Living Without Air Conditioning in a Hot Climate: Thermal Comfort in Social Context

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ABSTRACT

At least within the U.S., living without air-conditioning in a hot climate is now socially deviant behavior. In a time when every public building, every business and every new house is air-conditioned, the idea that someone would intentionally deprive himself or herself of thermal comfort by building a house without air-conditioning raises eyebrows, at least. The central focus of this study is a description of one such deviant case—a housing development whose residents voluntarily eschewed the installation of air conditioners. The findings from this case raise questions about the quantification of thermal comfort and the air-conditioning design standards derived from thermal comfort science, the expectations they create, the consequences they have for energy use, and the implications they have for substituting more benign cooling technologies for compressor air-conditioning.

Background

The research reported here was stimulated by the recognition of an important technological trend in residential construction in California: movement of air-conditioners into "transition" climates[2] where heretofore they had not been "needed." It was part of a larger study sponsored by the California Institute for Energy Efficiency (CIEE) on "Alternatives to Compressor Cooling." Much of the northern portion of California qualifies as a transition climate—including many portions of the central valley where even the hottest summer months are characterized by dry, cool, and breezy nights.

One plausible explanation of this movement is that the presence of air-conditioning is no longer climate-driven, but has become a standard feature of a normal house. As a result of such "standardization," air-conditioning is routinely installed and operated in climates where it may not be necessary, and may not work as efficiently due to low humidity levels. The recent expansion of air-conditioning into mild climates, and then primarily in new homes, suggests that something has changed, or is changing in the way people think about and use air-conditioning. If the climate has not changed, why would the "need" for air-conditioning, as evidenced by demand, increase now, more that 20 years after the technology became almost ubiquitous, at least in the U.S., in climates where heat is severe or accompanied by high humidity?

In and of itself, the continuing growth of air-conditioning in these areas questions the premise of "need" as an explanation. If this argument has some validity, then it leads to the possibility that—just as the air-conditioner appears where it is not needed—there could be some

[1]Opinions, conclusions, and findings expressed in this report are solely those of the author. This report does not represent the views or the official position of the California Energy Commission. Any citation of the report should reference the author individually.

[2]Areas of low average relative humidity are characterized by climates that may reach higher temperatures during the day but cool off sufficiently at night that houses keep relatively cool most of the time (Lutzenhiser 1994),

instances of its absence in settings where its need is taken for granted. The "deviant" case we detail here is just such an instance.

Living Without Air Conditioning in a Hot Climate

People rarely "choose" to have their houses built with compressor driven air-conditioning; instead, all those involved, the architect, the builder, the local building officials, the real estate agent, the mortgage lender and even the buyer treat it as a standard feature. Except for the rare "demonstration house" or custom design, alternative cooling choices are simply not available. Builders argue that people "demand" air-conditioning in new homes, although in milder climates a lively market for un-air conditioned older homes still exists. But this "demand" is difficult to examine empirically because people really know only the cooling technology available to them, not the options they were not offered. In a sense, concluding that the lack of a current market for passive design and alternative cooling technologies is evidence of people's "preference" for air-conditioning is like concluding that there is no market for Thai food by observing customer purchase patterns in a Baskin-Robbins.

We rejected collecting information on why people were buying air-conditioning instead of alternative cooling technologies as a methodological dead end. We did, however, have a unique opportunity to observe the reverse in a new community in Davis, California. We were able to interview residents of a new "cohousing" community where the houses were built without air-conditioning[3]. This development was unique in that the buyers participated in the design of the houses and the site layout. The fact that such homes were built at all in that location, at the warm edge of a transition climate zone where summer afternoon highs frequently exceed 100°F, suggests at least that compressor air-conditioning may not be as necessary as some suppose. The fact that the residents decided for themselves to pursue alternatives to compressor cooling allowed us to explore these ideas with a group of people who had given them some considered thought. And, the fact that these folks had been living without air-conditioning for two summers allowed us to ask detailed questions about the effectiveness of the alternative house designs, their experience with the heat, and given that experience, to explore the viability of alternative designs and non-compressor cooling technologies.

