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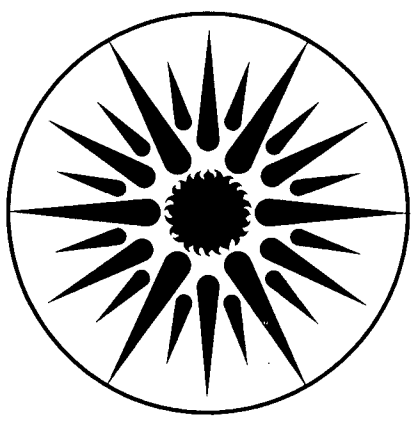

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Abstract

Two recent housing projects for the elderly --one rural, one urban-- are examined for how factors relating to design, construction, and occupancy affect energy consumption. The study focuses on this population both because the fixed-income elderly are particularly vulnerable to rising energy prices and because little is known about the energy and comfort needs of this group. The approach is interdisciplinary, drawing on the architects, housing authorities, utility companies, and the residents themselves. The goal of the project is to determine what information is needed when and by whom to provide energy-efficient housing for the elderly.

The methods used in the study include building energy modeling with the computer program CIRA; interviews with the architects, builders, and managers; measurements of indoor temperatures and outdoor weather conditions; and analysis of utility bills. Also, the author lived at one of the housing projects for two weeks, interviewing sixty residents about their use and knowledge of energy conservation as part of a general housing questionnaire.

Preliminary results from the study point out the importance of studying the context in which architects design buildings -- how they obtain, process, use, and discard information on energy. Utility data show how much gas and electricity are used, but say nothing of how this affects comfort and habitability. Because occupant behavior tends to dominate variations in energy use for these projects, studying occupant activities has been crucial to understanding the patterns of energy use.

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Energy and Housing for the Elderly:
Preliminary Observations

Introduction

Part of a larger study examining several aspects of the elderly and their housing (security, comfort, accessibility, health, activity, social contacts) this paper focuses on energy use in this population. The intent is to examine the processes of design, construction, and occupancy in housing facilities for the elderly in order to flush out hidden factors that affect energy use. In addition, some effort is made to assess the relative importance of these factors, for example, how does the architect's selection of a certain type of window later influence an elderly resident's decision to open that window?

On the basis of these findings, relevant materials will be developed for the specific use of the parties involved: for the architects, a series of design guidelines and construction specifications; for the managers, maintenance manuals; and for the residents, booklets on energy conservation for their homes. The overall goal is to determine what information is needed when and by whom in order to provide energy-efficient housing for the elderly.

Two housing projects recently constructed for the elderly, St. Mary's Gardens in Oakland and Winston Gardens in Oroville (both California) served as the case studies for this investigation. Despite the similarity in their names, these projects were selected to provide contrasting situations--in location, climate, building form, management, and residents. St. Mary's Gardens is a three-story, 100-unit complex located near the downtown section of Oakland. Completed in 1979, this facility is run by a private, non-profit organization. Winston Gardens is made up of 60 one-story cottages, arranged in clusters of up to five units, located in the rural community of Oroville, California. This project has been occupied since August 1982, and is administered by the county housing authority. Both projects offer subsidized rent under the U.S. Department of Housing and Urban Development (HUD) Section 8, which permits residents to pay a fixed percentage of their income as rent, less a predetermined utility allowance.

Because of the interdisciplinary nature of this study, the methods used are diverse:

- the architects and managers for each facility were interviewed to ascertain their energy concerns and objectives.

- utility bills were obtained for the projects and local weather data was collected.

- the computer program CIRA[1] was used to evaluate annual operating costs for typical units having different features, such as orientation, insulation, window strategies.

- individual units were pressurized with blower doors to determine their leakage areas as a way to assess construction quality.

- the author lived in one of the units for a two-week period while conducting interviews of all the residents.

This paper gives an overview of the approach, and presents some of the preliminary findings for one of the two sites, Winston Gardens.

The Actors

Central to this study is the idea that several "actors" are prominent in determining how energy is used in housing for the elderly--essentially, the residents, the architects, and the managers.[2] In addition, of course, are a number of supporting, or hidden actors--HUD, building and health code officials, city and local governments, and at some level, society in general, all of whom are involved in allocating the resources that determine the amount of heat in the room of the elderly resident. In this respect, there appears to have been a shift in attitudes in the four year interval between the construction of St. Mary's and Winston Gardens from providing decent housing to providing adequate housing.

