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and R. Ritschard

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DISCLAIMER

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THE SAN FRANCISCO PUBLIC HOUSING TENANT INCENTIVE PROGRAM: THE RESPONSE OF ELDERLY PARTICIPANTS

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EXECUTIVE SUMMARY

In 1985, the City of San Francisco initiated a tenant incentive demonstration project in public housing to stimulate energy conservation behavior among its tenants. The goals of the incentive demonstration project were to demonstrate energy savings and to measure the effectiveness of financial incentives in public housing. Two buildings for the elderly were selected to participate in the program (1880 Pine and 350 Ellis). Energy conservation workshops were held at both buildings; however, only the tenants at 1880 Pine received the incentives. We present the findings of a survey conducted among a sample of tenants at each of these buildings.

We found that elderly tenants believed they were already using a minimal amount of energy, and several barriers prevented other tenants from reducing their heating use. First, the age and physical condition of tenants prevented many of them from controlling their heat. Second, the location of furniture in apartments at Ellis Street prevented easy access to the radiator controls. Third, the design of the buildings and steam distribution systems led to overheating and poor ventilation, forcing many tenants to keep their windows open during the day and at night. And fourth, many tenants reported that their room radiators were inoperable.

Other factors were important in limiting the amount of possible energy conservation in these buildings. First, the tenants did not pay for their utilities, so they were not economically motivated to reduce their energy use. Second, for at least one-half of the tenants, energy was not an important issue, compared to other problems they were facing. Third, most of the tenants believed their personal efficacy in carrying out energy-conserving behavior was low. Fourth, monetary rewards (incentives) were not considered to be adequate incentives for people who felt they already were using minimal amounts of energy, though the money itself was greatly appreciated by the tenants. Fifth, so far, there has been very little effort in promoting the energy conservation ethic in public housing buildings at a group or community level. Tenants in these buildings must practice energy conservation by themselves without knowing the effects of their actions and others in their building. Sixth, the Housing Authority was seen by many tenants as not being responsive to tenants' complaints. And seventh, the demonstration program itself had a number of problems during its implementation.

Thus, because of the problems described above, we did not expect many elderly tenants in public housing to use less energy in response to an incentive program. Individual and social conditions prevented these tenants from responding to energy conservation programs. In fact, our preliminary analysis of energy use before and after the incentive program indicated increased gas consumption in both the control and experimental buildings.

In summary, the tenant incentive program did not work because of the circumstances surrounding the tenants and because of the design and implementation of the program. Consequently, we expect future attempts at saving energy in these kind of public housing buildings to occur at the Housing Authority level, rather than at the tenant level: for example, through further improvements to the supply and distribution of heat and to the thermal integrity of the building shell (e.g., wall insulation and reduced infiltration). If the situation were different—tenants paid for their utility bills and had control over their thermostat settings, radiators, and water heater temperatures, and if the program design was improved—then the potential for effective tenant incentive programs would be larger.

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INTRODUCTION

There is a large potential for saving energy in public housing, and public housing authorities have recently begun to address the need to contain rising energy costs through retrofit projects funded by the U.S. Department of Housing and Urban Development (HUD), utility companies, and local housing authorities (Ritschard et al., 1986). Since 1982, the City of San Francisco and its Housing Authority have participated in an energy conservation demonstration program in public housing, along with the California Energy Commission (CEC), the Pacific Gas and Electric (PG&E) Company, and third-party firms. The program first focused on the promotion of energy conservation in public housing projects through private financing arrangements. PG&E's zero-interest loan program was used to finance weatherization and lighting measures in public housing. The weatherization measures included installing attic insulation, exterior door weatherstripping, low-flow showerheads, and water heater blankets. After these retrofits were installed, annual natural gas consumption declined by 13% (after correcting for weather), and net savings relative to a comparison group were 8% (Goldman and Ritschard, 1986). The program was also found to be cost-effective, with a net present value of $399,000 or $220/unit (Ibid). In another program, third-party financing was obtained for installing solar domestic water heating and for boiler improvement and replacement in senior public housing projects. The savings in gas use (for space heat and hot water) resulting from the installation of the solar water heaters ranged from 0 to 23% (Greely et al, 1986).

In addition to developing energy conservation programs aimed at improving the thermal integrity of the building shell and efficiency of the heating system, the Housing Authority recently created a program specifically aimed at the tenants living in public housing buildings. Because tenants pay only a fraction of their utility bills, if any at all, there is very little incentive for them to conserve energy.* Accordingly, tenant incentive programs, in which tenants receive money for saving energy, have been suggested as a promising alternative for reducing energy use in apartments in public housing and, at the same time, for getting the tenants more involved in energy conservation programs. As part of their demonstration project, the City of San Francisco initiated in 1985 an incentive demonstration project in public housing to stimulate energy conservation behavior among its tenants. This approach to energy conservation in rental housing has not been

* Also, because of U.S. Department of Housing and Urban Development (HUD) policies, public housing authorities do not retain a significant portion of cost savings from their energy conservation programs (Mills et al., 1987).

documented in the literature, so that this evaluation of a tenant incentive program is the first of its kind.

THE TENANT INCENTIVE PROJECT

The goal of the incentive demonstration project was to measure the effectiveness of a financial incentive program to encourage residents of public housing to save energy.* The incentive project used an experimental design to measure the effectiveness of the incentives. Tenants in one senior building (the "experimental" group) received tenant education (workshops conducted by the local utility company and the Housing Authority) and financial incentives for tenant conservation. A second senior building (the "control" group, similar in makeup to the experimental group) received tenant education, but did not receive the tenant incentives. By comparing changes in energy consumption between the buildings, one can measure the effectiveness of the incentives, controlling for the influence of educational programs.

Project Buildings

As noted above, the buildings chosen in this study had to be similar in makeup (e.g., size of building, geographic location, building design, heating, ventilation and air-conditioning (HVAC) type, and pre-retrofit energy use). The buildings also had to provide the tenants with an opportunity to conserve energy: specifically, the tenants had to have some control over space heating and domestic hot water energy use. Out of the 20 senior public housing buildings in San Francisco, two senior buildings were selected for the incentive project: one at 350 Ellis Street and the other at 1880 Pine Street.** The former was a 11-storied building of 95 units while the latter was a 12-storied building of 126 units. Both buildings had central gas boilers with hot-water distribution systems, electric cooking, tenant associations, and similar location, building design, and pre-retrofit energy use. Tenants in both buildings did not pay for gas and electricity use. About 80% of the senior housing units were studio apartments and 20% were one-bedroom apartments, and, in general, one person occupied each unit. The tenants at Pine Street were chosen to receive the incentives (see below).

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* The incentive project targeted both "senior" and "family" housing projects; however, the evaluation presented in this paper is based only on the senior projects.

** Incentives were also given at two family buildings (Ping Yuen and Potrero), but tenants in these buildings were not surveyed and were not included in this evaluation.

Workshops

Two workshops were held at each of the selected senior buildings. The first workshop at 350 Ellis was on November 7, 1985, and the first one at 1880 Pine was on November 8, 1985. About 35 tenants attended the Ellis workshop, representing approximately 37% of all the tenants in the building; 80% of the audience was Asian. About 30 tenants attended the Pine workshop, representing approximately 24% of all the tenants in the building; 20% of the audience was Asian. A second workshop was held in April 1986 at each of the buildings to present a brief update on the program.

The workshops were organized by the tenant associations in each building, the Housing Authority, and the local utility company (PG&E).* Representatives from the Housing Authority and PG&E presented the same information at each building, except that the discussion of incentives was limited to the workshops at the Pine building. Chinese interpreters participated in the workshops to interpret for those Chinese tenants who did not understand English. The only other difference in the workshops at the buildings was that the building manager at Pine Street, in his opening remarks, was very enthusiastic about the importance of the project to the tenants.

At the workshops, the Housing Authority representative talked about the Authority's responsibility in reducing energy use in public housing, their efforts to that end, and the need for tenants to help the Authority save energy. At Pine Street, the incentive program was also discussed. The PG&E representative addressed specific actions that tenants could take to reduce energy use: not using the oven or hot plate as a source of room heat, keeping room temperatures at approximately 70 °F, lowering the thermostat or turning off the radiator before opening windows when the apartment gets too hot in the winter, turning lights off when not using them, and keeping refrigerator settings at 38 to 40 °F and freezer settings at 28 to 30 °F (or 0 to 10 °F if there is ice cream). Tenants were told not to give up things if they needed them for their comfort and/or health (e.g., a jaccuzi pump in the bathtub, or portable fans). The tenants receiving the incentives were told that the program would have no effect on their rent or social security. Tenants participating in the workshop were encouraged to talk to other people in the building who had not attended the workshop and tell them what they had heard in the workshops.

Tenants were promised two thermometers — one for the room and one for the refrigerator — so that they could monitor these temperatures. Tenants were also promised a

* The authors did not attend the 1986 workshops. The workshop discussion in the paper refers to the 1985 workshops which the authors did attend.

printed handout from PG&E, summarizing the workshop. A Chinese version of this handout was also to be made available, but, this version did not materialize. After the workshops, one thermometer was delivered to all the apartments in the two buildings so people would know their room temperatures. No thermometer was provided for the refrigerator or freezer. Tenants had to rely on the appliance dial settings which varied from a numbered 1 to 5 format to an A to D format, the meaning of which was left up to the tenants to determine. In addition, information sheets summarizing the workshop contents were distributed at key locations in the buildings, but were not given to each tenant.

Incentives

The California Energy Commission provided the funding for the incentives. Originally, the incentives were structured along the following lines: $10 a month for each apartment in January, February, and March 1986, followed by a six month period with variable monthly payments of $5, $10, or $15, depending on the change in energy-consuming behavior of the tenants (as reflected in the building's total energy use). Due to delays, the first incentive payment was not mailed until December 1986, in the form of one $30 payment for the first three months of the incentive program. A cover note (printed only in English) was sent to the tenants, with the incentive payments, explaining that the money was for their previous attempts at conserving energy. In August 1987, the second, variable payment was delivered to the tenants: $10 to each tenant at Pine Street and $5 to each tenant at Ellis Steet.