Davis is at the edge of the transition climate zone, experiencing high afternoon temperatures—some days well over 100°F—but with cooler nights due to a pattern of cooler air moving in during the evening hours from San Francisco Bay through the Sacramento River delta (the "delta breeze"). The climate is warmer than the transition climates that are the primary concern of the alternatives research community, and so provides a strong test of the questions raised here about the nature of thermal comfort and the viability of alternative technologies. Certainly the deviant case of people choosing to live without air-conditioning in a climate where

[3]Cohousing is a form of intentional community developed in Denmark during the 1970's and promoted in the U.S. beginning in the late 1980's Cohousing communities are similar to typical condominiums in that individually owned residences are grouped on a single site, or in a single building, with shared ownership of community areas and amenities (McCamant and Durrett 1988). What characterizes cohousing is the involvement of the future residents in the development and design of the project, a project design in which individual houses are scaled down in size and back in amenities to allow for construction of more extensive common facilities, self-management with cooperative, consensus-based decision-making, and a focus on encouraging community involvement through both organizational and architectural design.

it is "needed" provides a strong test of that conception of "need," especially when trying to inform the "need" justification for installing it in cooler transition climates.

Because this was a unique circumstance, we approached it from an inductive rather than deductive perspective; we wanted them to tell us about their experiences in their own words, and to learn something new from it—we didn't test any hypotheses because we were at a stage in our inquiry where we were developing an understanding of the issues and existing literature did not suggest a coherent enough theory that testable propositions could be developed. What we expected to achieve by talking to this group was a more thorough and nuanced understanding of what it was like to live without air-conditioning in fundamentally passive solar design in a relatively hot climate.

We used basic qualitative interviewing techniques[4] intended to engage the respondents in conversation about the issues underlying the research questions. We took great deal of care in wording the questions to avoid introducing bias into the responses. The questions were open ended and we utilized prompts where appropriate to get the respondents to expand on some topics, and to refocus them if the conversation strayed too far afield. We attempted, to the best of our ability, to record their responses using their own words, the "natural language" they used to describe their perceptions and experience.

The interviews were conducted by three different interviewers: a graduate student in Sociology, a Sociology professor, and a graduate student in Human Ecology (the author), then entered into word processing files within a few days of the interview (so as to facilitate the interviewer's memory when reviewing the notes) for later analysis.

Because of the relatively small number of households (26), we attempted to interview all adult residents. Although we were not able to achieve a complete census, we were able to interview at least one adult in 22 of 26 households and 31 of 40 (41 including the author) adults living there in the first round of interviews. In the follow-up interviews, 18 of the original interviewees, representing 14 households, participated.

Residents moved in during early September, 1991. We conducted the first round of interviews in April, 1993 and the second round in August, 1993. The timing of the two interviews was intended to pick up on any potential differences in responses due to weather, specifically, the heat of late Summer in the Sacramento valley. The April interviews took place during a typically mild Spring, while the Summer interviews took place when the afternoon temperatures were averaging in the 90's and occasionally moving into triple digits.

The number of responses coded for each questions varied. Not everyone interviewed had an answer for every question. In some cases, the conversation would veer away from the actual question to another topic; when coding these cases, the responses were included as a response to the question most directly addressing that topic.

A single case study does raise some issues for the possibility of using results outside the case; in other words, we were worried that these residents might not be able to inform the questions we were asking. Because of this, we explored the issue of the group "decision" to not install air-conditioning, giving the respondents opportunities early in the interviews to express their biases and level of "adherence" to the "party line." What we found was that the group dynamics—and their focus on other goals (building community; consensus decision-making, participating in the design process) made it possible for people who would otherwise have never considered buying a new house without air-conditioning to give living without it a try. On some

[4]See, for instance (Rubin1995) (Patton 1987) (Marshall and Rossman 1989)

level, a number of these otherwise "normal" folks found themselves in a position of making a compromise that they never would have considered, and then having to live with it.

The people who moved into the cohousing project were able, as a group, to make a choice that individually, many would probably not have made. Motivated by the need to reduce costs, inspired by a strong environmental ethic, and convinced by group members with a high level of knowledge and sophistication about energy efficient building design, the group was able to consider living without air-conditioning—even in a hot climate. The choice was further supported by a strong, practical negative characteristic: noise in the relatively confined spaces around the houses, and the effect it would have on other community members and the community itself.[5] The more skeptical members were assuaged by a group compromise of "air-prepping" the houses so the costs of adding air-conditioning (IF the passive design was inadequate) would not require extensive remodeling and thus be relatively affordable. "We felt comfortable," related one skeptical group member "because there was an out."

