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**Defining Healthy Housing:  
The Competing Priorities of Energy and Indoor Air Quality in the Early 1980s**

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*“While Government and industry have concentrated on cleaning up the Nation’s outdoor air, they have paid little attention to the quality of the indoor air in the nonworkplace. Yet indoor air pollution may pose a potentially more serious health problem since we spend 70-80 percent of our time indoors - at home, at work, or at play.”*

- United States General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, September 24, 1980<sup>1</sup>

In the early twenty-first century, we recognize that myriad factors shape healthy or unhealthy housing. To name just a few: lead paint persists in some pre-1978 buildings, posing a hazard for young children; there is increasing concern about volatile organic compounds (VOCs) in paint and carpet adhesive, leading to increased demand for and availability of VOC-free products; neighborhood layouts that encourage exercise and access to fresh food are increasingly cited as promoting public health; swimming pools at abandoned foreclosed homes have become breeding sites for mosquitoes, putting neighbors at risk; defective building materials, such as the infamous Chinese drywall that captured headlines in 2009 and 2010, can compromise the health of entire housing developments. Healthy housing is of course a complex issue involving a web of factors.

However, indoor air quality (IAQ) has arguably become a, if not the, defining criterion for healthy housing in the United States, especially within scientific and public health communities. In fact, these communities are increasingly concerned about the impending effects of climate change on *indoor* environments. But it is important to recognize that today’s intense focus on indoor environmental health emerged during the last thirty-to-forty years, and is directly related to the energy crises of the 1970s.

This paper is part of a larger project that situates American housing within the ecologically-oriented 1970s, when energy independence and environmental protection became political and popular priorities.<sup>2</sup> Here, I focus on the early 1980s as a critical period in the

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<sup>1</sup> United States General Accounting Office, *Report to the Congress of the United States by the Comptroller General, Indoor Air Pollution: An Emerging Health Problem*, CED-80-111 (Washington, D.C., September 24, 1980), i. My dissertation work was partially supported by the Meyer Dissertation Fellowship at the Joint Center for Housing Studies. I am grateful to the Joint Center for this opportunity, and particularly wish to thank Pamela Baldwin, Eric Belsky, Chris Herbert, Jackie Hernandez, and Alexander von Hoffman for their invaluable contributions to my project. I would be pleased to discuss or share the dissertation with interested readers, and can be reached at [mwolfson@fas.harvard.edu](mailto:mwolfson@fas.harvard.edu).

<sup>2</sup> This paper is excerpted from my recent dissertation, “The Ecology of a Healthy Home: Energy, Health, and Housing in America, 1960-1985,” for the Department of the History of Science at Harvard University. I have studied two California communities that shared geographical and temporal proximity but responded to the energy crisis with divergent approaches to the ideal of energy-conserving, healthy housing. The first is the Lawrence Berkeley Laboratory’s indoor environmental research program, one of the first of its kind in the United States. The second episode is a controversy over owner-built housing that erupted in 1974 in California’s Mendocino County, but soon spread to other regions of the state. One of the many American countercultural trends of the 1970s was the back-to-the-land movement, in which (mostly) young Americans bought inexpensive rural land on which to build their own homesteads or houses. In Mendocino, members of this movement came into conflict with the local building inspector over their self-built homes that usually lacked central heating, electricity, and plumbing. Although ostensibly a debate about health and safety, this controversy really revolved around autonomy and the right to

history of indoor air pollution awareness. Between approximately 1980 and 1985, indoor air pollution grew from a little-known field of academic research to a major threat actively discussed in scientific, popular, and policy circles. This rapid escalation of concern would have been impossible without the foundational research of the Lawrence Berkeley National Laboratory. In the wake of the oil embargo of 1973-1974, Berkeley Lab scientists quickly emerged as national and international leaders in the fields of residential energy conservation and indoor air quality, both of which became pressing and intertwined national issues that the Lab's researchers sought to reconcile in cost-effective ways.

### **The Residential Conservation Service Highlights the Tension between Energy Conservation and Indoor Air Quality**

From weatherizing and retrofitting America's oldest housing stock, to the design and building of airtight new homes, improving residential energy efficiency was a national priority throughout the second half of the 1970s. In a range of geographical locations and climates - from the Pacific Northwest, to southern California, to New York state - scientists from the Lawrence Berkeley Lab (LBL) quietly analyzed the performance of residential energy-conservation strategies. Hypothesizing that ever-tighter homes might trap harmful pollutants (especially nitrogen dioxide, formaldehyde, and radon, the "trifecta" targeted by early research), they soon added indoor air quality (IAQ) assessments to their research agendas. This was a young science: there were few sampling devices, established methodologies, or academic journals devoted to studying the indoor environment. But by 1980, after a series of studies by the LBL and other academic institutions had produced disturbing evidence of poor air quality in America's housing, the Federal government began to sound the alarm about indoor air pollution.<sup>3</sup> One of its first actions was to commission a report from the General Accounting Office (GAO) entitled *Indoor Air Pollution: An Emerging Health Problem*. Echoing the arguments that scientists at the Lawrence Berkeley Laboratory and other institutions had been making since the mid-1970s, the GAO reported: "traditionally it has been presumed that a person was protected from polluted air when indoors. Recent research has shown, however, that this may not always be true. Various harmful pollutants...have been found in the air in homes, offices, schools, and even in recreational facilities."<sup>4</sup> First and foremost, the GAO wanted to dispel the assumption that the home was an oasis protected from pollution. The disturbing reality was

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exercise it through housing, as well as the acceptance of unconventional lifestyles. In this context, healthy housing was defined as much by psychological and economic factors as by physical ones.

These two episodes both began in the mid-1970s, in response to the new reality of America's precarious and expensive reliance on foreign oil. Although the owner-builder controversy had largely subsided by the early 1980s, while the Lawrence Berkeley Lab's program remains an international leader in its field today, the Lab's first decade of indoor environmental research was foundational to the science of indoor air quality. The dissertation juxtaposes and analyzes these two case studies in order to illuminate the rich and diverse history of "healthy housing" as an American ideal.

<sup>3</sup> It is important to note that the popular press published numerous articles about indoor air pollution in the early 1980s as well, which raised public awareness of and concern about the problem. One of the most interesting aspects of America's healthy housing movement is the diversity of stakeholders involved in shaping it. The public has arguably been just as important as the academic scientific community.