The rest of this paper contains an analysis of the incentive demonstration program as it was perceived by the tenants of the senior buildings. We discuss the methods used to collect survey data in the next section and present our survey findings and observations in the following section. We describe the results of our preliminary analysis of energy use in the next to last section. In the concluding section, we summarize our basic findings and discuss the value of our conclusions for other public housing sites and other financial incentive programs in public housing.

METHODOLOGY

We surveyed the tenants in each of the two buildings to obtain information about their energy consumption patterns, the perceived value of the financial incentives, their comprehension of the conservation program, their attitudes to energy conservation, and their sociodemogaphic profiles. For the Pine Street residents, we included a section about the effect of the incentives on their behavior. Prior to preparing the questionnaires, we visited the maintenance staff at the public housing sites to discuss energy-related problems occurring in their buildings. In addition, we attended the first workshops held at each of the two buildings and listened to the presentations by PG&E and the Housing Authority and to the concerns of the tenants participating in the workshops.

Based on the site visits and our observations at the workshops, we designed a questionnaire and pretested it at both buildings in February 1986. However, the implementation of the survey had to wait until the financial incentives had been mailed — a delay of nearly a year. Because of this delay, we decided to exclude most of the workshop-related questions since too much time had transpired for tenants to remember the workshops and remember the impact of these meetings on their behavior. We conducted a second pretest in February 1987 and revised the questionnaire for ease of comprehension. A copy of the final questionnaire is contained in the appendix.

We conducted the survey in February 1987, using three trained interviewers (one spoke Spanish, and one spoke both Mandarin and Cantonese). Person-to-person interviews, ranging from 10 to 45 minutes in length, were conducted during the day at each of the sites. We interviewed 39 tenants at each of the two sites in the two days spent at each of the buildings; none of these people participated in the pretest, and each of the tenants were from different apartments (i.e., at each site, 39 apartments were visited). We attempted to contact all of the residents and, if there was no answer, second and third attempts were made. If a time was inconvenient, an alternate time was arranged. Apartments with no response seemed to be genuinely empty at the time. We were unable to interview a number of residents for the following reasons: they were not at home or did not answer the door when the interviews called (50% of the nonrespondents), were too ill or had some physical impairment (e.g., deafness) that prevented the interview from taking place, were unable to speak English (especially Korean, Russian, and Tonkinese residents), were unwilling to participate because of special circumstances (e.g., bathing, not fully dressed, or had guests visiting), or were just not willing to be interviewed (Table 1). We do not feel that any systematic biases were introduced into the samples and, therefore, consider the samples to be random.

Table 1. Response Profiles for Tenant Survey

Response Rates and Explanations:	Pine Street	Ellis Street	Total
Completed Interview	39	39	78
	31.0%	42.0%	35.3%
No Answer	69	42	111
	54.8%	41.0%	50.2%
Ill or Physically Incapable	6	0	6
	4.7%	0.0%	2.7%
Language Problems	5	3	8
	3.9%	3.1%	3.6%
Unfavorable Circumstances	3	2	5
	2.3%	2.1%	2.3%
Refusals	4	9	13
	3.2%	9.5%	5.9%
Column	126	95	221
Total	57.0%	43.0%	100.0%
Interviewer's Judgement of Tenant's Comprehension of Program and Survey:			
Comprehends	26	19	45
	72.2%	51.4%	61.6%
Resisting	4	8	12
	11.1%	21.6%	16.4%
Can't Follow	6	10	16
	16.7%	27.0%	21.9%
Column	36	37	73
Total	49.3%	50.7%	100.0%
	Gamma	0.4	

It is important to note that interviewing in public housing requires special considerations. Tenants in both buildings were afraid of strangers, and police bulletins were posted in the buildings advising tenants not to let strangers into their apartments. Accordingly, we attempted to notify residents of the possibility of their being contacted by LBL researchers. For example, at the workshops, attendees were notified that their building would be surveyed as part of the demonstration program. Also, at a tenant association meeting at 1880 Pine, the building manager announced that LBL interviewers would be contacting residents; there was no similar announcement at Ellis Street. Interviewers presented picture identifications at each apartment, and had a letter of introduction signed by the building manager at Pine Street. Managers were available by phone to confirm to the tenants that the interviewers were legitimate.

It is also important to be aware of the possible effects of the respondent's evaluation apprehension and possible self-interest in the test situation ("test effects"). At Pine Street, the incentive payment was perceived as a significant amount of money for some tenants. They needed that money and would have done all they could to continue to get it, including responding to the questionnaire in a way that was favorable to the program.

In addition to this caution, there were other special conditions in the survey that might qualify the findings presented in this paper. Some tenants appeared to have the attitude that the interview was a device for the Housing Authority to intrude in their privacy and to obtain information that might be used against the tenants at a later date. At the beginning of the interview, the interviewer informed the tenant that the information was for a research study by the University of California and not for the Housing Authority and that the results would not be used against them by the Housing Authority. Nevertheless, some tenants were guarded in their responses, and some refused to answer a number of the questions. This response was particularly evident at Ellis Street where many tenants were not aware of the demonstration program and, therefore, were suspicious as to why the interviewers were asking questions (Table 1).

Finally, there did seem to be differences in the tenants' ability to follow the questions and comprehend the nature of the program (Table 1). This could have been due to factors associated with age, or simply low levels of education. Those at Ellis Street again seemed to be more likely not to comprehend the questions.

SURVEY RESULTS

We present the survey results in two formats: tables and pie charts. The tables contain the distributions of responses, or, where appropriate, simply the sample means. Where possible, descriptive statistics have been presented to indicate any evidence of statistically significant differences between the two buildings (1880 Pine and 350 Ellis). For dichotomous variables of the "yes/no" variety, a difference of proportions Z was calculated. This Z score is significant at the 0.05 level if Z is greater than $\pm$ 1.96. For other nominal variables, we present Chi-square (a test for independence) along with Cramer's V, or, in the case of 2 by 2 tables, Phi, both of which are statistical measures of association. We use a 0.05 level of significance for indicating statistically significant relationships. For ordinal level variables, Gamma is shown. Gammas have no significance levels associated with them, though in their interpretation, values in excess of 0.3 often indicate a strong relationship; as the value approaches 1, the degree of association approaches unity. Where the ordinal measure has an extensive range, or where the measure was at an interval level, a T-test (t) was used to statistically compare means. Along with the t value, we provide the degrees of freedom (D.F.) and the level of probability (Prob.) associated with the statistical test. Statistically significant variables had probabilities of 0.05 or less. For the pie charts, we have indicated statistical significance (at the 0.05 level) with an asterisk (*) next to the title of figure.

These statistics may be helpful in indicating the strength of certain differences, but the statistical measures should be used with caution. Given the small sample sizes and the kind of information we have, the frequency distributions presented in the accompanying tables provide important information that is not captured by descriptive statistics (e.g., mean, median, and standard deviation). Thus, if the statistics do not indicate a statistically significant relationship, then one should not infer that no real differences between the two buildings exist. In sum, one should examine the distributions of the responses in addition to the statistical measures.

SAMPLE DEMOGRAPHICS

Most of the tenants interviewed in this study were single, elderly (average age was 75 years) women who have lived in the senior buildings for approximately 8 years (Figs. 1 and 2, Table 2). The tenants interviewed come from a number of diverse ethnic backgrounds, with a strong representation from the Asian community (Fig. 3, Table 2). Those tenants who were immigrants had lived in the United States for an average of 15 years (Table 2). More than 50% of the sample had not graduated from high school;

Table 2. Demographic Information About Tenants Interviewed

	Pine Street	Ellis Street	Total
Years in Building:			
Mean	7.56	7.92	7.74
	t = -0.33	D.F.* = 76	Prob. = 0.74
Age:			
Mean	76.37	72.95	74.66
	t = 1.91	D.F.* = 76	Prob. = 0.06
Sex of Respondent:			
Male	12	11	23
	30.8%	28.2%	29.5%
Female	27	28	55
	69.2%	71.8%	70.5%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Chi-Square = 0.06	D.F.* = 1	Prob. = 1.0
	Phi = 0.03		
Marital Status of Respondent:			
Single	37	32	69
	94.9%	82.1%	88.5%
Married	2	7	9
	5.1%	17.9%	11.5%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Chi-Square = 2.0	D.F.* = 1	Prob. = 0.16
	Phi = 0.2		

* D.F. = Degrees of Freedom

Table 2 cont.: Demographic Information About Tenants Interviewed

	Pine Street	Ellis Street	Total
Ethnicity:			
Caucasian	16	12	28
	41.0%	30.8%	5.9%
Black	11	7	18
	28.2%	17.9%	23.1%
Asian	9	18	27
	23.1%	46.2%	34.6%
Hispanic	3	2	5
	7.7%	5.1%	6.4%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Chi-Square = 4.7	D.F.* = 3	Prob. = 0.20
	Cramer's V = 0.24		
Years in United States:			
Mean	19.8	16.9	18.41
Number	20	19	39
	t = 0.78	D.F.* = 37	Prob. = 0.44
Respondent's Education:			
No formal education	2	2	4
	5.3%	5.4%	5.3%
Elementary School	8	13	21
	21.1%	35.1%	28.0%
Some High School	10	9	19
	26.3%	24.3%	25.3%
High School Graduate	10	8	18
	26.3%	21.6%	24.0%
Some College	2	4	6
	5.3%	10.8%	8.0%
College Graduate	5	0	5
	13.2%	0.0%	6.7%
Advanced Degree	1	1	2
	2.6%	2.7%	2.7%
Column	38	37	75
Total	50.7%	49.3%	100.0%
	t = 1.45	D.F.* = 73	Prob. = 0.15