Were the people in this community uncomfortable without air-conditioning? Sure, most of the respondents talked about being uncomfortable at times, but they also reported being "okay" most of the time—the times they were uncomfortable were exceptional. In qualifying those exceptions, instead of attributing their discomfort to the absence of air-conditioning, they talked instead about the limits of their house design (the upstairs got hot or the overhangs were not deep enough) or the weather. The talk about weather was uncritical and accepting. "Sure, there were a couple of days it was hell, but hey, 110 degrees is hot!" The fact that there were some times of day it was uncomfortable, or even some multi-day periods when it didn't cool down, most respondents reported that it was "okay most of the time."

The respondents tended to describe the "few days" or the "bad spell[s]" by how the heat affected their lives rather than in abstract terms such as temperature or even "comfort." The most severe problem mentioned had to do with it being rarely, but significantly, "too hot to sleep". This was often mentioned in the same breath as the "upstairs" problem[6]. Another effect was that people felt "lazy" or unable to "get things done."

The findings presented here should not be automatically dismissed due to potential bias and the likelihood that this group was not "representative" of the population of new homebuyers. While there was a very strong group identity and certainly an element of peer pressure in the decision to leave air-conditioning out of the houses, these folks did get uncomfortable sometimes, and do use air-conditioning when available in their cars, at work, etc. However, the experience of living without air-conditioning, and of living in houses that were designed, albeit in a very basic way, to stay cool, gave them some perspective on their experience and, it appears, made them quite clever about managing their own comfort.

In most of the questions we asked, there is an implicit perspective that living without air-conditioning is a deviant choice—after all, why would we be asking questions about what they did and how they did it? We did attempt to approach the problem from another perspective by asking what they liked about not having air-conditioning. Some responded directly to the

[5]When talking about the noise concerns, many respondents talked about having lived in confined places, primarily apartment complexes, where the noise from the neighbor's air conditioning intruded on their ability to enjoy being outside on balmy evenings.

[6]Residents of two-story houses frequently noted that the upstairs became significantly hotter, and took longer to cool down, than the downstairs

question, but most gave their answer in terms of what they didn't like about air-conditioning, a type of response we really hadn't anticipated.

The things people liked about not having air-conditioning reflected their responses as to why they made the decision in the first place; saving energy, "doing something for the environment", "reducing energy demand," [lack of] noise and, the most common response, saving money. They talked with relish about their low utility bills, comparing them to the bills from their old places, and those of friends or family. Comments like these led to talk about how well the houses worked and, for a few, how "pleased" they are that "the house doesn't need [AC]."

A few mentioned the "natural" or "healthy" air, but those comments were usually contrasted with the idea that air-conditioning was somehow unnatural and unhealthy. One person talked about hating the "sensation of artificial air," of it somehow being "not clean and pure, but refrigerated . . ." That same person did acknowledge that air-conditioning could feel good when it was "so hot you don't care" whether it's "fresh" or not, and another pointed out that the air in a passive house that had been closed up all day was not all that fresh, either.

A number of people talked about the contrast between indoor and outdoor temperature being a negative feature of air-conditioning, as well as the sense that air-conditioning was "too cold". This was also thought unhealthy because the body has to make a "major adjustment" in short order; the contrasts don't allow one to "adjust" or "acclimate" to the summer heat. One person suggested that "constant temperature is a bad idea" and that thermostats should instead "track the outside temperature." Another echoed that same idea, saying that when he was hot he didn't "want cold air . . . just [to be] cooler than I am." Another talked about preferring a "constant temperature," but in the sense of consistent between inside and outside. She noted that air conditioned buildings are "either too hot or too cold."

One theme that kept coming up in the interviews was that of "those times," the periods when it was "really hot" or "the breeze didn't come up at night." We followed this theme in asking people what they did on "really hot days." Based on the first exploratory interviews, we began prompting respondents about a wide range of activities, including what they did to cool themselves and whether they went other places to cool off.