<sup>4</sup> U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, unnumbered first page.

that it was a neglected environmental threat to public health. The analogies seemed straightforward enough: as the Federal government had historically worked to make both workplace and outdoor air cleaner and safer, it should now do the same for indoor air. The GAO's concluding recommendation was that the Environmental Protection Agency assume responsibility for indoor air pollution under an amendment to the Clean Air Act. So far, "Federal efforts to deal with the problem [had] been piecemeal." Until one agency took responsibility for the problem, the GAO predicted that responses would remain "ineffectual."<sup>5</sup> The GAO's recommendation of 1980 is striking because, first, it relies upon an analogy between outdoor and indoor environments; and second, indoor air pollution would prove to be extremely difficult to regulate, especially within the private setting of the home.<sup>6</sup>

Indeed, housing was a particularly contentious - if not the most contentious - aspect of the Federal government's attempts to address indoor air pollution in the early 1980s. The GAO's report reflected a conflict - and a war of words - between two major Federal agencies: the Environmental Protection Agency (EPA) and the Department of Energy (DOE). At issue was the DOE's proposed Residential Conservation Service (RCS), a set of energy-conservation efforts that would have tightened American homes using weatherstripping, caulking, and other weatherization and retrofitting techniques.<sup>7</sup> The point of the program was to address the energy shortages that had disrupted the American economy and lifestyle during the 1970s.<sup>8</sup> Selected studies of tightly-constructed new homes with dangerous levels of indoor pollutants had begun to give the impression that energy-efficient housing was inherently unhealthy,

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<sup>5</sup> U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, 11-13.

<sup>6</sup> Allison Shore, "Indoor Air Pollution: Environmental Inequality Inside," in *Synthetic Planet: Chemical Politics and the Hazards of Modern Life*, ed. Monica J. Casper (New York: Routledge, 2003), 25-50. Shore focuses mostly on proposals for, and the failure of, indoor air pollution legislation in the 1990s. None of this legislation "ever considered regulating the *manufacture* of the substances known to pose the greatest threats to human health through indoor air" (48-49). Since at least the early 1980s, indoor air scientists have argued that source control - eliminating, removing, or otherwise mitigating sources of indoor air pollution - is an important and effective way to protect indoor air quality. A major step toward effective source control would be regulation of dangerous substances and products, but as Shore shows, manufacturers such as the Chemical Specialties Manufacturers Association, the Business Council on Indoor Air, and the Building Owners and Managers Association, have effectively fought such regulation (33-36). Instead of regulation, the EPA has favored public education about indoor air pollution over regulation, as seen in the Agency's current "Care For Your Air" campaign. The assumption behind this approach is that the home is a private space and exposure to indoor air pollution is therefore voluntary. Shore argues that this assumes a target audience of middle-class suburban homeowners, which raises important issues of environmental justice and environmental inequality.

<sup>7</sup> At this time the RCS program was under development and therefore its details were still under discussion. According to the DOE, the EPA had erroneously accused the DOE of planning to reduce infiltration rates by 50 percent in "all of the nation's dwellings." The DOE countered that, first, the RCS program was not, according to Congressional mandate, "responsible for the entire residential building stock, nor [was] it expected to cause a 50 percent reduction in air infiltration rates." Letter from Jack E. Hobbs (DOE) to J. Dexter Peach (GAO), July 15, 1980, in U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, 31-33. Considering the sheer volume and decentralized nature of America's housing, a 50 percent infiltration reduction in 100 percent of homes was probably unrealistic.

<sup>8</sup> On November 7, 1973, President Nixon asked Americans to lower their home thermostats to a national average temperature of 68 degrees. On February 2, 1974, over half of the gas stations in the New York City area closed after selling out of fuel. These and other restrictions resulted from the Arab oil embargo of 1973-1974, a pivotal event in American history that made residential energy conservation an immediate national imperative.

prompting some consumers to value ventilation over energy conservation. During much of its first decade of indoor environmental research, the Lawrence Berkeley Laboratory (LBL) had researched residential energy conservation *and* indoor air quality in relation to each other, seeking an “optimal balance” between the two and working to show that they need not conflict. The LBL repeatedly emphasized that while ventilation was important, it was not enough to guarantee good indoor air quality, particularly in a home already containing high levels of combustion products, formaldehyde, or radon. In short, the relationships between energy use, ventilation, and IAQ were complicated; they were affected by an ever-increasing number of variables. To portray energy savings and health as diametrically opposed was an oversimplification of a complex problem.

### **Houses as Laboratories: Extrapolating from the LBL’s Experiments**

Despite scientists’ increasingly nuanced understanding of the relationship between energy use, ventilation, and IAQ, the conflict over the Residential Conservation Service centered on the problem of prioritizing one of these factors at the expense of the others. The controversy was writ large on a national scale, as the RCS was a proposed nationwide program. Although the LBL was not officially involved in development of the RCS, the program was indebted to research conducted by the Lab’s scientists. Two of their projects - a study of indoor air quality in a set of relatively modern weatherized homes in Medford, Oregon; and a study of indoor air quality in a 150-year old retrofitted home in Cranbury, New Jersey - were considered potential test-cases for the energy-conservation measures the RCS might mandate. In both cases, LBL researchers had used their state-of-the-art mobile laboratory to analyze energy consumption and air quality in typical American homes. The LBL’s study of the Model Conservation Standards, conducted in partnership with the Bonneville Power Administration, was an especially extensive evaluation of the type of energy conservation standards that would be so contentious in the context of the RCS.<sup>9</sup> Thus, in experiments conducted in the laboratories of ordinary American homes - in collaboration with utility companies and homeowners - LBL researchers were testing approaches to energy conservation that had the potential to become national policy, with potentially large impacts on both energy and indoor air quality. The conflict between the Department of Energy and the Environmental Protection Agency centered on whether or not these proposed changes would endanger Americans within the walls of their own homes.<sup>10</sup> Fewer than five years earlier, the crux of this controversy - the

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<sup>9</sup> Chapter 2 of the dissertation discusses the LBL’s Medford, Cranbury, and Midway research projects. In their reports on these and other projects, LBL authors noted the potential application of their work to the RCS and other national building standards, such as the Building Energy Performance Standards. For example: James V. Berk et al., “Impact of Energy-Conserving Retrofits on Indoor Air Quality in Residential Housing,” LBL Report 12189, January 1981, 3; and Rodger A. Young et al., “Energy-Conserving Retrofits and Indoor Air Quality in Residential Housing,” LBL Report 12847, September 1981, 1.

<sup>10</sup> From its inception the EPA had been given responsibility for “protection of natural resources, for pollution control, and for public health and quality of life.” In 1977 President Jimmy Carter appointed Douglas M. Costle as the EPA’s Administrator. Costle especially emphasized the Agency’s role as a protector of human health. By 1984, Administrator Lewis Thomas de-emphasized human health as the Agency’s primary focus. John Opie, *Nature’s Nation: An Environmental History of the United States* (Fort Worth: Harcourt, 1998), 470. During the early 1980s, the EPA was particularly concerned with possible increases in lung cancer as a result of radon in American homes,

complex relationship between ventilation and indoor air quality - had been mostly confined to academic scientific papers, many of them originating at the LBL.