* D.F. = Degrees of Freedom

Figure 1. Sex of Respondents

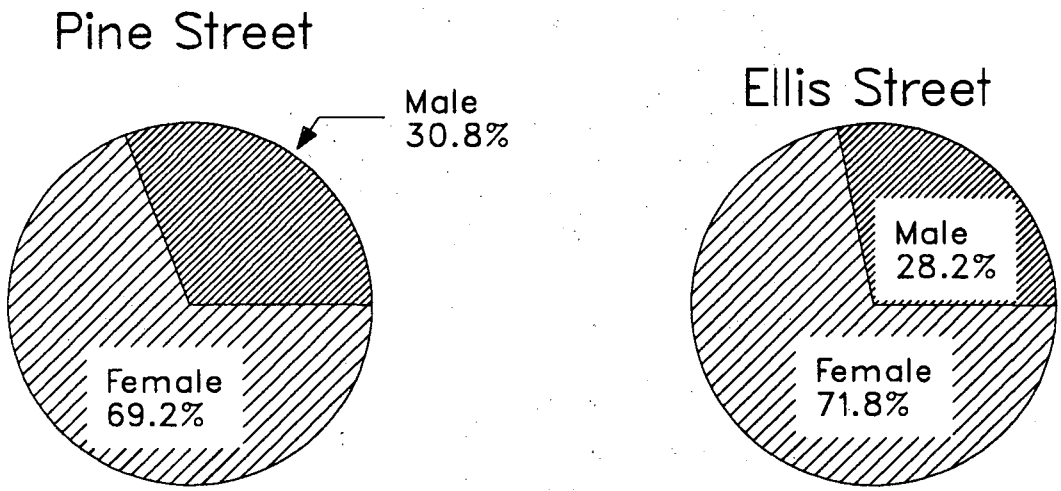


Figure 2. Marital Status of Respondents

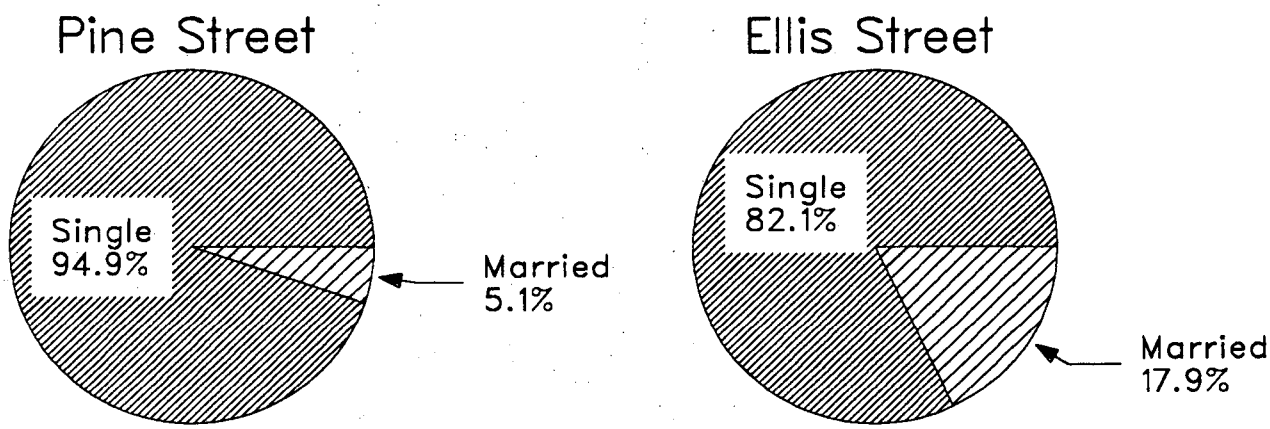
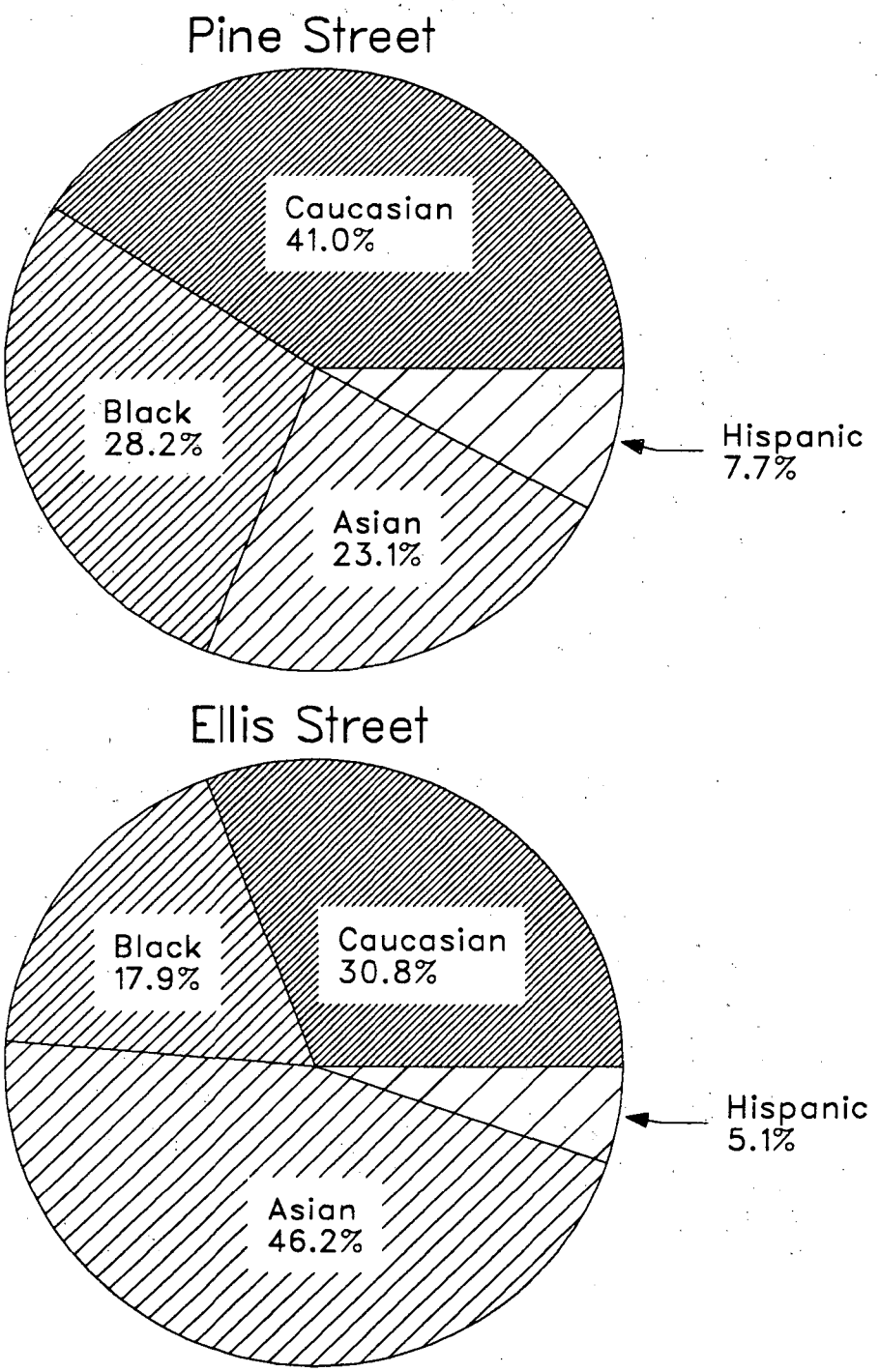


Figure 3. Ethnic Backgrounds



some respondents had no formal education, while a few had advanced degrees (Fig. 4, Table 2). Pine Street tenants were more highly educated than those at Ellis Street. The tenants in the two buildings were similar to one another in terms of sex, income (all low-income), tenancy, and years in the U.S., while the tables also suggest that there are differences in marital status, ethnicity, and education, although they were not statistically significant. Pine Street tenants were more likely to be single or widowed, more highly educated, less Asian, and more Black. The educational differences seemed to be preponderant among the Caucasians. The implications of these differences are discussed in the concluding section.

ENERGY-USE PATTERNS

Heating

One of the basic ways tenants can control the amount of energy used in their apartment is by regulating their heating system. Both buildings in the study had central heating systems, hot water distribution systems, and room radiators. The heat given off by the radiators was controlled by shutoff valves. However, these were not always reliable: for example, according to our interviewees, about 10% of their radiators did not work (Fig. 5, Table 3).* A greater percentage of radiator valves worked at Pine Street than at Ellis Street (the high Gamma indicates a strong relationship).

During our interviewing at Ellis Street, we noticed that the placement of furniture did not favor the tenant's control of their heating system: radiators were often placed along walls against which chests of drawers, beds, and side tables were located. The placement of the furniture prevented easy access to the radiator valves, so that tenants sometimes did not know whether their radiator valve worked, and, therefore, did not change it. In contrast, at Pine Street, the radiator was usually located underneath the window, an area least likely to be obstructed by furniture and, therefore, more accessible to tenant control.

We asked tenants how they normally operated their radiators during three different time periods (before the incentive program): when they were awake and at home, asleep, and away from home (Figs. 6-8, Table 3). The Pine Street tenants often used their radiator when they were home, but they usually turned their heat off when they were asleep

* We discovered broken radiator valves during our site visits at other public housing buildings. In addition, a few tenants indicated to us that their radiators were not working, even if their valves were operable, and the wall thermostats, where present, were not functioning.