The most frequently mentioned strategy for keeping themselves cool was "dressing accordingly." Often preceded by "of course," they mentioned shorts, t-shirts, "light tops," and cotton; a few talked about "wearing less" or wearing "as little as possible." It is an important element of this group of people that most were employed in occupations where casual clothing was acceptable or even the norm (graduate students, home-based businesses). Those who did work in office settings that required more formal dress would change immediately upon arriving home from work.

A number of people talked about "making sure" to drink "lots of water" in anticipation of the heat; preparing their bodies for it as they would for a hike or a long run. This raises some interesting ideas about the way people viewed their experience on the hottest days; not only would they prepare their houses by maximizing the amount of "coolth" they stored, they paid very careful attention to dressing and hydrating their bodies to endure the experience.

They also talked about strategies to ameliorate the heat. A number of people mentioned taking additional (to their routine bathing) showers specifically to get cool. Some talked about "getting wet" or even "hosing [themselves] down" during extreme times. Fans were also

mentioned, but for most it seemed almost an afterthought in the sense that, like light clothing, it was a given; everybody used fans.

A few people also talked about "taking it easy" or "laying low" during the hot part of the day, or on the hottest days. This idea that surfaced in our question about times they might have been "uncomfortable, or might have liked to have air-conditioning" is that the heat makes one "lazy" or makes it difficult to "get things done." Responding to this question, there was a greater sense of adaptation; they responded in a matter of fact way that they would "plan the day to be out in the morning, when it's cool" or "get things done" before it got too hot. Then, when the heat came, they could be "sedentary" and "wait for the heat to pass."

One way of coping with the heat is to go someplace else where it isn't hot. We asked this question with the idea that if the houses were unacceptably hot without air-conditioning, people would go other places to find it. While we did find some "escape" activities, by and large, people described relatively infrequent events or talked about how they adapted to the heat in their homes.

A few residents talked about leaving town for a cooler environment. One talked about frequent trips to their mountain cabin, but said that "avoiding the heat is not the main reason . . . it's an added plus." Others mentioned going to the coast or planning vacations to avoid the hot parts of the summer, but their responses, like the family with the mountain cabin, suggest that these decisions were not really avoiding the heat in their houses, but the hot weather in general.

A few people talked about "going to the mall" specifically to "get out of the heat." One resident sniffed "I don't do malls" when it was included on a list of example places people might go when it's hot. Another talked about planning their shopping as a "family outing" while another described going "when I don't want to be lethargic, just to do window shopping."

Most residents—especially those with kids—talked about going to the pool to cool off on hot afternoons. Some went almost daily, but most went at least occasionally. One mother of young children confided that "sometimes it makes me hotter to take the kids somewhere . . . it's a lot of work for me so it makes me hotter and irritable." In a similar vein, a few people mentioned that their cars did not have (functioning) air-conditioning, and that they avoided going places specifically because driving somewhere was no "escape" from the heat. One observed that not having air-conditioning in the car was "more of a hassle than not having it in the house" because the car "gets hotter." The same idea, but from the opposite perspective, was expressed by another resident who related that she and her partner had "given in and had air-conditioning installed in the new car," thus it "lets us get out."

The terms "lethargic" and "sedentary" came up a number of times to describe the experience of the hot afternoons. In that context, people talked about "lounging around," often drinking "iced tea", an image that brings to mind the sultry South. It also confirms the logic of the siesta. People talked about drawing the shades both the keep the sun out, as part of their house management routine, but also to make the house dark "like a cave" because "darker feels cooler." While lounging in their caves drinking iced tea, they describe being careful not to "generate heat" with activity; one even spoke of handling the heat "psychologically" by "not resisting" and "visualizing the heat passing through and over me." Yet another resident who had grown up in the area had a completely opposite strategy: "the best thing to do about the heat is to get out in it and work!"

With these responses in mind, we asked the residents about any improvements they had made, or were planning to make, on their houses. These questions explicitly provided the opportunity to talk about adding air-conditioning. In the Spring interviews, we asked if there were

any changes they were "planning to make." In the Summer interviews we asked if they had already made any changes, and then followed again with the question of future plans.