The residents of the two projects can be classed as old and poor, yet there is a wide range in their ages and income. For the most part, all 160 residents can and do live independently. Although some require daily assistance with bathing and cooking, and others have weekly help, by and large, the residents maintain an independent lifestyle. And even though most have various physical ailments, they are a robust elderly population, compared to the fragile members of their cohort who receive institutionalized care.

The two architectural firms responsible for the projects are both well-established Bay Area firms, highly regarded by their profession. Both are known for their social concerns, and both have endeavored to include energy considerations in their work. The firm that designed St. Mary's Gardens has three partners and a small support staff. The three principal partners of Winston Gardens have a somewhat larger staff, approximately fifteen people. Both firms were extremely cooperative throughout this study, and expressed interest in any feedback that might assist them in future projects.

St. Mary's Gardens is run by a private non-profit organization that manages an additional 600 units in the city of Oakland. Winston Gardens is administered by the county housing authority, which oversees another 1000 units for the elderly and low-income residents. The directors of both projects are concerned and knowledgeable about energy conservation, and if they have not already undertaken retrofits in their housing projects, intend to do so in the next year. Again, their cooperation and assistance reflects their interest in what they regard as an area of prime concern.

Context

Energy conservation, despite being an issue of concern to the architects, is not entirely in their control. How efficient energy can ultimately be in a building must be evaluated in the context of all the design issues that compete and conflict in the course of the building process. In housing projects, where the entire design phase is completed usually in a few months, there is next to no time for research and evaluation of different energy strategies. Rather, experience, intuition, codes, and existing guidelines (such as the HUD Minimum Property Standards) determine the outcome. Construction of the projects, if HUD-financed, goes to the lowest bidder who, in the current tight market, ends up having to cut more than corners. At some point, it falls on the managers to instruct the residents on how to safely and efficiently operate the units, and to provide for their maintenance and upkeep. Finally, a confounding factor is, of course, the residents themselves, who move in with a wide variety of prior experience, and who will use the building as best suits their needs.

Preliminary Observations: Winston Gardens

Winston Gardens is located 250 km (150 mi) to the northeast of the Bay Area, in the town of Oroville (pop. 8000). The 60 units and community building are spread across a six-acre site on the edge of town (see Figure 1).

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Figure 1. Winston Gardens, Housing for the Elderly, Oroville, California.

For a HUD-financed project such as Winston Gardens, the Minimum Property Standards (MPS) determine the economic budgets. For the architect, these standards represent "the worst quality that can be acceptable to code. They're comparable to the lowest developer standard. The contractor must have submitted the minimum bid, which means every subcontractor must already be at cost. Ten years ago, there would be four to six bids per project. Today, 20 bids are common because of the extreme competition just to get work."[3]

Working within the strict limits of the MPS, the architects were still able to introduce a number of social and aesthetic elements. They also included three efforts at conserving energy: orienting the major window to the south in as many units as possible, providing exterior shading of south- and west-facing windows, and specifying an electric heat pump for heating and air conditioning (Figure 2). (The town of Oroville requires air conditioning for all housing for the elderly; here, because of the layout of the rooms, a central air conditioning/heating unit was considered most efficient.)