Table 3. Radiator Condition and Use

	Pine Street	Ellis Street	Total
Radiator Valve Condition:			
Working	34	27	61
	87.2%	69.2%	78.2%
Don't Know	1	6	7
	2.6%	15.4%	9.0%
Not Working	4	6	10
	10.3%	15.4%	12.8%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Gamma	0.4	
Radiator Use When Awake and At Home:			
Always Closed	11	17	28
	28.2%	45.9%	36.8%
Sometimes Open	21	11	32
	53.8%	29.7%	42.1%
Always Open	7	9	16
	17.9%	24.3%	21.1%
Column	39	37	76
Total	51.3%	48.7%	100.0%
	Gamma	0.2	

Table 3 cont. Radiator Condition and Use

	Pine Street	Ellis Street	Total
Radiator Use When Asleep:			
Always Closed	28	23	51
	71.8%	62.2%	67.1%
Sometimes Closed	7	4	11
	17.9%	10.8%	14.5%
Always Open	4	10	14
	10.3%	27.0%	18.4%
Column	39	37	76
Total	51.3%	48.7%	100.0%
	Gamma	0.3	
Radiator Use When Away From Home:			
Always Closed	33	23	56
	84.6%	65.7%	75.7%
Sometimes Open	2	2	4
	5.1%	5.7%	5.4%
Always Open	4	10	14
	10.3%	28.6%	18.9%
Column	39	35	74
Total	52.7%	47.3%	100.0%
	Gamma	0.5	

Figure 4. Education of Respondents

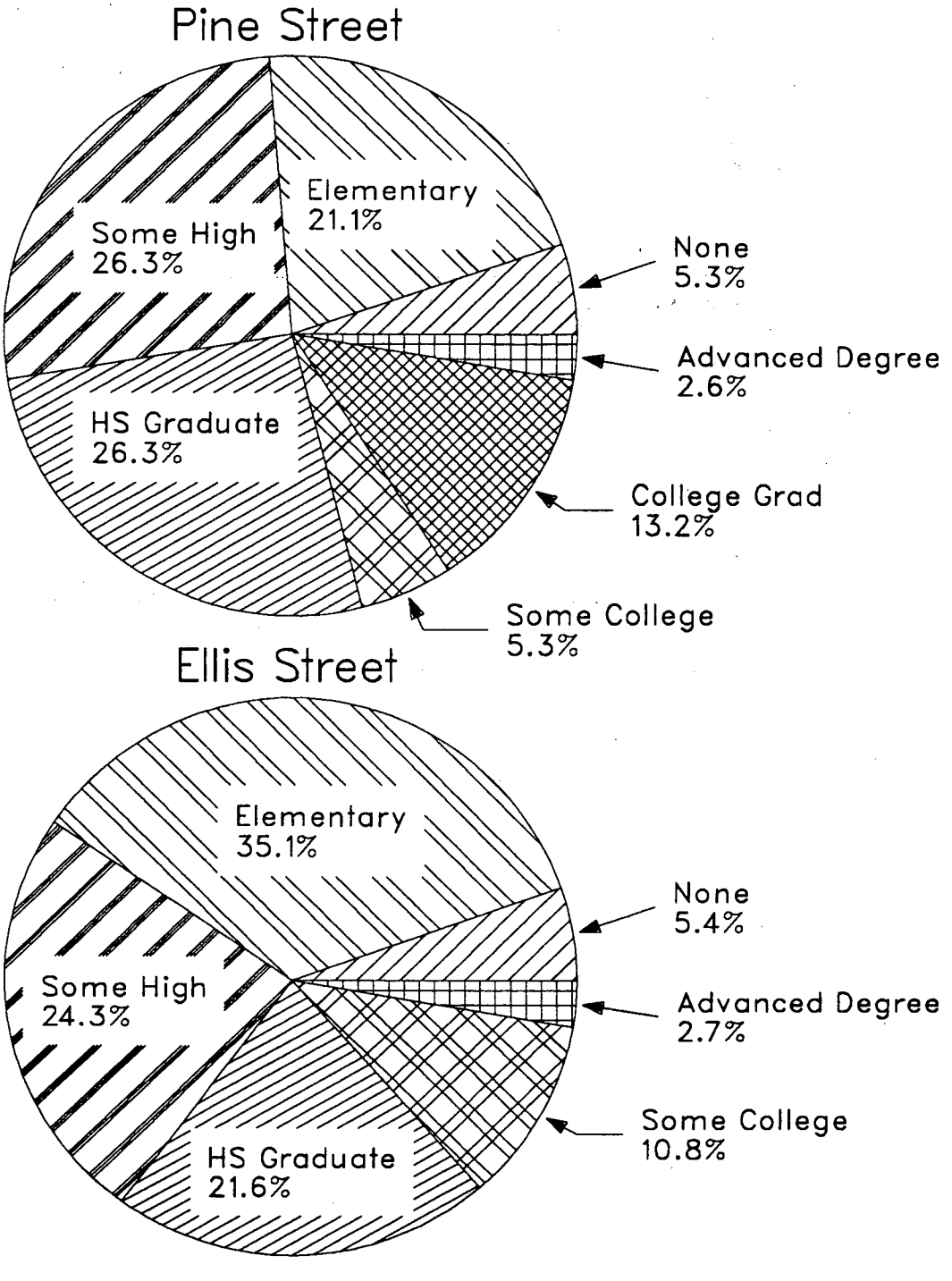
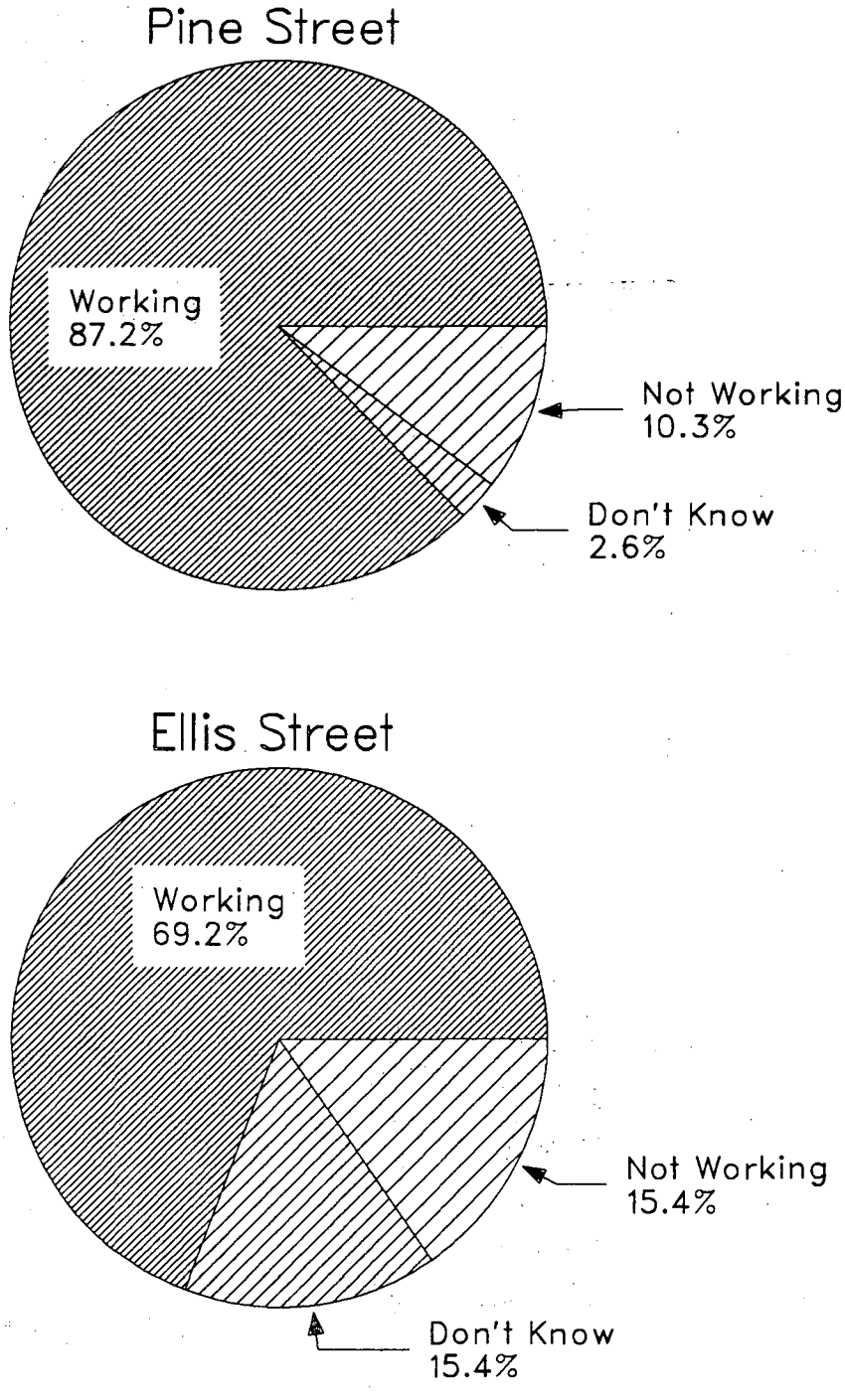


Figure 5. Radiator Valve Condition *



* Statisically significant at p = 0.05 level.