What is remarkable about the responses is the fact that only two people mentioned air-conditioning at all, and in both cases, in terms of having thought only casually about adding it. Further, a number of people had no plans to make improvements; they were satisfied with the way the house was performing as it was. Those who had already made improvements had planted trees or built trellises to shade windows. One mentioned that she was "watering the plants and ivy [trying to get them to] grow quickly" while others were simply "waiting for the trees to grow."

Of those who were planning some kind of improvement, adding a whole house fan topped the list. Only two people mentioned evaporative coolers, and those—like the two who mentioned air-conditioning—were thinking speculatively.

Finally, we asked "If money were no object, would you change things in some way?" as a way of probing for some desire or need for air-conditioning that they otherwise might not mention when presenting themselves as proper cohousers. In fact, one comment illustrates the issue: "I still feel that peer pressure against adding air-conditioning might slow me down, but I think that's good; it's good for people to be aware of their neighbor."

Three people said they "might consider" or "would get" an air conditioner. However, one qualified his answer by saying it wouldn't be "the first thing I'd do if I had the money," while another admitted "I don't know much about other alternatives . . . I might try something else if I knew what was out there and could find out about it." The other responses focused on enhancements to the passive design, including tile floors and whole house, attic, and ceiling fans. A number were careful to point out that money wasn't really an issue for them: "Money doesn't' really hold us back from doing this—if comfort were an issue we would find the money."

Our respondents do not appear to "need" air conditioning. Sure, they want to be cooler when it is hot, but their "preference" for thermal comfort is very different than a traditional engineering view would suggest. These case study responses illustrate the idea that demand for air conditioning may not be nearly as universal as the expansion of the technology indicates. At least some people's cooling "preferences" may be more contextual and adaptable than those standards assume. A review of the development of thermal comfort standards and some of the debate concerning the application of those standards under field conditions follows.

Air-Conditioning and Thermal Comfort Standards

Current California standards for the design of Heating, Ventilation and Air-Conditioning (HVAC) systems require that they be able to maintain constant "design" temperature for both heating and cooling under local climatic conditions (CEC 2002). Residential buildings in California are required to provide heating, but not cooling. The heat source is required to "be capable of maintaining a temperature of 70 at a distance three feet above the floor throughout the conditioned space of the building." When space cooling is included, however, it is subject to a 78°F design temperature requirement (CEC 2002, p. 2-31). According to the standards[7], "An HVAC system should . . . be properly sized to provide correct air flow, and meet room-by-room calculated heating

[7]ASHRAE thermal comfort standards underlie the space conditioning requirements of the California Energy Commission Building Standards (CEC 2001). The standards are applied in greater detail to requirements for commercial buildings, but even residential structures are required to have the ability to maintain a constant temperature set-point within the "comfort range."(Pennington 2003).

and cooling loads." (CEC 2002, p. K-1) The code specifies that system sizing "shall be determined using a method based on" the methods described in one of three standard practice manuals, including the ASHRAE Handbook (ASHRAE 1981a) and ASHRAE Standard 55 (ASHRAE 1981b) (CEC 2002, p. 2-30,2-31). By this definition, cooling is an all or nothing proposition. If mechanical cooling is included at all, only a full central air conditioning system will meet code requirements

Development of Thermal Comfort Standards

For years mechanical engineers have been using psychrometric charts to determine just how cool buildings should be for people to be comfortable. First developed by Prof. John Wilkes Shepard in 1916 and refined by Willis H. Carrier in 1922 (Cooper 1987, p. 129), these charts originally indicated the ranges of temperature and humidity that affect "human comfort." These techniques have been substantially refined over the years, with Fanger's "Thermal Comfort" (1970) being the most frequently cited work of this type to date. The premises behind these models are quite reasonable: homoeothermic human bodies must maintain temperature. According to this view, the more difficulty the body has staying cool--that is, the more it has to regulate temperature--the more uncomfortable the person.

To obtain data on the thermal comfort preferences, Fanger constructed his study to test the thermal comfort preferences of individuals using a "comfort chamber," a windowless 9 x 16 foot room where the illumination and sound levels were kept constant with a high level of (filtered) air exchange.