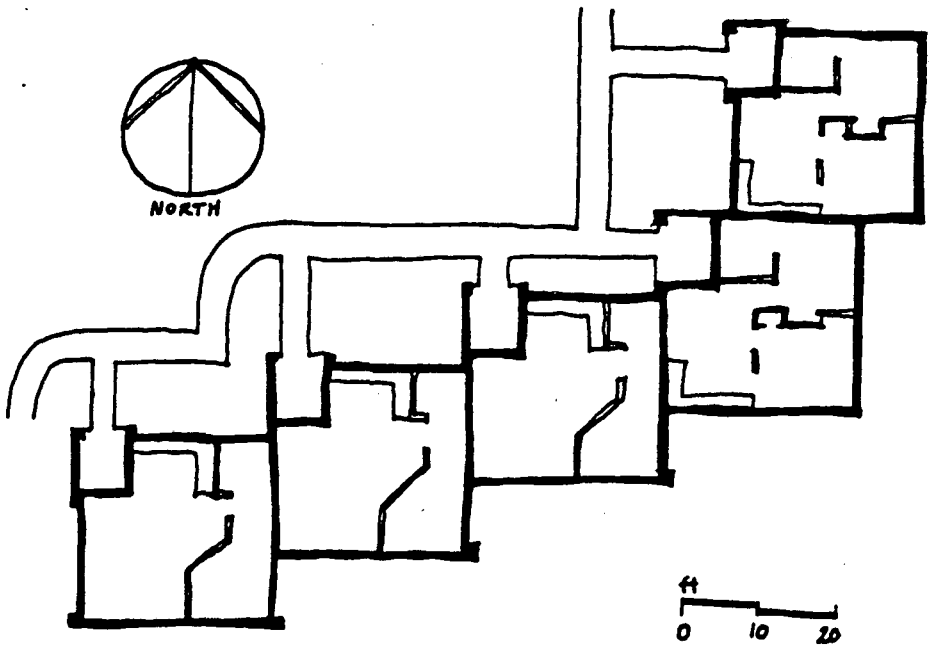

Figure 2. Winston Gardens: Unit Cluster Plan.

Winston Gardens was completed in the summer of 1982 and has been occupied for over a year. For the first month, the utility bills were unreasonably high. It turned out that the residents weren't receiving the lower lifeline rates for their electric heat pumps because the utility thought they had gas-heated units. Although the utility refunded the bills, for a period of several months there was a great deal of alarm. Even after the rates were corrected, several bills were abnormally high. The housing authority, suspecting residents of using their thermostats incorrectly, made efforts to demonstrate their correct use. Some residents, unhappy with the system, gave up entirely, and bought portable electric space heaters.

Prior to obtaining releases from the residents for copies of their individual utility bills, aggregate data were collected for the six-month heating season (November-April) for all 60 units. Starting from this measured aggregate consumption, an end-use breakdown was calculated based on the known appliance ratings. Using the energy rating given for the refrigerator model, and making a best guess for lights and other appliances, energy consumption was broken down as shown in Figure 3.

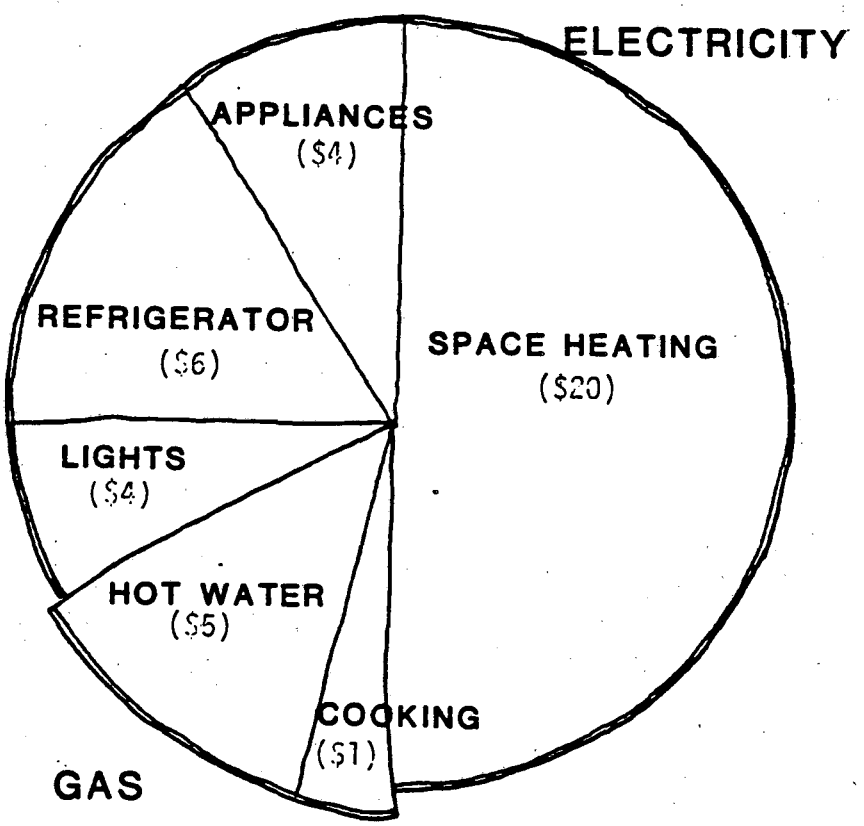

Figure 3. Monthly Energy Use Breakdown for average unit at Winston Gardens (October 1982-March 1983).