Figure 6. Radiator Use – At Home and Awake

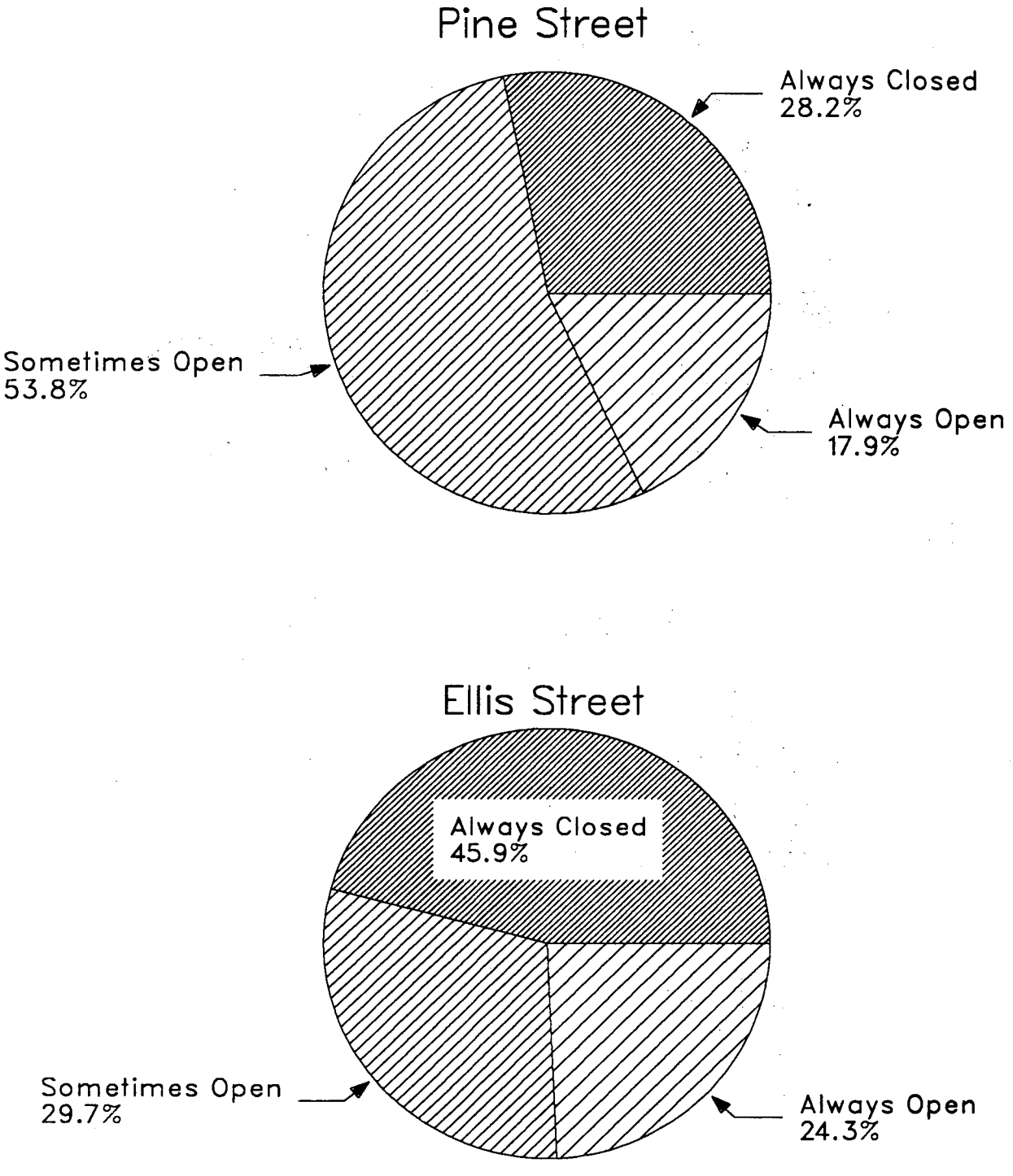


Figure 7. Radiator Use – At Home and Asleep

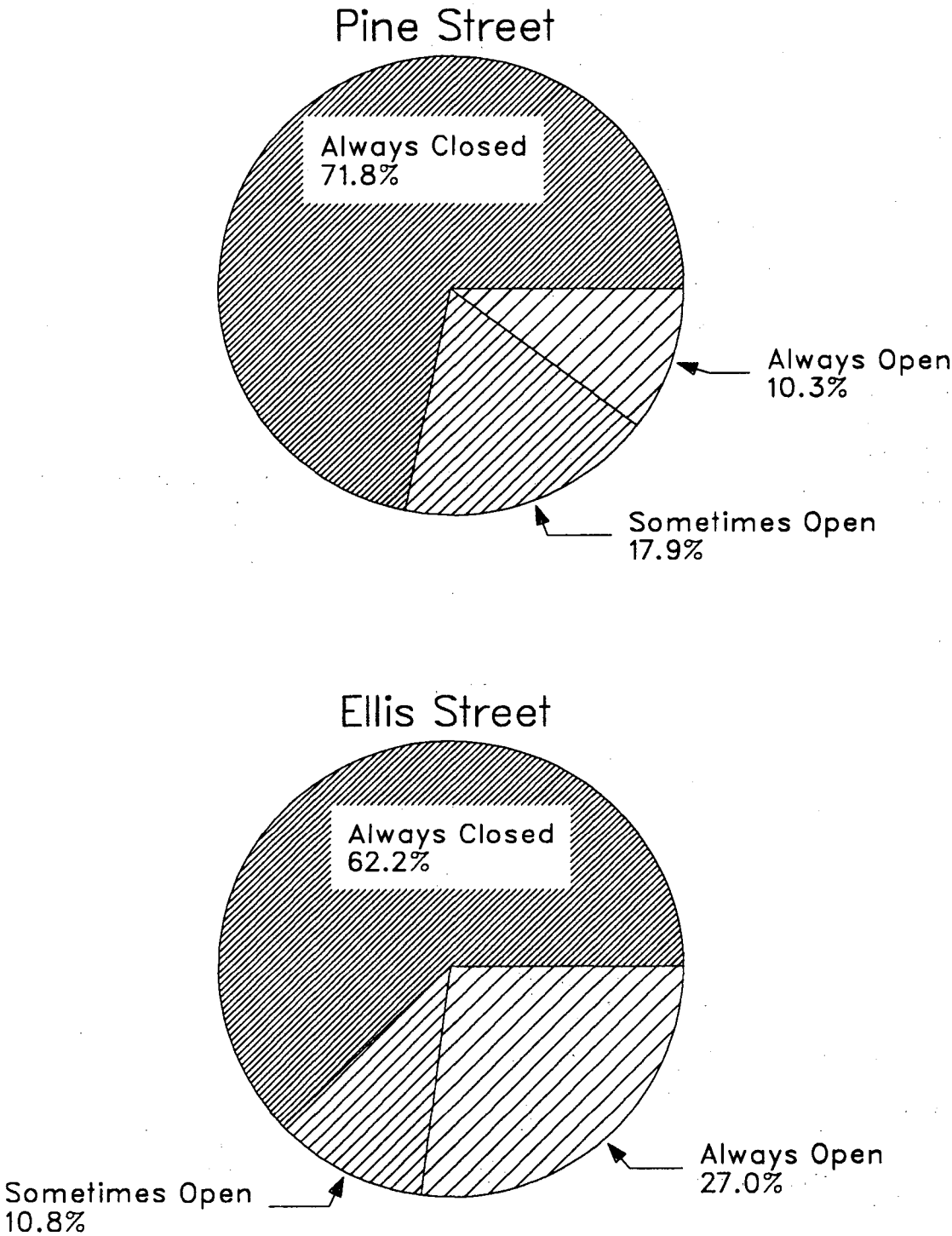
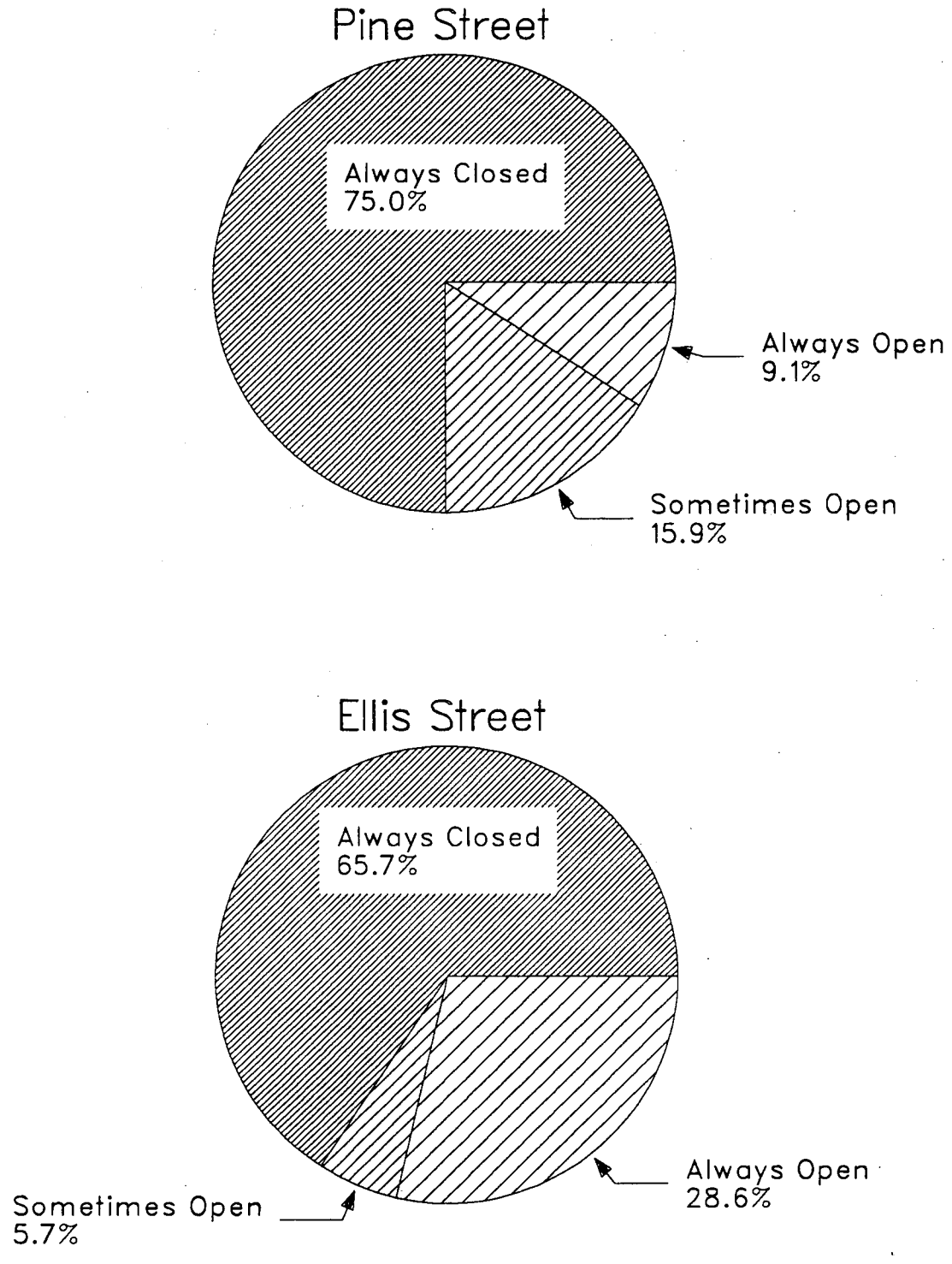


Figure 8. Radiator Use – No One at Home *



* Statistically significant at p = 0.05 level

or were away from their apartment. The tenants at Ellis Street exhibited similar behavior but with slightly different tendencies: almost half of them turned off the heat when they were at home and, compared to Pine Street tenants, three times as many (on a percentage basis) kept the heat on when they were asleep or were away from their apartment. Possibly, this was because they did not have access to the radiator valve to turn the radiator off.