A hallmark of the Berkeley Lab's research was its use of actual homes, usually occupied and therefore providing the scientists with what they called "real-life experimental conditions." Knowledge of such conditions was lacking in the proposed RCS, concluded an LBL scientist after reading a draft of it on a trip to Department of Energy headquarters in Washington, D.C. "No doubt, the actors are intelligent and have tried very hard," he wrote in a memo to his LBL colleagues, "but the lack of field expertise and real world exposure is the principal flaw of this document...actual utility data could be used more effectively....I don't know if we should be glad that we are not officially involved in the proposed RCS rule or if we missed our chance to prevent another haphazard regulation!"<sup>11</sup> Ironically, the RCS proposed to implement many of the energy-conserving methods that LBL had been studying for several years. Both sides of the conflict - the DOE and the EPA - cited LBL's research in their arguments for and against the program.<sup>12</sup> In his letter responding to the GAO's report, the DOE's Jack Hobbs objected to the recommendation that the EPA assume responsibility for indoor air pollution: "the draft GAO report consistently underplays the DOE dedication and accomplishments in this area in its discussion of current Federal activities and in justifying its recommendations." Hobbs felt the GAO had focused exclusively on the potential health problems of "infiltration reduction," ignoring its "known benefits....[including] the avoidance of construction of tens of new power plants (each with its own environmental and health risks, as the new power plants are expected to be either coal or nuclear-powered), an improved standard of living (increased comfort, noise reduction, and the use of [formerly] drafty rooms)...and finally the saving of vast amounts of our energy resources and an attendant increased national independence from foreign oil sources." He argued that DOE's research programs - such as those at the LBL - were showing that "these substantial benefits...may in fact be accomplished without any increased health risk." It was probable that "both residential energy efficiency and public health [would] actually be improved."<sup>13</sup>

From the DOE's perspective, the EPA had failed to understand (and oversimplified) the nuances of residential energy conservation, and was ignorantly dismissing a potentially worthwhile program. As the primary sponsor of the LBL's indoor environmental research program, the DOE likely believed that its authority, expertise, and investment were being ignored. For several years, LBL scientists had been arguing that outdoor air pollution standards were not necessarily applicable to indoor air pollution; the indoor environment was a world - an

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charging that the RCS program could potentially *double* America's rates of lung cancer. The DOE emphatically disagreed. On radon in the American home and the EPA's response, see "A Natural Contaminant," and "S.O.S. Radon," chaps. 4-5 in Ellen Bales, "An Element of Uncertainty: Radon and the Quantification of Risk in 20th-century America, 1945-2000" (PhD diss., University of California, Berkeley, 2009). ProQuest (UMI 3382833).

<sup>11</sup> Memorandum from Robert Sonderegger to Art Rosenfield, Ted Edlin, Craig Hollowell, David Grimsrud, and Steve Selkowitz, September 6, 1979. LBL Archives, ARO-4652, Container 8, Folder "Grimsrud Studies."

<sup>12</sup> Letter from William N. Hedeman, Jr., Chief, Office of Environmental Review, EPA, to the Assistant Secretary for Environment at the DOE. LBL Archives, ARO-4652, Container 4, "Interagency Task Force" Folder. This and other letters charged that the RCS would reduce residential ventilation by half, thus increasing occupant exposure to indoor pollutants including radon, carbon monoxide, nitrogen dioxide, tobacco smoke, formaldehyde, and respirable particles.

<sup>13</sup> U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, 32.

ecosystem - unto itself, requiring its own research and regulation. Given the lack of established standards regarding indoor air pollution (and the lack of progress toward setting them), empowering the EPA to oversee indoor air using the Clean Air Act relied on an untenable analogy between outdoor and indoor air pollution. The Clean Air Act of 1970 had indeed been a landmark achievement in environmental and health protection. However, this did not make it transferable to the indoor, built environment.<sup>14</sup>

## Lessons of the RCS

More important than the minutiae of the never-implemented Residential Conservation Service are the three larger issues that it raised. First and most important, the conflict it ignited between the EPA and the DOE echoed the tension between indoor air quality and energy conservation that had characterized the LBL's buildings research since the inception of its program following the oil embargo of 1973-1974. Although buildings researchers at LBL and elsewhere worked hard to correct the misperception that each of these goals could only be achieved at the expense of the other, the RCS dispute shows that they were still very much *perceived* as irreconcilable.

Second, the RCS was an attempt to apply on a national scale those energy-conserving measures (such as weatherstripping, caulking, and insulation) that had previously been tested and used on the local level (through, for example, partnerships between the LBL and utilities in California and the Pacific Northwest). To some extent, this was an attempt to implement the "aggressive retrofit campaign" that energy expert Daniel Yergin had advocated in *Energy Future* (1979), and the Energy Extension Service that Sierra Club President Theodore Snyder had endorsed in his Alternative Energy Plan.<sup>15</sup> An Energy Extension Service, modeled on the Agricultural Extension Service, had been the focus of an LBL Summer Workshop in 1976.<sup>16</sup> From environmental activists to academic energy researchers, many Americans recognized the need to implement residential energy conservation on a national scale. The RCS was the DOE's controversial response.

Third, the RCS was an attempt to deal with a decentralized problem in a centralized way: in endorsing a national retrofit campaign, Yergin had argued that "standards and regulations also need to be pushed...Residential homes comprise the most decentralized sector of energy consumption, and therefore public education and information is particularly

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<sup>14</sup> The extent and power of the Clean Air Act continue to be contested. For example, in 2007, the United States Supreme Court ruled that the Environmental Protection Agency has the authority, under the Clean Air Act, to regulate automobile emissions that contribute to global warming. This ruling was seen as "a strong rebuke" to the George W. Bush administration, which had argued that "carbon dioxide and other heat-trapping gases" did *not* fall under the jurisdiction of the Clean Air Act. The state of Massachusetts had sued the EPA over regulation of greenhouse gases in *Massachusetts v. Environmental Protection Agency*, No. 05-1120. See Linda Greenhouse, "Justices Say E.P.A. Has Power to Act on Harmful Gases," *New York Times*, April 3, 2007.

<sup>15</sup> Daniel Yergin is the author of the Pulitzer Prize-winning book *The Prize: The Epic Quest for Oil, Money, and Power* (1990) and was an early advocate of conservation as a response to America's energy crises.