Gas use, for water heating and cooking, was surprisingly low. In this case, the breakdown was based on estimating a seven-minute shower, every other day (9.6 therms), with the remaining therms (2.6) going for cooking. With this assumption, the gas used for cooking was so low as to bring up images of people eating cold meals, eating out, or simply not eating. Subsequent interviews and inspection of the garbage dumpsters answered many of the questions about the diet and cooking practices of the residents. Part of the explanation for the low gas use was

that residents used toaster ovens and microwave ovens rather than their gas ranges. Also, it was later calculated that a pilotless gas range, using two burners for two hours a day uses only 3 therms a month.

The major energy use, nearly 50% of the bill, was in the electricity for space heating. Simply knowing the amount of energy, however, indicates nothing about the comfort and habitability of the units: are the residents comfortable, or are they living in cold rooms? Plotting the electric usage for a sample of units showed a 5-to-1 variation both in winter and in summer (Figure 4).

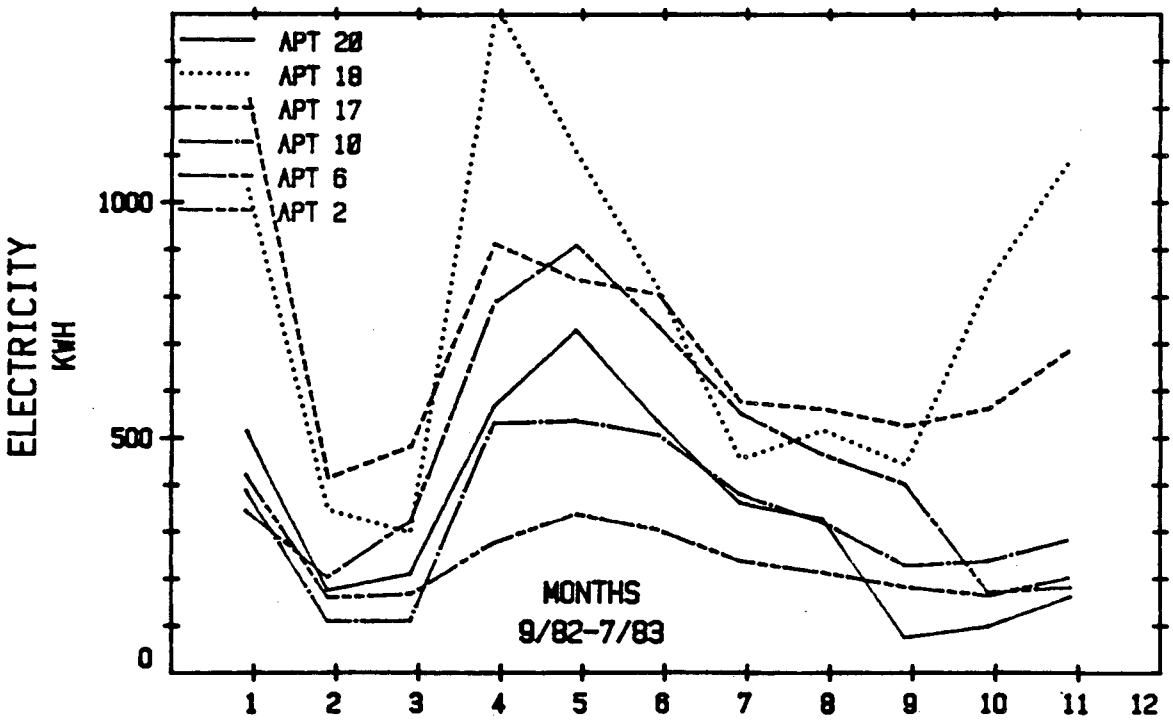

Figure 4. Electricity Usage for Sample Units at Winston Gardens.