During our interviewing, many of the tenants indicated that they were too old to bend over to make valve adjustments, and that the mechanics of regulating the valve were incomprehensible for them. Even if the tenants were able to regulate the radiator valve, they were often afraid to turn the valve, in case they might turn the heat off (by turning the valve in the wrong direction) or make the room too hot. Consequently, settings on the radiator valve were often not changed and were left "as the man set it." For Ellis tenants, in particular, indoor temperatures were usually regulated by opening and closing windows (see below).

During the workshops and pretests, several people (especially at Ellis Street) mentioned that they never turned on their heat because their apartments were always warm. A possible reason for overheating is that the hot water distribution systems go up the walls from the boilers in the basement to the apartments at the top floor of the building. The heat from the pipes warms the walls of the apartments, even though the radiator may be turned off. Thus, many tenants reported that they needed to cool their apartments during winter days, when their radiator was off, by opening windows.

Opening windows for ventilation is a common practice in the residential sector, and public housing is no exception (DeCicco and Kempton, 1986). During the day, more than 90% of the sample reported keeping their windows open while, at night, this percentage decreased to 66% (Figs. 9 and 10, Table 4). The two senior buildings were alike during the day, but, at night, more tenants at Ellis Street than at Pine Street kept their windows open. This difference may reflect a difference in geographical location: the Pine Street building is located at a higher elevation than the Ellis Street building and, therefore, the former may experience stronger (gustier) ocean breezes than the latter, so that windows must be closed. Also, during our interviewing, we noticed that the Ellis Street building had poor ventilation: in addition to overheating, strong chemical odors and condensation were very noticeable. Accordingly, the need for fresh and cooler air was met by opening windows.

Table 4. Window Use

	Pine Street	Ellis Street	Total
Daytime Window Use in Winter:			
Open	14	17	31
	37.8%	44.7%	41.3%
Sometimes Open	20	18	38
	54.1%	47.4%	50.7%
Closed	3	3	6
	8.1%	7.9%	8.0%
Column	37	38	75
Total	49.3%	50.7%	100.0%
	Gamma	0.1	
Nighttime Window Use in Winter:			
Open	10	19	29
	27.0%	50.0%	38.7%
Sometimes Open	11	10	21
	29.7%	26.3%	28.0%
Closed	16	9	25
	43.2%	23.7%	33.3%
Column	37	38	75
Total	49.3%	50.7%	100.0%
	Gamma	0.4	

Figure 9. Window Opened in Winter – Daytime

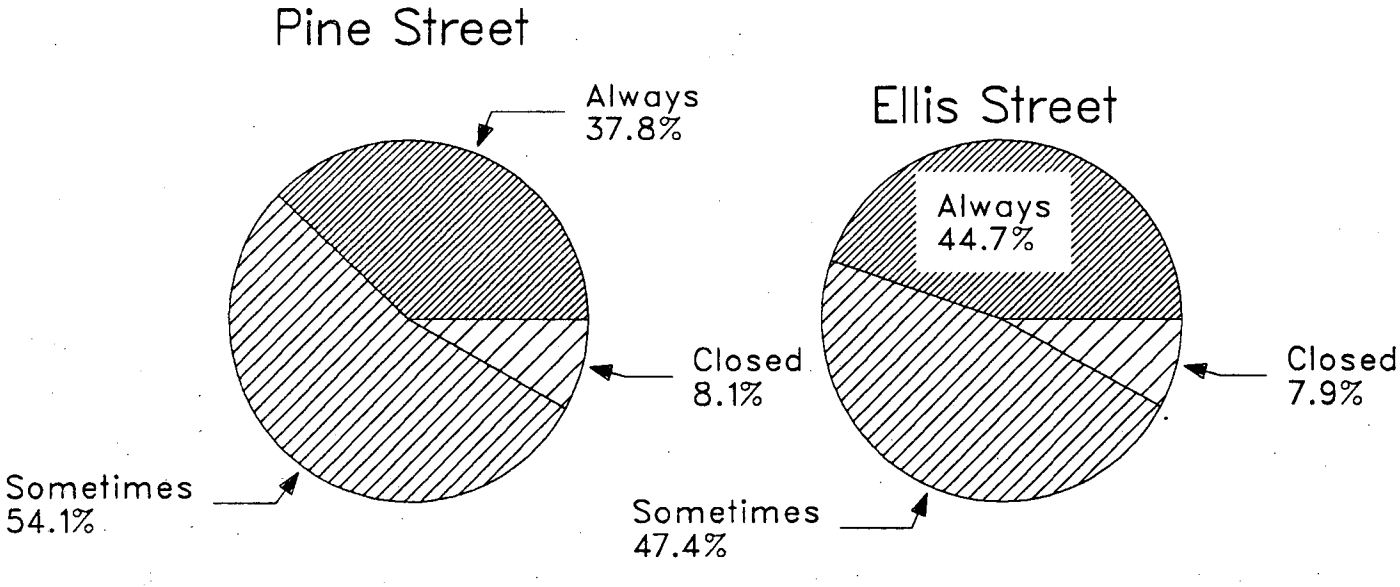
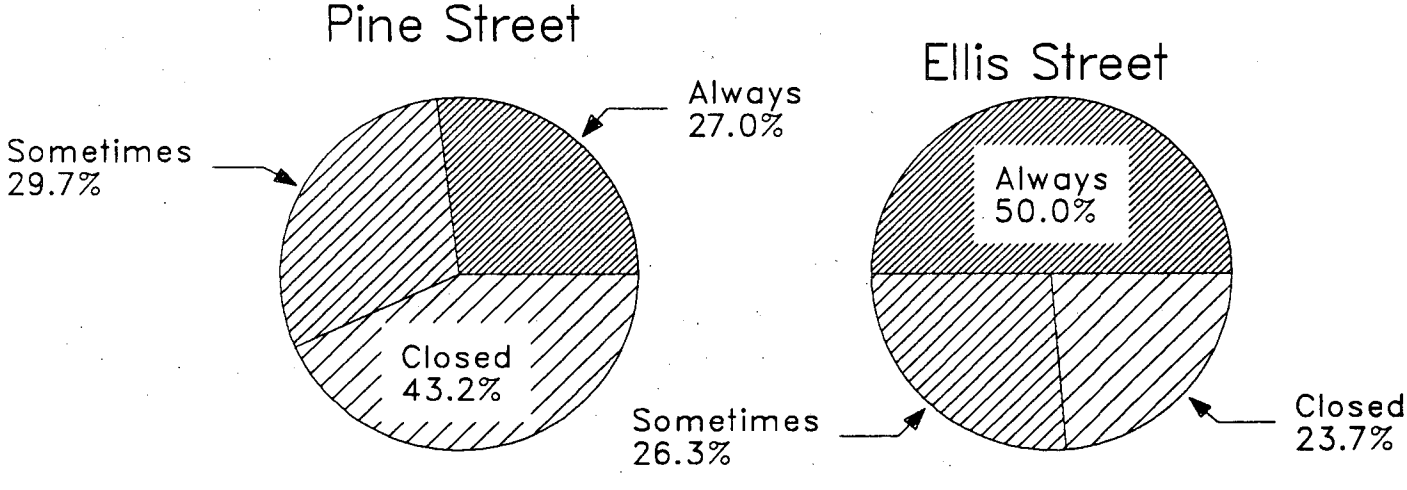


Figure 10. Window Opened in Winter – Night–time *



* Statistically significant at p = 0.05 level

Cooling

Although the primary focus of the tenant incentive demonstration program was the reduction of gas heat during the winter, we were also interested in how tenants cooled their apartments during the summer. The San Francisco climate is moderate, and hot days during the summer are infrequent, so that there are no air-conditioners in the public housing buildings. Tenants are allowed to have portable electric fans to cool their rooms, and tenants in the two buildings differed in this: over 40% of the tenants at Ellis Street used portable fans during the summer, in contrast to the 20% who used them at Pine Street (Fig. 11, Table 5). On the other hand, the Ellis tenants were less likely to use their fans as often as the tenants at Pine Street (Fig. 12, Table 5).

Water Heating

Water heating can account for a large percentage of energy use in public housing (Ritschard et al., 1986). We examined one aspect of hot water use: showering and bathing. About one-half of those that responded to this question took at least one shower a day, and about one-third took one bath a day (Figs. 13 and 14, Table 6). For showering, there were no statistical differences between the buildings; for baths, there was a statistically significant difference: bathing was a more frequent activity at Pine Street than at Ellis Street. There were some small differences in the amount of time spent showering; about one-half of those that answered showered for 5 minutes or less and the remaining 50% showered for 6 to 10 minutes (Fig. 15, Table 6). Sponge bathing was practiced by some households (Table 6), and these were mainly Ellis Street tenants. Of those who bathed daily in some form (50% showered, 25% bathed, and 25% had a sponge bath), many tenants expressed concern about the dangers of the elderly and infirm in taking a shower or bath. In particular, the building at Ellis Street contained badly designed wash areas for such elderly tenants.