<sup>16</sup> Daniel Yergin, "Conservation: The Key Energy Source," in *Energy Future: Report of the Energy Project at the Harvard Business School*, ed. Robert Stobaugh and Daniel Yergin (New York: Random House, 1979), 174, 168; *Proceedings of 1976 Summer Workshop on an Energy Extension Service*, LBL Report 5236, May 1977.

important.”<sup>17</sup> Yet, intense disagreement between two Federal agencies with competing priorities ensured that a united front on behalf of the RCS would be difficult to achieve. The EPA argued that the DOE had minimized the health risks of reduced ventilation. However, the DOE had spent several years, millions of dollars, and much scientific brainpower (much of this at the LBL) studying the relationship between residential energy efficiency, reduced ventilation, and indoor air pollution. Each agency had its own areas of expertise, and most likely had something important to contribute to this important national conversation. However, the GAO had concluded that the only way to avoid a “piecemeal” and “ineffectual” approach to indoor air pollution was to delegate responsibility to one agency, thus silencing the perspective of others. It was the simplest solution, if not the best.

### **The UFFI Crisis Shines a National Spotlight on Indoor Air Pollution**

In recommending that the EPA assume responsibility for the Federal response to indoor air pollution and use the Clean Air Act to address the problem, the GAO implicitly and explicitly questioned the safety of the nation’s energy-conservation agenda. Indoor air pollution, they wrote, “may even be made worse by Government energy conservation programs which encourage the ‘buttoning-up’ of buildings.”<sup>18</sup> Specifically, they cited a contemporary high-profile example: “the Federal Government is using tax credits to encourage citizens to better insulate their homes. One material qualifying for this incentive is urea-formaldehyde foam insulation, which is a source of potentially harmful indoor air pollution. In attempting to resolve the Nation’s energy shortage, the Government may very well be advocating solutions which will adversely affect public health.”<sup>19</sup> In 1980, there was probably no more fear-inducing example of energy conservation gone awry than the case of urea-formaldehyde foam insulation (or UFFI).

During the late 1970s, UFFI was routinely sprayed between the interior and exterior walls of houses. It was effective, affordable, and relatively easy to install. However, if it failed to set and dry properly, it could release formaldehyde gas into the home’s interior, causing health problems ranging from irritating to debilitating. Local and national newspapers ran alarmist headlines and frightening articles about Americans sickened by their homes and forced to relocate. “Contaminated House Brings on Formaldehyde Nightmare,” reported the *Hartford Courant* in 1977. The Palmero family, with two teenage children, had developed extreme chemical sensitivity and other health problems after their house had been insulated with UFFI.<sup>20</sup> In 1978, the *New York Times* ran a comprehensive investigative article on the UFFI problem, profiling two young couples who had had severe reactions to formaldehyde. “Such cases,” the newspaper reported, were “typical of hundreds...coming to the attention of doctors, lawyers and government officials all over the country.”<sup>21</sup> Even more disturbing, the article disclosed, was the fact that “there never has been a decent cancer study or a study of the long-term effects of formaldehyde...manufacturers, in effect, have been using the public as

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<sup>17</sup> Yergin, “Conservation: The Key Energy Source,” 173-174.

<sup>18</sup> U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, unnumbered first page.

<sup>19</sup> U.S. General Accounting Office, *Indoor Air Pollution: An Emerging Health Problem*, ii.

<sup>20</sup> Nancy Pappas, “Contaminated House Brings on Formaldehyde Nightmare,” *Hartford Courant*, November 20, 1977.

<sup>21</sup> Ann Crittenden, “Built in Fumes Plague Homes,” *New York Times*, May 7, 1978.



a laboratory.”<sup>22</sup> The *Times* captured the fragmented and ineffective Federal response to the problem with the wry headline, “Fumes: Washington Is Confused.” The article described a “Catch 22” in which no agency was investigating the long-term effects of formaldehyde exposure, yet no agency was willing to take action *against* formaldehyde-containing products without knowing more about these very effects. The Department of Housing and Urban Development, the Consumer Products Safety Commission, the Environmental Protection Agency, and the Federal Trade Commission were all cited as potential stakeholders in the problem.<sup>23</sup> By February of 1982, the Consumer Products Safety Commission (CPSC) had banned UFFI and essentially put the industry out of business. Individual and class action lawsuits multiplied, and stories of health problems continued to capture headlines. A New York lawyer who had represented victims of Love Canal saw parallels in the two episodes: “the kind of trauma these victims have is very similar to the Love Canal residents....They’re trapped in their homes with a hazardous substance that may be making them sick now and may also cause cancer in them or their children, and most of them don’t have the financial resources to take out the insulation or to move.”<sup>24</sup> To an American public increasingly informed and concerned about residential indoor air pollution, the UFFI situation was a nightmarish worst-case-scenario.

Even after the CPSC took the decisive step of banning UFFI, homeowners around the country were left with the problematic substance insulating - and potentially polluting - their homes. The popular press - responding to and reinforcing public worry - reported on both the lack of safety testing for UFFI and the failure of any single Federal agency to assume responsibility for the problem. The “confused” and uncoordinated Federal response to the UFFI disaster exemplified the Federal reaction to the problem of indoor air pollution generally. However, unlike UFFI, indoor air pollution was not a discrete product that could be banned and removed from the market. As the UFFI disaster unfolded, the GAO was simultaneously evaluating the Residential Conservation Service and its potential impact on indoor air pollution. Although conservation of energy was both necessary and desirable, the UFFI controversy influenced the GAO to take a cautionary approach to a national program of retrofitting and weatherization, thus reinforcing the dichotomy between energy and health that indoor air scientists wanted to overcome.<sup>25</sup>

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<sup>22</sup> Robert Harris, an environmental biochemist with the Environmental Defense fund and a researcher at U.C. Berkeley, quoted in Crittenden, “Built in Fumes Plague Homes.”

<sup>23</sup> “Fumes: Washington is Confused,” *New York Times*, May 7, 1978.

<sup>24</sup> Attorney Richard Lippes quoted in Tamar Lewin, “Formaldehyde Issue Stirred by U.S. Ban: Insulation Lawsuits Abound,” *New York Times*, May 25, 1982. Love Canal was a neighborhood in Niagara Falls, New York in which barrels of chemical waste had been buried by the Hooker Chemical Company between 1942 and 1952. By 1978, the chemicals had leaked into the community’s soil, water, and air, and the site was declared a “great and imminent peril” to health, as residents’ homes were irrevocably contaminated. As the case captured headlines between 1978 and 1981, it was fresh in the American memory during the UFFI crisis. Love Canal has been studied as a precedent-setting example of citizen activism in response to environmental injustice. See Adeline Levine, *Love Canal: Science, Politics, and People* (Lexington, MA: D.C. Heath and Co., 1982). Also see Hal Rothman, *The Greening of a Nation? Environmentalism in the United States since 1945* (Fort Worth: Harcourt Brace: 1998), 148-151.