Before attempting to analyze the reasons for variation in the utility bills, blower door measurements were made of all the units to determine whether differences in construction quality might explain the spread in energy use. During these leakage area tests, a number of construction flaws were uncovered: leaky recessed lighting fixtures, cracks in front door panels, windows not seated properly in their tracks, and lack of weatherstripping on doors leading to exterior vented water-heater closets, among others. The results of the pressurization tests showed that the units on the whole were fairly leaky--leakage areas averaged 529 cm^2 (82 in^2) [n = 27]. The low standard deviation in the measurements, 84 cm^2 (13 in^2) or 16%, suggests that differences in construction quality would not be able to account for the wide variation in energy consumption.

In August 1983, all but three of the sixty residents were interviewed with a 95-question questionnaire that asked about their previous living situation, current living habits, health, and energy-related activities. The energy questions addressed their satisfaction with the

heating and cooling systems, their knowledge of their own energy use, and their general awareness of energy conservation practices. Some of the questions were open-ended to allow for free responses. The first energy-related question, yielded the following:

What do you do when you're too cold?

- Turn up the heat [39%]
- Wear more clothes [33%]
  (usually a light sweater was mentioned)
- Watch TV [4%].

The remainder either had recently moved in, used electric blankets or heating pads, or would simply go to bed. As one woman put it: "I lie on the chesterfield, put on an afghan, and freeze." Another woman said she stayed in bed all winter because it was the only way she could stay warm. The parallel question, yielded:

What do you do when you're too hot?

- Turn on the air conditioner [69%]
- Use portable fan(s) [16%]
- Open windows [10%]
- Sit and sweat [2%].

This last response was observed to be more common than a percentage value suggests, and reasons for this are presented later. An early hypothesis was that windows were rarely opened because of residents' concern for security. When questioned, however, most felt perfectly secure having their windows open, but kept theirs closed: (1) because of the difficulty in opening a latch system that required both hands to manipulate and lift--particularly difficult for someone with arthritis and (2) because some of the outdoor sprinkler fixtures were positioned in such a way that when they automatically turned on, they would spray inside. Several residents had their air conditioners running with a window open, and expressed surprise that they were doing anything wrong. Swamp coolers, common in this area, require a window to be open while they are in use. As many of the residents had used swamp coolers previously, they operated the air conditioner in the same way. One resident, a retired mechanical engineer, who had his window open and the cooling system on,[4] was quite surprised when the return air register was pointed out to him.

When asked:

Are you satisfied with the heating system?

- yes [55%]
- no [31%]
- don't know [14%]

The primary reasons for dissatisfaction were that it was too expensive, too noisy, too slow, cycled off and on too much, often started up with a blast of cold air, and felt cold. This last comment reflects a peculiarity of heat pumps, which typically deliver heat in a range of

95-110 °F (35-43 °C), compared to gas furnaces, which deliver in a range of 120-140 °F (49-60 °C); the result is that the air supplied by a heat pump feels colder. The manager had estimated that 80% of the residents used portable space heaters, primarily for the bathroom, which has no register. Although the residents weren't asked specifically about them, six percent mentioned using space heaters.[5] Only one resident mentioned using the gas range for heating--"just for a little heat in the kitchen." One previous resident had heated extensively with the gas stove, which resulted in major condensation and mildew on the walls and the resident being asked to leave.

More residents were satisfied with the cooling cycle of the heat pump:

Are you satisfied with the cooling system?

- yes [63%]
- no [37%]

although often the people satisfied with one were dissatisfied with the other. The main reasons given for dissatisfaction with the cooling were the noise, the expense, and "the cold draft coming right down on you." This is due to the location of the registers in the ceiling (the unit is in the attic). The air flow often comes down on the sofa in the living room or the bed in the bedroom. The heat pumps, the smallest available, are still oversized for the size of the apartments, which have a floor area of 58 m^2 (628 ft^2), and this explains the problems of flow, noise, and frequent cycling. (The management is currently looking at ways to correct these problems.)

Perhaps the most significant factor in the energy puzzle is shown in Figure 5.