Energy-related Conditions

We wanted to find out if the elderly tenants in our study had any health conditions which might affect their energy use. Based on what we observed in our interviews and on what respondents indicated, we found only 2 residents clearly having important health needs: tenants with emphysema and with high blood pressure preferred lower temperatures and good air circulation, resulting in windows being kept open all the time and the heater turned off (Fig. 16, Table 7). Another 19 tenants indicated similar conditions, particularly high blood pressure, and often connected these ailments with their preference for cool temperatures; however, it is not clear whether these health conditions had any

Table 5. Summer Fan Use

	Pine Street	Ellis Street	Total
Use Fan in Summer:			
Yes	7	16	23
	18.9%	41.0%	30.3%
No	30	23	53
	81.1%	59.0%	69.7%
Column	37	39	76
Total	48.7%	51.3%	100.0%
	Difference of Proportions		
	Z = 2.10	Prob. < .01	
Frequency of Fan Use:			
Often	4	4	8
	57.1%	25.0%	34.8%
Sometimes	3	12	15
	42.9%	75.0%	65.2%
Column	7	16	23
Total	30.4%	69.6%	100.0%
	Gamma	0.6	

Table 6. Hot Water Use

	Pine Street	Ellis Street	Total
Showers Per Day:			
0	0	1	1
	0.0%	7.1%	2.9%
.1	2	0	2
	10.0%	0.0%	5.9%
.2	1	0	1
	5.0%	0.0%	2.9%
.3	3	4	7
	15.0%	28.6%	20.6%
.5	2	3	5
	10.0%	21.4%	14.7%
1.0	12	6	18
	60.0%	42.9%	52.9%
Column	20	14	34
Total	58.8%	41.2%	100.0%
	t = 0.73	D.F.* = 32	Prob.= 0.47
Baths Per Day:			
.1	0	3	3
	0.0%	18.8%	8.6%
.2	1	1	2
	5.3%	6.3%	5.7%
.3	3	1	4
	15.8%	6.3%	11.4%
.5	8	7	15
	42.1%	43.8%	42.9%
1.0	7	4	11
	36.8%	25.0%	31.4%
Column	19	16	35
Total	54.3%	45.7%	100.0%
	t = -2.48	D.F.* = 43	Prob.= 0.02

* D.F. = Degrees of Freedom

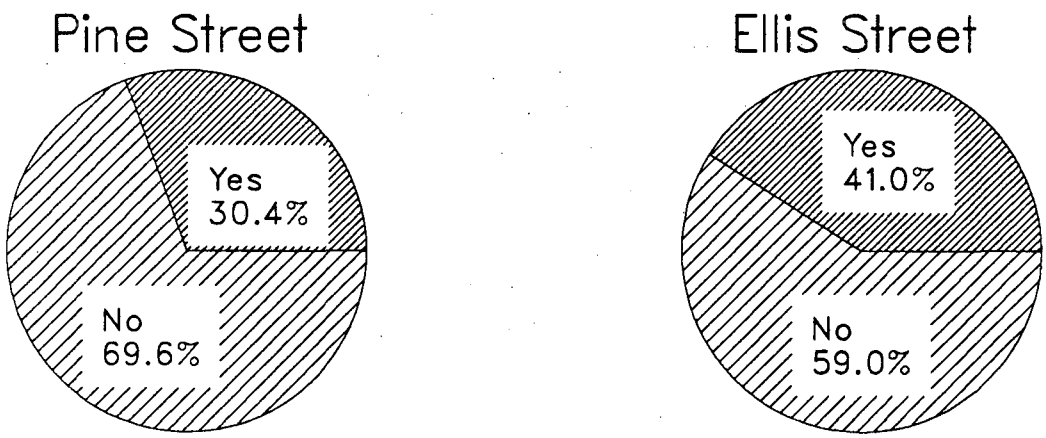
Table 6 cont. Hot Water Use

	Pine Street	Ellis Street	Total
Time Showering:			
5 mins or less.	7	6	13
	38.9%	54.5%	44.8%
6-10 mins.	10	5	15
	55.6%	45.5%	51.7%
11-15 mins	1	0	1
	5.6%	0.0%	3.4%
Column	18	11	29
Total	62.1%	37.9%	100.0%
	Gamma	0.3	
Sponge Bathing:			
Yes	1	9	10
	2.6%	23.1%	12.8%
No	38	30	68
	97.4%	76.9%	87.2%
	39	39	78
	50%	50%	100%
	Difference of Proportions		
	$Z = 2.7$	Prob. $< .01$	

Table 7. Energy-Related Conditions

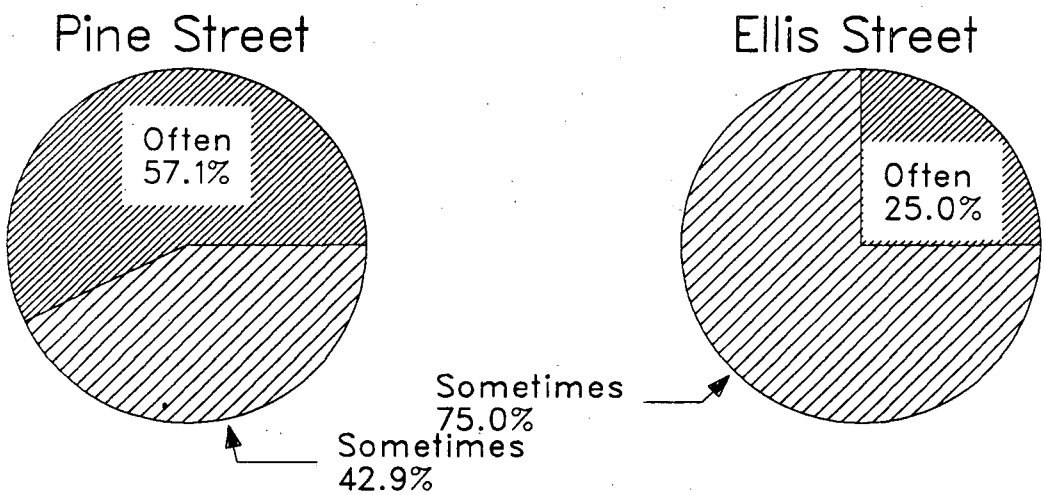
	Pine Street	Ellis Street	Total
Interviewer's Evaluation of Relevance of Health Factors:			
Irrelevant	25	26	51
	71.4%	68.4%	69.9%
May have consequences	7	12	19
	20.0%	31.6%	26.0%
Important needs	3	0	3
	8.6%	0.0%	4.1%
Column	35	38	73
Total	47.9%	52.1%	100.0%
	Gamma	0.0	
Left Unit for More Than One Week:			
Yes	11	6	17
	28.2%	15.4%	21.8%
No	28	33	61
	71.8%	84.6%	78.2%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Difference of Proportions $Z = 1.4$	Prob $> .05$	
Number of Times Left Unit:			
1	9	6	15
	81.8%	85.7%	83.3%
2	2	0	2
	18.2%	0.0%	11.1%
6	0	1	1
	0.0%	14.3%	5.6%
Column	11	7	18
Total	61.1%	38.9%	100.0%

Figure 11. Use of Fan in Summer *



* Statistically significant at p = 0.05 level

Figure 12. Frequency of Fan Use *



* Statistically significant at p = 0.05 level

Figure 13. Number of Showers Per Day

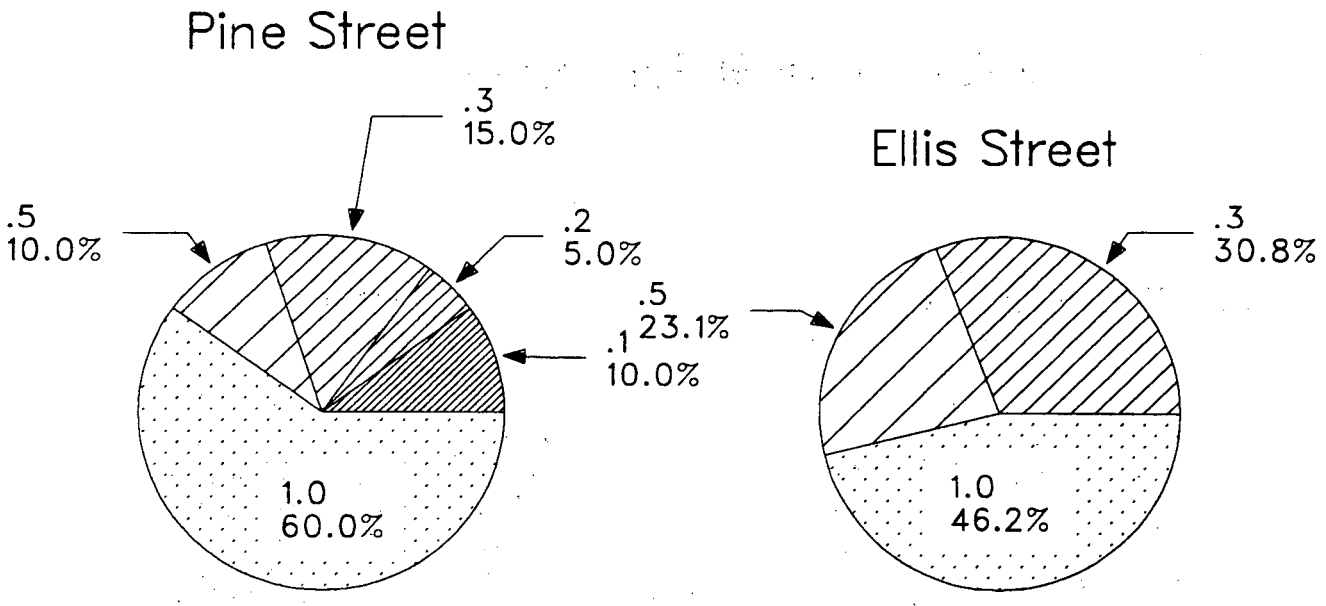
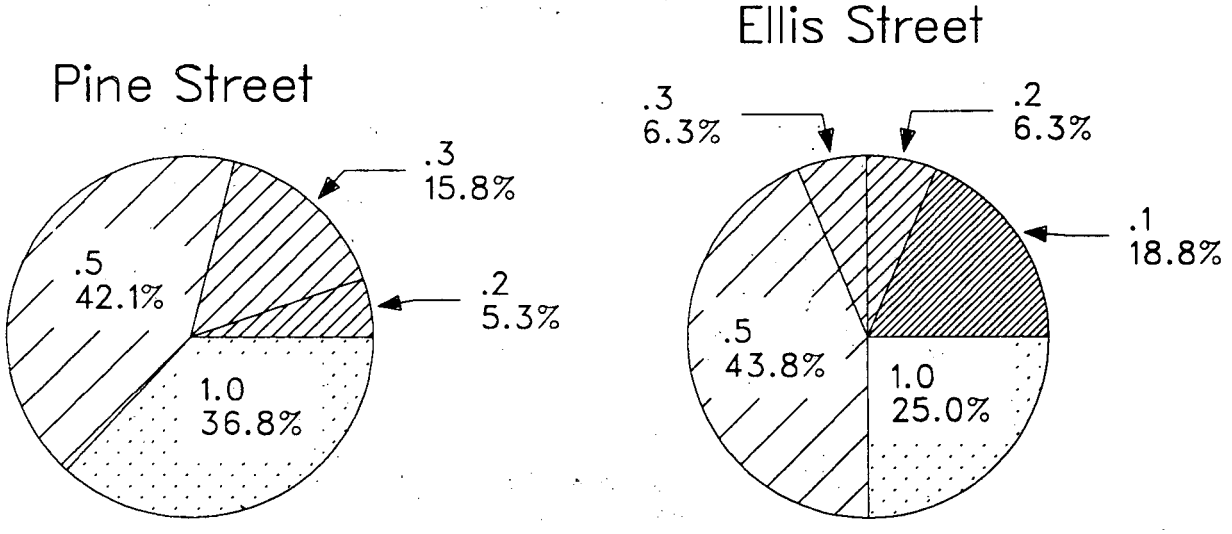