<sup>25</sup> For a concise summary of this perspective, see Hal Levin, “IAQ: Whose Responsibility?” *EPA Journal*, October-December 1993, 34-35. Levin argues that “only two types of conservation measures directly increase indoor air pollutant concentrations: inappropriately reducing ventilation and using sealants and caulks that emit pollutants.” Therefore, “architects and designers can substantially reduce indoor air pollution by proactively minimizing

## Cleaning Up the Great Indoors: a Worldwide Concern

The conflict over the Residential Conservation Service, and the attention it focused on energy conservation and indoor air quality as ostensibly opposing priorities, was representative of the early 1980s as a watershed era for indoor air pollution awareness in the United States. For example, the Interagency Research Group on Indoor Air Quality, a collaboration that included leading indoor air scientists and representatives from several Federal agencies, held an open Workshop on Indoor Air Quality Research Needs in December of 1980 in Leesburg, Virginia. Over 200 people attended, including both experts and members of the public.<sup>26</sup> Citing this concentrated attention to indoor air pollution as “long overdue,” the participants discussed the existing knowledge of indoor air science and strategies for future research. The DOE and the EPA, which had clashed over the proposed Residential Conservation Service, collaborated in organizing the Workshop and in producing its Report. In 1981, a Committee on Indoor Pollutants, convened by the National Research Council and sponsored by the EPA, produced a comprehensive report, *Indoor Pollutants*, whose authority was soon frequently cited in scientific, governmental, and popular literature. In October of 1981, an International Symposium on Indoor Air Pollution was held at the University of Massachusetts, Amherst. This was the first such conference in the United States and included 520 participants from 12 countries.<sup>27</sup> The journal *Environment International* soon followed up in 1982 with a special issue devoted entirely to indoor air pollution, in which it featured a large number of the conference’s papers.<sup>28</sup> In 1984, another international symposium on indoor air took place in Stockholm, Sweden, attended by several researchers from the Lawrence Berkeley Laboratory. In 1982, the World Health Organization issued a comprehensive report on the health effects of indoor air pollution.<sup>29</sup> By 1985, the EPA had established its own Office of Indoor Air Quality.<sup>30</sup>

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undesirable sources.” Tighter, energy-efficient buildings, Levin argues, need not *necessarily* cause poor indoor air quality if building materials are chosen carefully.

<sup>26</sup> Departments and agencies represented were: Housing and Urban Development, Health and Human Services, Consumer Products Safety Commission, Environmental Protection Agency, Department of Energy, Department of Defense, Department of Labor, Department of Commerce, Department of the Interior. See: Interagency Research Group on Indoor Air Quality, *Interagency Energy/Environment R&D Program Report*, Department of Energy and Environmental Protection Agency Workshop on Indoor Air Quality Research Needs, Conf-801259 (Washington, D.C., 1980), iii.

<sup>27</sup> John D. Spengler and Demetrios J. Moschandreas, “Editorial: Indoor Air Pollution,” *Environment International* 8 (1983): 3-4.

<sup>28</sup> *Environment International* 8 (1982). The issue was dedicated to Craig D. Hollowell, who had been instrumental in establishing LBL’s indoor environmental research program. Hollowell had died suddenly of a heart attack in January of 1982 at the age of 41.

<sup>29</sup> World Health Organization, *Indoor Air Pollutants: Exposure and Health Effects* (1983). This publication was also dedicated to Craig Hollowell, who had been a member of the Working Group that produced it. It is notable that in the year 2000 the WHO issued another report, *The Right to Healthy Indoor Air*, which was modeled on “fundamental principles in the fields of human rights, biomedical ethics and ecological sustainability.”

<sup>30</sup> California had already supported early action on indoor air pollution before these national and international efforts began in earnest. In 1978 the state’s Department of Consumer Affairs had hosted its “Clean Your Room” conference on indoor air pollution, and produced an accompanying guidebook of the same title. The California chapter of the American Institute of Architects held an indoor air symposium in 1981. See *Indoor Air Pollution: The Architects’ Response* (American Institute of Architects and the California Council of the American Institute of Architects: San Francisco, 1984).

The popular press was also increasingly interested in the emerging problem of indoor air pollution between the late 1970s and the mid-1980s. "Has it Become a Case of Insulation or Pollution?" asked the *Washington Post*, setting up the very dichotomy that threatened to make Americans wary of energy conservation: "government officials and researchers across the country are investigating the possibility that the very measures meant to turn the nation's homes into energy fortresses in the name of saving fuel may be creating a whole new area for public concern: indoor air pollution."<sup>31</sup> In the introduction to its special section on "the energy-saving value of caulking, weather stripping, and repairs for leaky windows," the popular magazine *Consumer Reports* asked "Can You Make a House Too Tight?" In its "Environment" section, *Business Week* reported on "How Insulation Traps the Bad and the Good," embellished with a drawing of a skull-and-crossbones superimposed over a charming suburban home.<sup>32</sup> The *Chicago Tribune* warned that "The Great Indoors Has Pollution Too," and led with an alarmist anecdote: "you rush home, close the door and windows, and breathe in relief - you're safe. Only you are not safe....The air inside the home often is more polluted than air on a smoggy day outdoors."<sup>33</sup> "Cleaning Up the Great Indoors," read the front-page headline on *The Energy Daily*, accompanied by a feature on "Formaldehyde: The Scare of '79." A San Francisco newspaper reported: "Expert Says Conservation May Pose Some Hazards," and cited a recent report on indoor air pollution by scientists at the Lawrence Berkeley Laboratory, which was increasingly becoming the public face of academic indoor air expertise.<sup>34</sup> The popular science magazine *Science 80* described a state-of-the-art demonstration house, a "veritable fortress against the loss of energy," that had produced harmful unintended consequences: "without the drafts of fresh outside air typical in most homes, the indoor air went bad." The bottom line? "By sealing up their homes, conservation-minded Americans may be aggravating a hidden health threat."<sup>35</sup> The *San Francisco Examiner*, one of that city's two flagship newspapers, devoted an editorial to governmental "Inattention to Indoor Air." Citing President Carter's recently-delivered environmental message, the newspaper argued that the indoor environment required the same attention to "clean up" as the outdoor environment: "by sealing up homes and buildings to better conserve energy, we unwittingly may be sealing ourselves into harmful climates conducive to infectious diseases and various contaminations....In the long run, it may be better to open the window - the air may be cleaner outside!"<sup>36</sup> In its spotlighting of indoor air pollution, the *Examiner* made two notable statements: first, it implicitly endorsed the "well ventilated but energy wasteful" houses that the LBL was concurrently trying to discourage. Second, it implied regret for the "at least 70 percent of their time" that most people were spending indoors, preferring to endorse open windows and outdoor air, both reminiscent of an earlier, simpler, healthier time when domestic life was not fraught with energy and health

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<sup>31</sup> Ed Bruske, "Has It Become a Case of Insulation or Pollution?," *The Washington Post*, September 2, 1979.