Each test was conducted with individuals from each age/gender (college students and "elderly persons") group. They were clothed in the same light cotton shirt and trouser "uniform" and were exposed to a constant thermal environment for three hours, they were asked to vote on a "thermal sensation ballot"[8] every half hour throughout the experiment. The votes were then averaged for each individual to construct his "comfort vote" at that set of environmental conditions. During the experiment, the subjects were allowed to read, study, and engage in "quiet conversation" (but not about the "thermal environment").

Because he assumes everyone has a set-point of thermal satisfaction at which he feels ideally comfortable, Fanger implicitly assumes that constant thermal conditions are both comfortable and desirable. And this is all that the experimental design can yield. Because there is variation in this "set-point" in the population, a sample can be used to develop a "comfort range" based on the distribution of responses, in which each individual in the population has a (high) statistical probability of being within a standard deviation or two of his own "set-point." Fanger's application of this principle to the development of thermal comfort standards for buildings is described in detail in Fanger (1970, Ch. 4) as well as the ASHRAE Handbook (ASHRAE 1981a, Chapter 8).

"The reason for creating thermal comfort," Fanger writes, "is first and foremost to satisfy man's desire to feel thermally comfortable, in line with his desire for comfort in other directions." The research subjects voted on their level of comfort given the constant thermal environment they were experiencing. Because they were not allowed to select their optimum temperature, the optimum temperature for the population was selected based on a regression of the environmental

[8]The thermal sensation ballot contained the scale "used in most ASHRAE studies" composed of a scale of choices: cold, cool, slightly cool, neutral, slightly warm, warm, hot.

variables on the comfort vote. Thus Fanger's experiments skip a critical step in the research process—testing the hypothesis that people desire thermal neutrality—and instead moves on to the step in which the preferred ambient temperature for thermal neutrality is "found" experimentally.

A logically consistent understanding of thermal comfort then would be that the state of being comfortable means experiencing no thermal sensation at all. *Dis*comfort, then, would range between that set-point and environmental extremes where the body cannot maintain temperature. Given that the purpose of these experiments has been to establish the point at which the "average" human body is most comfortable, the development of air-conditioning systems which seek to maintain a constant, ideal temperature, humidity, and air speed seems reasonable, although problematic in terms of energy consumption. As a descriptor of human behavior, this method falls short.

Taking the assumptions and methodology of this line of research together reveals a picture of a particular type of person—a person whose experience of the thermal environment is reduced to the essentials of physical sensation and physiological response. This person is really just a body that registers sensations like the instruments in Fanger's lab. A body such as this becomes a mere stick figure represented by the heat balance model, and the experience of thermal comfort is reduced to pure (lack of) sensation—devoid of history, experience and meaning. This conception of comfort assumes that people constantly maximize their thermal comfort, or rather, include thermal comfort in their "utility function", to be maximized in relation to concurrent maximizations of other needs and desires. So, for example, people might trade discomfort for a lower energy bill, people might *demand* less comfort to save money, but they would still be uncomfortable.

Of course, the caricature we draw of Fanger's "average" subject is simplistic; the level of measurement detail that his research carefully documents provides useful information for the design and management of air-conditioning systems. However, because his methods do not allow for, or test, non-air-conditioned subjects, his results may not hold for people not using air-conditioning. Unlike a person who experiences heat or coolth in social situations, Fanger's "stick-figure" representation of a human body *requires* a thermally controlled environment.

The common-sense assumption that a person's comfort requirements are *a priori* and independent of the devices used to satisfy them obscures these facts and, in effect, prejudices coolth-provision in favor of compressor air-conditioning. But if thermal comfort has become, fundamentally, "air-conditioned" comfort, then it stands to reason that other technologies may provide their own forms of comfortable experience. It is just point that this case study illustrates. These folks not only adapted to their environment in a physical sense, by making themselves physically cooler, they adapted the *meaning* of heat and comfort to their situation by adapting their expectations for thermal comfort.