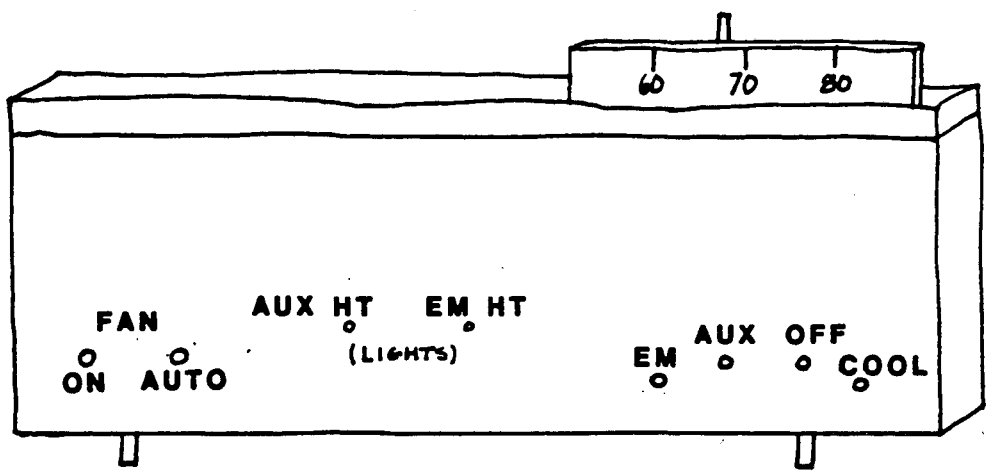

Figure 5. Thermostat Control for Heat Pump at Winston Gardens.

Thirty percent of the residents mentioned having trouble with their thermostat, but it is likely that an even higher number use it incorrectly without knowing it. The problem is one of poor control design, compounded by the typically poor eyesight of the residents. Look at Figure 5. How would you set for cooling? Set a temperature on top and move the switch on the bottom to the far right. And for heating? Ignoring the cryptic labels, "AUX" and "EM", move the switch to the far left. A green light comes on, and the room starts to heat up. "AUX" stands for auxiliary, which means the heat pump, and "EM" stands for an emergency backup, 17 kW, electric-resistance strip. (The green light is to warn you that the system is on the more expensive system.) The backup system will also go on whenever the temperature setting is moved a few degrees. Heat pumps work efficiently only when they maintain even heating. A schedule of night setback or frequent on-and-off use will run the system on the emergency backup.[6] This characteristic, combined with the user's unfamiliarity, may account for the high heating bills last winter. Figure 6 shows histograms of summer and winter thermostat settings as reported by the residents.

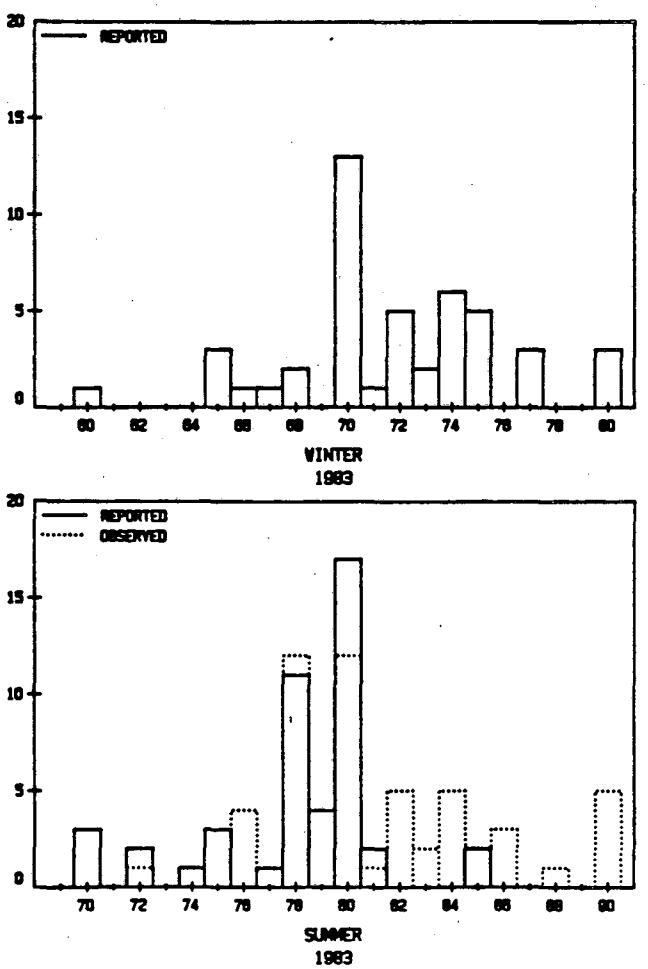

Figure 6. Thermostat Settings: Winter (reported) and Summer (reported and observed).