<sup>32</sup> "Can You Make a House Too Tight?," *Consumer Reports*, October 1981, 582; "How Insulation Traps the Bad and the Good," *Business Week*, December 24, 1979, 66.

<sup>33</sup> William Carlsen, "The Great Indoors Has Pollution Too," *Chicago Tribune*, July 6, 1977.

<sup>34</sup> "Cleaning Up the Great Indoors," *The Energy Daily* 8, no. 1, January 2, 1980, Washington, D.C; "Expert Says Conservation May Pose Some Hazards," *Daily Pacific Builder*, February 5, 1980.

<sup>35</sup> Michael Gold, "Indoor Air Pollution," *Science 80*, March 1980, 30-33. This article described the Mount Airy House in Maryland, a project on which the LBL had collaborated.

<sup>36</sup> "Opinion: Inattention to Indoor Air," *San Francisco Examiner*, August 25, 1979.

concerns.<sup>37</sup> Even in environmentally-conscious northern California, energy conservation was called into question as a potential antagonist of healthy fresh air, and by extension, human health. Alerts like these continued to appear in popular periodicals throughout the first half of the 1980s. As the ubiquitous *U.S. News and World Report* announced in 1985, “Now You Can Worry about Bad Air Indoors, Too.”<sup>38</sup> When energy conservation and indoor air quality faced off in the narrative of a popular article, indoor air (and human health) frequently came out the loser.

Researchers at Berkeley and other institutions had been arguing for several years that indoor air pollution was an emerging public health problem requiring accelerated, comprehensive action. By the early 1980s, the problem was finally receiving attention from the highest levels of government - the General Accounting Office, the Environmental Protection Agency, the National Research Council, and of course the Department of Energy.<sup>39</sup> But when

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<sup>37</sup> These sentiments are familiar from the housing ideals discussed in Part II, such as the owner-builders’ preference for rural life and simple cabins, Ken Kern’s preference for natural building materials, and John Ott’s arguments for natural sunlight. On these sentiments, see Charles Rosenberg, “Pathologies of Progress: The Idea of Civilization as Risk,” *Bulletin of the History of Medicine* 72, no. 4 (1998): 714-730.

<sup>38</sup> “Now You Can Worry about Bad Air Indoors, Too,” *U.S. News and World Report*, September 23, 1985. Anxiety about the toxic threats of late-20th century life influenced literature as well as journalism. The plot of Don DeLillo’s 1985 novel *White Noise* revolved around an “airborne toxic event” that forced the evacuation of a Midwestern American town. The book captured the mixture of danger, absurdity, and comedy surrounding the event and responses to it. Reviewers praised its accurate capturing of the American *zeitgeist*: “in light of the recent Union Carbide disaster in India that killed over 2,000 and injured thousands more, *White Noise* seems all the more timely and frightening - precisely because of its totally American concerns, its rendering of a particularly American numbness.” Jayne Anne Phillips, “‘White Noise’ by Don DeLillo,” *The New York Times*, January 13, 1985. In the twenty-first century, health-oriented scrutiny of the domestic environment is a widely-publicized trend. For example, two architects recently began compiling a database of the chemical content of housebuilding and furnishing materials (something that LBL’s scientists had proposed several times in the 1980s). As one architect told the *Times*: “people need to understand: no material is pristine these days. Even if it starts out natural, it ends up being transformed through industrial processes.” See Fred A. Bernstein, “To Help Make Sure your Home is Healthy, An Ingredients List,” *New York Times*, February 1, 2012. In New York City and elsewhere, consultants can be hired to evaluate “everything from scented candles to shower heads” for possible hazards. See Penelope Green, “Domestic Detox: Extreme Home Cleaning,” *New York Times*, May 27, 2010. Finally, on the exhaustive purging of household chemicals by mothers of young children, see Michael Tortorello, “Is It Safe to Play Yet?” *New York Times*, March 15, 2012.

<sup>39</sup> The Presidency of Ronald Reagan severely limited the funding and authority of the Environmental Protection Agency, which had begun addressing indoor air pollution. One historian has referred to the “Reagan-Bush backsliding years,” during which both Presidents reduced regulation and environmental protection, while giving more power to corporations. Reagan’s first appointed Secretary of Energy, James B. Edwards, was a dentist who threatened to dismantle the DOE, which was the primary funder of the national laboratories. By 1981, the LBL’s budget had been cut significantly, requiring a workforce reduction of 19 percent. But by 1982, a new Secretary of Energy, Donald P. Hodel (previously Director of the Bonneville Power Administration), renewed the DOE’s commitment to basic research. See Catherine Westfall, “Retooling for the Future: Launching the Advanced Light Source at Lawrence’s Laboratory, 1980-1986,” *Historical Studies in the Natural Sciences* 38, no. 4 (Fall 2008): 569-609. Under Reagan, the EPA’s budget was cut by 22 percent, and Anne Gorsuch - a vocal opponent of the Agency - was appointed as its Administrator. Reagan-appointed Secretary of the Interior James Watt was equally hostile to environmental protection. See Opie, *Nature’s Nation: An Environmental History of the United States*, 381, 489; Hal Rothman, *The Greening of a Nation? Environmentalism in the United States since 1945* (Fort Worth: Harcourt Brace: 1998), 169-192; Ted Steinberg, “In Corporations We Trust,” chap. 16 in *Down to Earth: Nature’s Role in American History* (New York: Oxford University Press, 2009). Reagan especially limited solar research, cutting its

the popular press picked up on the issue, it arguably overemphasized the threats facing the typical American homeowner. Many IAQ researchers felt that popular articles on indoor air pollution were excessively alarmist and perhaps counterproductive from an energy-conservation perspective; they had oversimplified the complex relationships between energy conservation, ventilation, and indoor air quality in the interest of producing sensational stories. Legitimately frightening episodes like the UFFI disaster undoubtedly heightened public anxiety about and interest in indoor air pollution as a general problem. In short, having IAQ in the national spotlight was a double-edged sword.

But of course, interest in indoor air did not begin in the early 1980s, or even with the Lawrence Berkeley Laboratory's research program in the mid-1970s. Recognition of air as an influence on health was ancient and diffuse. In the context of American housing, the Victorian era had been particularly obsessed with ventilation. Industrial hygienists had scrutinized indoor occupational settings during the first half of the twentieth century, eventually turning their attention to the health effects of outdoor "community" air pollution. Theron Randolph and other environmentally-oriented physicians (calling themselves "clinical ecologists") had been concerned about residential indoor air pollution in the 1950s and 1960s, well before residential energy conservation became a national priority. Nevertheless, the oil embargo that began in 1973 and launched a decade of energy consciousness was a pivotal event in shaping the dominant approach to healthy housing of the late twentieth and early 21st centuries. The research done at the LBL and other institutions helped to establish and shape the modern science of indoor air quality and define the core issue of healthy housing as the relationship between energy conservation, ventilation, and indoor air pollution.