Over the past few years, at least partially as a result of concern with the environmental implications of increasing electricity demand and growing interest in less energy intensive (than compressor air-conditioning) cooling technologies, a number of researchers have conducted studies that call into question the methodological limitations and universal applicability of the current standards (for a review of this literature, see Brager et al., 1998). They are also beginning to raise concerns about some of the underlying assumptions of a purely quantitative thermal comfort standard (see, for instance, Humphreys 1998). This research supports this notion by challenging the current narrow definition of thermal comfort that underlies current

building practice[9]. In part this work supports the idea that people are adaptable to a wider range of thermal conditions than the current standards assume, and in part it provides some justification for the use of "alternative" cooling technologies and strategies—including strategies that are behavioral as well as technological, some of which may be especially suitable to transition climates or even hot, but arid, settings.

Another challenge to the Fanger approach lies in the fact that if humans prefer constant environmental conditions, then users could be expected to use them to maintain a constant temperature, making slight adjustments to the thermostat until reaching an ideal setting. Available evidence from the residential research suggests that at least some, and possibly most people do not do use thermostats the way the designers intend. Instead, some tend to treat the thermostat and fan switches in ways that create fairly large-amplitude temperature fluctuations that exceed the "comfort range" on either side (Kempton et al., 1992; Lutzenhiser 1992). It is possible that people make a rational decision to be slightly uncomfortable in order to avoid getting up to adjust the air conditioner. But another explanation is that people may tolerate a greater range of temperature than a set-point conception of comfort would allow; that people do not experience the phenomenon of discomfort until the temperature has moved toward some extreme or until something like the question "Are you too warm?" draws their attention to it.

The combined evidence provided by the current debate in thermal comfort science, the work of scientists developing alternative cooling technologies, and the experience of the respondents strongly suggest that the "need" for air-conditioning is overstated. In addition, the evidence reported here implicating the science underlying the constant-temperature requirements of building standards suggests that such standards be relaxed to accommodate alternative cooling technologies and designs.

Alternative Cooling Technologies and the Experience of Thermal Comfort

Each technology that has the potential to replace compressor air-conditioning has its own unique set of thermal and operational characteristics. Some need to be "designed in" to a new building and are largely unsuitable for retrofit. Some, like evaporative cooling, have important historical and symbolic characteristics. Some are new and unproven. Each has its own particular set of cost characteristics (Feustel et al. 1992).

Feustel has pointed out that the alternatives can be used in combination with each other as well as in combination with compressor air-conditioning to minimize cooling costs while achieving a "desired level" of thermal comfort. But combining these technologies to achieve the same kind of thermal "product" as compressor air-conditioning can be expensive and perhaps unnecessary.

Attempting to mimic compressor air-conditioning implicitly acknowledges the superiority of the dominant technology. Instead, what our case study respondents experience—and much of the other research reviewed here—suggests is that people do not necessarily need, or want, an "air-conditioned" experience; to paraphrase Blumstein (1992): they just want to be cooler when it gets too hot. The "need" for cooling is distinguishable from the "need" for air-conditioning. People can adapt both their "demand" and their "need" for cooling. People can adapt their expectations to what the alternatives can do.

[9]See, for instance, Brager and deDear 1998, Schiller 1990, Heinemeier et al. 1990

Lisa Heschong, (1979) in a provocative essay written over twenty years ago, explores the thermal experience from a different perspective than those discussed in this paper. She suggests that the thermal experience is not just sensed, but is *sensual* and can be experienced with a broad array of meanings, like touch, where cool and hot can be quite desirable; like a gourmet meal, where contrast and extremes define the experience. She compares touch and taste with thermal delight, speaking in somewhat romantic terms about the meaning of the beauty, aural delight and sweet scents as well as the thermal contrasts, extremes and complexities of an Islamic garden. The thermal environment, she suggests "has the potential for such sensuality, cultural roles, and symbolism that need not, indeed should not, be designed out of existence in the name of a thermally neutral world."

Conclusions

These examples, and the lessons we've learned from the people living without air conditioning, serve to illustrate the idea that thermal comfort is an experience composed of much more than the physical and physiological characteristics acknowledged in Fanger's research. Each different cooling technique and technology has its own particular set of social, operational, thermal, political, ethical and possibly even spiritual characteristics, both in the coolth they produce and in the technologies themselves. Certainly one possible outcome from the expanding comfort standards might be to gradually free alternative cooling technologies from the constraints of having to meet a narrow, set-point conception of comfort.

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