The summer histogram also shows the observed thermostat setting at the time of the interview. The reported winter mean thermostat setting was 71 °F (sd = 4.1) and the reported summer setting was 78 °F (sd = 4.1) with the observed setting at 81 °F (sd = 4.2). Residents may have been under-reporting the summer thermostat setting because they wanted to give the impression that they were able to keep their home at a comfortable temperature, when in fact they were sweating it out.

A number of questions were asked specifically to test the residents' knowledge of energy conservation and to assess its importance to them. When asked:

Do you have gas or electric heating?

- electric [82%]
- gas [4%]
- not sure [14%]

most answered correctly. Several mentioned that they preferred gas, and one woman offered, "I think they were running out of gas, so they had to use electricity". Most residents knew the amount of their last utility bill, and several volunteered the amount of the highest bills from the previous winter. When asked:

Do you think your energy bills are higher, lower, or about the same as the other people at Winston Gardens?

- more [18%]
- less [34%]
- about the same [18%]
- not sure [30%]

those who thought they used more energy said that they didn't understand the thermostat, or there were health reasons, or they were not conserving, or that they used the air conditioner more. Those who reported using less energy thought they were simply more conservative, more sparing in using the air conditioner, or simply didn't know.

The residents were quite accurate in knowing or guessing where energy was used in their homes. When asked what three things used the most energy, the air conditioner scored highest, followed in order by heating, the TV, the water heater, and the refrigerator. Only a few listed minor appliances or lights among the top three. As has been reported elsewhere,[7] televisions are ranked as high energy consumers apparently because of their high degree of visibility, as well as the sacrifice associated with watching less. This is particularly true of the elderly, who often spend ten hours a day or more with the television on.[8] It is also interesting that the four items ranked high (the air conditioner, heater, TV, and refrigerator) are all quite audible presences, and often the only signs of life in an otherwise quiet place. One aspect of having a noisy air conditioner outside each unit is that everyone can hear when the system is on. Residents would say of their neighbors "...they run their cooling all the time, I don't know how they can afford it," or, of one whose air conditioner was always silent, "the

poor dear, she just sits and sweats all day."

Residents gave extensive and varied ways of saving energy. While 33% had no idea how to save energy, the most frequent responses to the question, What things do you know about that someone could do to save energy? were: don't use the air conditioner so much; and be careful. The amount the residents thought they could or did save on their monthly bills ranged from 2 cents to $20. One measure cited here for its originality, was to "eat less fat--it makes the blood hot, and you have to use the air conditioner to cool yourself down". Another woman reported, "...one lady unplugs and plugs her refrigerator all the time. I know that isn't good."

One factor that emerged from the interviews was the degree to which the residents exercised control over their situation. Several mentioned never touching the thermostat: "...my son-in-law sets it for me"; or "I get the manager to move it". In many cases, these same residents never moved or adjusted their mini-venetian blinds: "I don't know how to adjust them"; "I never touch anything I don't understand"; or "I just leave them the way they are, I like 'em just fine." One woman said, "There's nothing wrong with the thermostat, only the dummy who tries to use it." Several of the residents expressed dissatisfaction with their showers. One woman had been taking baths simply because she didn't know how to work the shower, which only required a knob to be pulled up. In most of these cases, there was the willingness to do something--if only one knew what to do; afraid of doing the wrong thing, many simply lived with the problem.