### **Beyond Indoor Air: The "House Ethic" as an Alternative Approach to Healthy Housing**

But some energy-conscious Americans of the 1970s and early 1980s pursued alternative approaches to healthy housing. Owner-builders and their supporters in northern California's Mendocino County responded to the energy crisis with both minimalist and innovative housing choices, from simple cabins to architecturally and technologically sophisticated homes. Although Mendocino's owner-builder community was especially active and attracted national attention, owner-building from the late 1960s to the early 1980s was a national movement and its cousin, self-help housing, was an international one. Both of these movements saw in housing the potential for meaningful societal change, a major component of which was the improved psychological and economic health of owner-builders, and by extension, the communities they

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funding by two-thirds and reducing the staff of the Solar Energy Research Institute (SERI) from 950 to 350, choosing instead to emphasize nuclear power as an alternative energy source (he also famously removed from the White House lawn the solar panels that Jimmy Carter had installed). In 1984, two historians of American energy policy wrote that "since its inception, American energy policy has been guided more by confusion and drift than by rational decision making." See Harvey Strum and Fred Strum, "American Solar Energy Policy, 1952-1982," *Environmental Review* 7 (1983): 14-16. Cuts to the Department of Energy's budget during the 1980s directly affected the LBL, forcing drastic reductions in staff and research. As one LBL employee wrote in a personal letter, "the news from LBL is not cheerful, I'm sorry to say. The program is currently projecting a \$1200K deficit for FY[19]87...Nine people have recently received notices of layoff...every staff member who isn't a scientist or grad student got notice....perhaps a little \$ will materialize to save a person or two; on the other hand, if no additional \$ is found, additional layoffs might happen." LBL Archives, ARO-4652, Container 4, Folder 6.

formed. Their approach to health was grounded in autonomy, and they eschewed government obstruction of the fundamental right to build and occupy their own houses. In this setting, a house was much more than a consumer or conserver of energy, or a container of clean or polluted indoor air; it was an extension of the self *and* an intimate connection to the world outside (sometimes even referred to as a “third skin”).<sup>40</sup>

Significant contrasts notwithstanding, this juxtaposition of the Lawrence Berkeley Laboratory’s research program with the owner-builders’ campaign for self-shelter illuminates a shared interest in residential energy conservation. After the oil embargo, the desire to reduce dependence on foreign oil was not exclusive to academic scientists or to back-to-the-landers, or to any other sector of American society. It was a widely-recognized national necessity and priority. Berkeley’s scientists and Mendocino’s owner-builders even tested some of the same innovations, such as residential solar heating and alternative building materials like earth-bricks. But the scientists did not devote the same attention to researching solar power, earth-building, shading with vegetation, or cooling with roof ponds as they did to retrofitting, weatherization, and mechanical ventilation - all of which were more familiar to American homebuilders, buyers, and owners. Those owner-builders who clashed with local building inspectors over their solar or earth-brick homes argued that they could not wait for the building industry’s slow adoption of these innovations; instead, they took the problem into their own hands and built the houses they wanted for themselves. This was as much an expression of psychological and economic autonomy as it was an expression of environmental ideals. For many, self-building was also the only realistic path to homeownership.

In his *Sand County Almanac* of 1949, Aldo Leopold’s seminal essay “The Land Ethic” used the example of the Dust Bowl of the 1930s to illustrate the devastating impact of a purely economic approach to land - an approach that treated it as property. A land ethic, Leopold argued, “simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land....A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land.”<sup>41</sup> These ideas had helped to shape the ecological ethos of the 1970s, including campaigns against resource depletion, for protection of wilderness, and for preservation of air and water quality. Leopold’s book has been called “the undisputed sacred text of the modern environmental movement.”<sup>42</sup> He - and the environmental activists who followed him - rejected a solely economic view of land, one that valued only tangible, quantifiable products, or commodities. Northern California’s owner-builders, most of whom identified with this same environmental movement, similarly objected to the commodification of housing. Their goal for housing during this era of energy crises went far beyond reduced consumption of foreign oil,

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<sup>40</sup> This idea comes from the German *Baubiologie* (“biological building”) movement, which had heavily influenced owner-building expert and author Ken Kern. I discuss Kern in chapter 5 of the dissertation.

<sup>41</sup> Leopold’s *A Sand County Almanac* is integral to Gregg Mitman’s article “In Search of Health: Landscape and Disease in American Environmental History,” *Environmental History* 10, no. 2 (April 2005): 184-210. Citing the “striking” allusions to land health in Leopold’s book, and Leopold’s argument that health “was the most vital function of living organisms,” Mitman advocates “a focus upon health” for environmental historians (185). One of my goals in this dissertation has been to use housing in precisely the way that Mitman advocates, as a focus for a health-focused environmental history.

<sup>42</sup> Opie, *Nature’s Nation: An Environmental History of the United States*, 396.

although this was an important criterion. They valued the use of natural and sustainable building materials, passive heating and cooling (achieved, for example, through solar power and earth-sheltering), and, above all, owner-builder autonomy. This, they argued, was the foundation of an individual or family's mental, physical, and economic health. "All people," wrote Ken Kern in *The Healthy House*, "should have the right to build their own homes, to care for their own health, and to avoid the continued pollution of our global environment."<sup>43</sup> A truly healthy house would never be attained solely through remediation or regulation of its indoor air. A house was worthy of careful thought prior to its construction, an ecologically-conscious approach to building (including site, design, materials, and labor), and ongoing care once it existed. Such an approach to healthy housing, written at the height of the environmental movement, applies the essence of Leopold's land ethic to housing by making the house part of "a community of interdependent parts."<sup>44</sup> As a land ethic cultivated healthy land, a "house ethic" created a healthy house. A new building and residential ethic suited to the circumstances of the 1970s was not exclusive to California's owner-builders. When the journal *Energy and Buildings* - in many ways representative of the new scientific field of buildings research - published its debut issue in 1977, it declared: "in industrialized nations the built environment is the largest easily addressable consumer of energy. It is also one of the ripest candidates for a new *ethic* and technology of conservation."<sup>45</sup>

