engineering community almost fifteen years to apply this outlook toward CFCs—an

[130] United Nations Environment Program, et al, *Report of the International Ozone Trends Panel – 1988*, (Nairobi: UNEP, 1988) Volume I, 5.
[131] ASHRAE, "Industry at Risk," *ASHRAE Journal* 30 (August 1988): 45.
[132] Billy Guin, "Industry at Risk," *ASHRAE Journal* 30 (August 1988): 47.

outlook they had so long held in the face of other demands for technological change, such as the energy crisis.

ASHRAE's Kent Anderson, now the Chairman of the CFC Advisory Committee, belatedly underscored, "How we respond to the challenges posed by the CFC problem will go a long way towards mitigating the potential adverse environmental effects of CFCs. Our response also will determine whether our industry as a whole ultimately has a positive public image."[133] ASHRAE's response so far had been underwhelming. Over the past fifteen years ASHRAE had spent many millions of dollars on research, supporting hundreds of projects on energy efficiency, solar heating and cooling systems, indoor air quality, and other areas of concern to the HVAC&R industry, but only two of those had anything to do with CFC alternatives.[134]

By the end of 1989 the Montreal Protocol had been in effect for a full year. The cutback of CFCs was finally underway. Looking back *ASHRAE Journal's* editor, William Coker, suggested that "the promotion of scientific literacy should help the public better understand such issues as CFCs."[135] Readers of this article will see the irony in Coker's statement, but it was likely lost on him. Coker's standard of scientific literacy, his interpretation of scientific proof and uncertainty, was very different from that with which an atmospheric scientist, or a philosopher or sociologist of science, would look at the CFC issue.

[133] Kent Anderson, "Industry at Risk," *ASHRAE Journal* 30 (August 1988): 50.
[134] One was on the "Measurement and Formulation of the Thermodynamic Properties of R-134a and R-123" and the other was titled "A Comprehensive Evaluation of Alternative CFC Refrigerant from the Molecular Structure." ASHRAE, "ASHRAE Research," *ASHRAE Journal* 30 (October 1988): 48; ASHRAE, "ASHRAE Research," *ASHRAE Journal* 29 (October 1987): 49.
[135] William R. Coker, "Commentary," *ASHRAE Journal* 31 (December 1989): 5.

David S. Butler's 1989 ASHRAE Presidential address suggested that some within the HVAC&R industry were finally beginning to see the adverse effects of their technology on the environment:

> Our sole objective is…advancing the arts and sciences of heating, refrigeration, air conditioning, ventilation, their allied arts and sciences, and related human factors for the benefit of the general public…[but] in doing so, we also must recognize the effect of our technology on the environment and natural resources in order to protect the welfare of posterity.[136]

Quoting the Vice President of the World Resources Institute, an international NGO, Butler warned: "Despite the power of modern technology, mankind depends on the normal functioning of the planet, especially the climate system."[137] In recognizing the primacy of some environmental issues over and above technology, Butler hinted that for a brief moment in ASHRAE's long affair with CFCs the promise of technology had taken a back seat to the needs of the planet and its creatures.

An engineering consultant and an Episcopalian, Butler, responding to his own question of why ASHRAE members volunteered their energy, knowledge, time, and resources to the Society, said[138]:

> The answer, I believe, lies not in engineering or technology…but rather in a philosophy of life…"whoever shall compel thee to go one mile—go with him twain…" that [second] mile of voluntary effort [is] where men strive for special excellence, seek self expression more than material gain and give that unrequited margin of service to the common good which invests work with a wide and enduring significance.[139]

Butler's was not just a spiritual message. It was one that had the potential to dismantle the blind faith in technology that impelled ASHRAE's denial of the ozone crisis. It marked an unequivocal about-turn in ASHRAE's rhetoric of technological optimism. In urging members to act out of

[136] David S. Butler, "Presidential Address," *ASHRAE Journal* 31 (August 1989): 12.
[137] Ibid., 12.
[138] Clarion Ledger Obituary, "David S. Butler," (August 2, 2012), Retrieved from: http://www.legacy.com/obituaries/clarionledger/obituary.aspx?pid=158888682, Accessed on: March 31, 2016.
[139] David S. Butler, "Presidential Address," *ASHRAE Journal* 31 (August 1989): 12;

selfless service, Butler offered a path that might have prevented the fifteen-year long battle that had severely delayed proactive regulation from protecting the ozone layer.

Denial can easily serve the interests of those who stand to gain from maintaining the status quo. By perpetuating denial amongst the engineers at ASHRAE, the CFC interests were able to lend popular and political support to the defense of their multi-billion dollar industry. But denial in the face of regulatory extinction is not a pre-determined outcome. Many large, relatively autonomous organizations such as ASHRAE have the resources to research and implement procedural and technological alternatives to those processes and substances that provoke the scepter of regulation. Their failure to do so in many cases has inspired this investigation into the mechanisms of denial.

The path to mitigating those environmental issues that face widespread denial lies in probing the deepest assumptions, hopes, and dreams, of those who deny the evidence. This study has found that merchants of denial play on the faiths and fears of their consumers. Faith in technology, and fear of losing face to a nation less-than-enamored by engineers and their inventions, were powerful motivations that primed the ASHRAE community to be seduced by the false dichotomy: deny-or-die. Their denial was further rationalized and reinforced by a rhetoric of so-called scientific uncertainty—a bullet proof target that continues to be used with great success by climate-change deniers in the twenty-first century.

That there is uncertainty in science is not the wrong assumption, but to suggest and wait for total "certainty" is impractical as there is no end to greater and greater certainty. Industry, media, and the government were unable, in the case of the ozone crisis, to understand and

convey the inescapability of scientific uncertainty. For that reason reasonable people had unreasonable expectations off of science, and therefore were unable to make informed decisions from the best that science could offer.

In a perfect world, allegations of uncertainty would not deter meaningful policies based on the best that science can offer. Despite all of science's epistemological shortcomings it remains our best source of reliable knowledge about the physical world. It may not provide infallible facts, but it is the best we have in an age of climate change. In revealing the nature of science's wager on certainty rests some hope for not just a habitable planet, but a desirable one.