When it is not a question of a technological remedy, some method needs to be devised to enable residents to better understand and control their environment. One solution might be to prepare an illustrated booklet on "living comfortably and safely at Winston Gardens". Perhaps more effective would be to have the manager, who is well-liked, call at each unit and have the resident demonstrate the use of the controls. He could then instruct the resident in the correct use, and have the tenant repeat the action several times until comfortable and familiar with it. Besides the thermostat, other demonstrations should include the pilotless gas stove and oven, the smoke alarm, the refrigerator/freezer controls, shower pull-up and head removal, the communal washer/dryer, and the venetian blinds. Tenants also need to be informed of the lifeline rates and allowances for electricity. The current life-line rate is $0.054/kWh which goes to $0.070/kWh above a summer allowance of 480 kWh/mo and a winter allowance of 1040 kWh/mo. One reason residents think they use more energy for cooling than for heating is that they have a smaller quota for summer life-line usage, and consequently, end up paying more. HUD has increased the utility allowance $17 to a total of $34, but increasing the subsidy will not solve the problem. Whatever the solution, residents should be involved in it to be sure it is responsive to their needs.

The importance of energy to the elderly at Winston Gardens is evident in several ways. For some, their energy bills are higher than their rent. They all know how much they spend for energy, often to the penny, and most know how it is being used. The turnover rate for the

first year at Winston Gardens was about 30%.[9] Although due to a number of reasons (illness and death, family relocation, or other social reasons) some of the turnover can be attributed to dissatisfaction with the heating and cooling system, both in terms of performance and its expense. Moving from one's home, often a traumatic experience, is especially so for this age group, and is usually a measure of last resort. Several residents said: "the next time I move it's going to be when they carry me out." Others intimated that they would move now if they could, because of the heating and cooling system. On the other hand, it is difficult to assess the real significance of this factor: the people who have left can't be reached, and those who say they want to move may have other reasons.

Conclusions

What this study has shown so far is that conventional energy features, such as levels of insulation, window or building orientation, and construction details are only part of the picture; the residents' understanding and control over their environment are equally important considerations. The location of a heating register and its flow rate can be more significant in determining energy use than the seasonal efficiency of the furnace. The type of thermostat installed may influence the space conditioning energy use more than the level of attic insulation. Whether a window has blinds that are easy to adjust and hardware that is easily operable may be more important than whether it is double-paned. Ideally, it should be possible to design and build taking all these considerations into account. What computer simulations and design budgets often ignore is that little details are important, and that human factors count for a great deal.

The fixed-income elderly are particularly vulnerable to rising energy prices, both because of their living at the margin to begin with, and because for many, their health is seriously affected by extremes in hot and cold, by walking on cold floors, and by exposure to drafts. As the number of elderly increase in our society, more resources will have to be allocated for maintaining comfortable, healthy, safe environments for the aged. One resident, at the end of the interview added, "we're too poor a country to waste money on a bunch of old women." Can we afford to do otherwise?

Acknowledgments

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Notes

1. CIRA is a microprocessor-based residential energy analysis program. See, Sonderegger, R.C., et al., CIRA, Lawrence Berkeley Laboratory Pub-425R, March 1982.

2. One of the first studies that looked at how the various actors in the development process affect energy use was an early report on Twin Rivers, New Jersey, by Harrison Fraker and Elizabeth Schorske, "Energy Husbandry in Housing: An Analysis of the Development Process in a Residential Community," Center for Environmental Studies Report No.5, Princeton University, NJ, December 1973.

3. Interview with the architect, June, 1983.

4. The author was equally embarrassed when, on moving into the unit and listening to the manager explain the controls for the energy-saving thermostat, spent the night hearing the system cycle continuously, only to discover in the morning that all the windows were open.

5. The rental agreement states that "no extra heaters are to be used, except those provided by the [Housing] Authority". Initially, the manager stated that no heaters would be provided, or permitted. As problems and complaints grew, the manager allowed the use of a portable heater, but only "in the bathroom".

6. For a discussion of thermostat setback with heat pumps see Ronald Benton, "Heat Pump Setback: Computer Prediction and Field Test Verification of Energy Savings with Improved Controls," ASHRAE Journal, December, 1982.

7. Kempton et al. (see bibliography)

8. A large color television on for ten hours will use 2.5 kWh/day, which is comparable to the refrigerator in these units.

9. St Mary's Gardens has had a remarkably low turnover rate of 5% a year for the last three years, almost entirely through death.

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