Lofty ideals should not obscure the fact that for many young people of the 1970s, owner-building was the only affordable path to homeownership. The bottom-line costs of land, labor, materials, and energy were essential factors in this population's housing choices. Although their setting and circumstances were very different, LBL's researchers also made cost-effectiveness a decisive factor in their recommendations about residential energy and indoor air quality. However impressive a technology might have been at conserving energy or preserving indoor air quality, LBL reports were unlikely to endorse it without compelling evidence of cost-effectiveness. In this setting, then, the pursuit of healthy housing was inseparable from economics. From the commercial homebuilder perspective, the financial costs of potentially energy-saving innovation were prohibitive. This caused builder objections to such energy-efficiency requirements as California's Warren-Alquist Act and the nationwide Building Energy Performance Standards. In their respective approaches to housing, such seemingly distinct groups as rural owner-builders, academic scientists, and even commercial builders all struggled to balance competing goals. Similarly, today's consumers must balance energy, environmental, and economic pressures in making decisions about residential energy.<sup>46</sup>

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<sup>43</sup> Ken Kern, *The Healthy House* (Clovis, CA: Owner-Builder Publications, 1978), 11. Ken Kern was one of the best-known leaders of the American owner-builder movement in the 1960s and 1970s. His book, *The Owner-Built Home*, became a bible...

<sup>44</sup> "The Land Ethic," in Aldo Leopold, *A Sand County Almanac* (New York: Oxford University Press, 2001), 167-191.

<sup>45</sup> "Editorial," *Energy and Buildings* 1 (1977). Emphasis added.

<sup>46</sup> For example, in a recent feature story on "The Return of Fossil Fuels," a leading personal finance magazine questioned whether savvy investors should still invest in alternative energy, such as solar and wind power companies. Citing the "enormous new reserves of natural gas" released by fracking ("enormous" referring to a 75-year supply), as well as extraction of domestic oil from sand and shale deposits, the magazine reported: "nowhere has the impact of cheaper fuel been more stark than in the alternative-energy industry, which has had the green rug pulled out from under it." This is especially relevant to the domestic setting, where "economists say, the

## Climate Change Revives Past Indoor Air Concerns and Raises New Ones

Climate change is widely recognized as *the* environmental issue of our time. The Institute of Medicine, at the request of the Environmental Protection Agency, recently convened an expert committee to study a problem that has received relatively little attention: how climate change may affect indoor air and public health. Dr. John Spengler, who thirty years earlier had chaired the National Research Council's landmark 1981 Committee on Indoor Pollutants, also chaired this twenty-first century effort. These two committees and their reports shared more than just continuity of leadership. Both committees argued that indoor air posed a potentially significant public health threat and therefore required increased attention and action. The committee of 1981 argued that the health of the indoor environment had been ignored in favor of cleaning up and protecting the outdoor environment, when in reality most Americans spent at least 75 percent of their time indoors. By the time of the Institute of Medicine's report in 2011, the importance of indoor air quality no longer needed justification, yet the report's language could have been lifted from that of the General Accounting Office in 1980: "no government or private body has lead responsibility for investigating this question, and the lack of leadership is hindering action on identifying potential hazards, formulating solutions, and setting research and policy priorities."<sup>47</sup> Like the cleanup of the indoor environment thirty years earlier, preparing today's indoor environment for climate change would require a centralized effort, something easier to endorse on paper than to accomplish in reality. If the novelty of 1981 was the discovery that the indoor environment was subject to air pollution of its own, the novelty of 2011 was that it was subject to climate change as well.

How so? The Institute's committee identified several potential "climate-induced indoor environmental problems." For example, climate change might exacerbate concentrations of outdoor pollutants, which could in turn affect indoor concentrations; "extreme weather conditions" such as flooding might encourage the growth of fungi and bacteria, as well as building decay; if weather and climate variability supported new infectious agents and pests, these might find their new "ecologic niches" in buildings; "extreme weather events" might lead to power outages, exposing vulnerable populations to excessive heat and cold. In addition to these predictions, the Institute's committee identified one category of problems with particular historical resonance: problems related to energy conservation. Again, the report's language could have been lifted from LBL reports of the late 1970s or early 1980s: "measures to reduce energy use in buildings, such as lowering ventilation rates, may cause higher exposures to pollutants emitted from indoor sources....Climate change may make ventilation problems more common or more severe by prompting the implementation of energy-efficiency (weatherization) measures that limit the exchange of indoor air with outdoor air. The introduction of new materials and weatherization techniques also may lead to unexpected exposures and health risks."<sup>48</sup> The Committee's concluding recommendation for action in 2011

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battles of the energy revolution are being fought house by house and car by car." See Reshma Kapadia, "The Return of Fossil Fuels," *Smart Money*, August 2012, 54-55, 60.

<sup>47</sup> Institute of Medicine, "Climate Change, the Indoor Environment, and Health," Report Brief (Washington, D.C.: June, 2011). For an excellent recent summary of indoor air pollution, but without emphasis on climate change, see Charles J. Weschler, "Changes in Indoor Pollutants Since the 1950s," *Atmospheric Environment* 43 (2009): 156-172.

<sup>48</sup> "Climate Change, the Indoor Environment, and Health," 2-3



echoed the GAO's report of 1980: it advocated "spearheading an effort across the federal government to make indoor environment and health issues an integral consideration in climate change research and action plans and, more broadly, coordinating work on the indoor environment and health."<sup>49</sup>

As experts of 1980 called for more centralized attention to the "emerging health problem" of indoor air pollution, so experts of 2011 (some of them the same individuals) called for more centralized attention to the relationship between indoor environmental quality, health, and climate change. Indoor air scientists of the late 1970s and early 1980s continually corrected the assumption that homes were a refuge from outdoor pollution: not only did they exchange air with the outdoors, but they produced pollution of their own. The explosion of interest in residential indoor air - from scientists, government, architects, and the public - from the early 1980s onward reflects recognition of the home as an ecosystem unto itself, requiring its own research tools, methods, Task Forces, conferences, and more. But in making the home, and its air quality, a focus of intense research, perhaps we have too emphatically severed it from the local, regional, and global environments it occupies. If it is counterintuitive to learn that climate change affects our homes and other buildings, perhaps it is because they are simultaneously ecosystems of their own *and* inseparable from the ecosystems outside their walls. The Institute of Medicine's report is just one of many reminders that we now confront an energy and environmental crisis on par with that which launched the modern era of indoor environmental research. Indoor air and environmental quality are now established criteria for public health; most scientists who entered these fields in the late 1970s are now at the peaks of their careers and training the next generation. For more than thirty years, housing in the United States has been a nexus of competing energy, health, and - most important - economic priorities. Balancing these priorities - especially in a setting that is both private and psychologically meaningful - may be assisted by a robust science of the indoor environment, but this makes it no less complex or challenging.

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<sup>49</sup> "Climate Change, the Indoor Environment, and Health," 4.