Figure 14. Number of Baths Per Day *



* Statistically significant at p = 0.05 level

Figure 15. Time Spent Showering

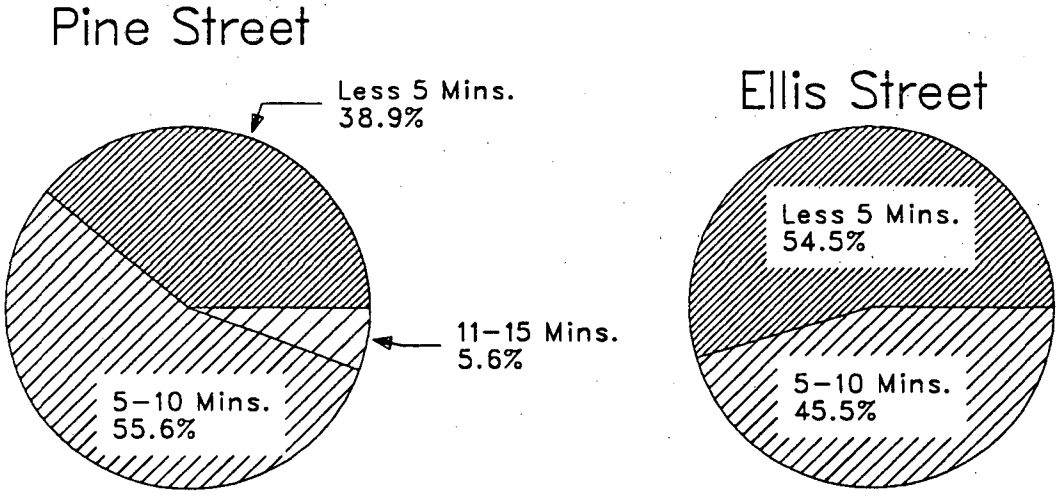


Figure 16. Relevance of Health Factors To Energy Usage

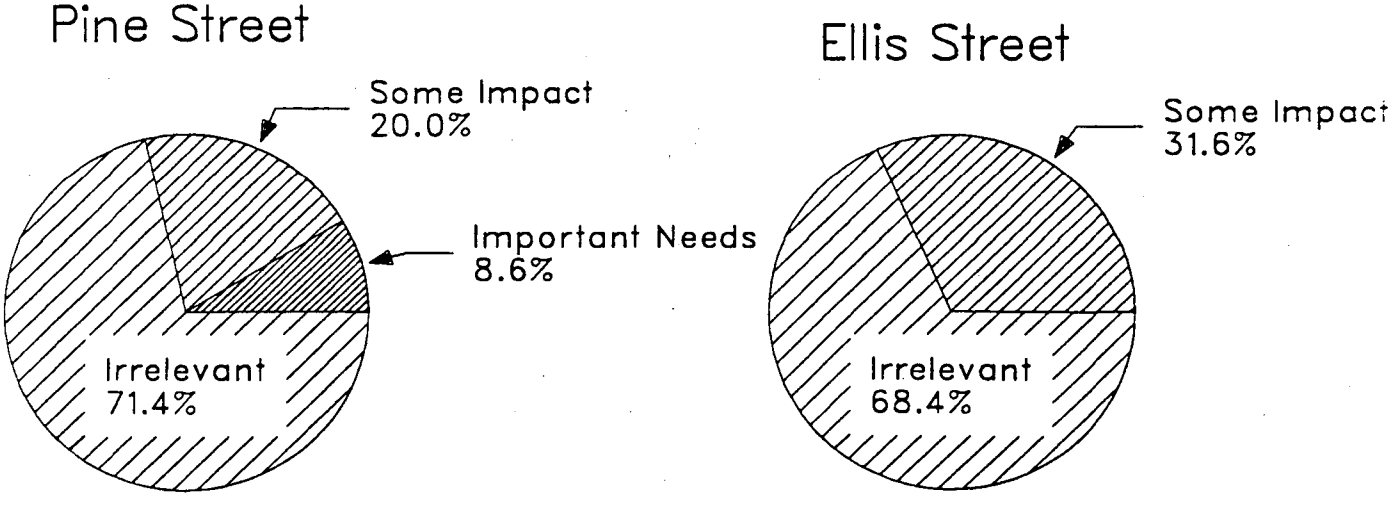
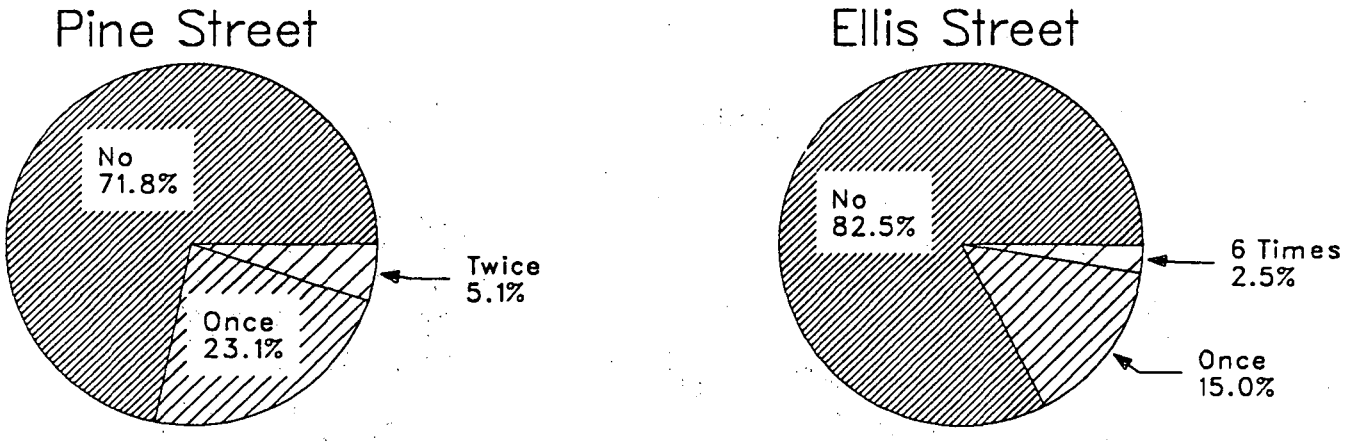


Figure 17. Unit Left Vacant More Than One Week



special impact on their behavior.

We were also interested in the amount of time these tenants were away from their apartments, in order to adjust for the building's energy usage. We found that a larger percentage of tenants at Pine Street left their apartments for more than one week per year than did Ellis Street tenants (Fig. 17, Table 7). The differences were not statistically significant between the buildings.

ATTITUDES

We asked a few questions about tenants' attitudes towards the energy problem and energy conservation, personal comfort, and, for those receiving incentives, their understanding of and reaction to the incentive demonstration program. Most tenants felt they were already using a minimal amount of energy and/or did not think they could save more energy ("unable to save") (Fig. 18, Table 8). These people thought that any reductions in energy use would result in a negative impact on necessary services (e.g., cooking, heating, and lighting). Only 24% of the Pine Street tenants and 5% of the Ellis Street tenants felt they were able to save energy in their apartment. In addition, we found a statistically significant difference between the two buildings: more Ellis Street tenants (95%) believed they were already using a minimal amount of energy, compared to 77% at Pine Street.

The tenants were almost evenly divided about the relative importance of energy compared to other problems: 42% believed energy to be an important problem while 47% thought it wasn't (Fig. 19, Table 8). There were some differences at the building sites: 50% of the Pine Street sample believed energy to be an important problem while only 33% of the Ellis Street sample felt so. Only about one-third of all the tenants believed that their individual energy-conserving efforts would affect their building's energy consumption (Fig. 20, Table 8). About 50% of the tenants did not know what effect their efforts would have, and about 14% did not think their efforts would have any effect (21% at Pine Street and 8% at Ellis Street). Most tenants (75%) did not know whether other tenants in the building were saving energy (Fig. 21, Table 8). However, of the few who did express an opinion, more tenants at Pine Street thought the other tenants in their building were saving energy compared to the tenants at Ellis Street.

Most of the tenants reported that they were comfortable in their apartment during the winter, but less comfortable during the summer (Figs. 22 and 23, Table 8). Except for those apartments where overheating was a problem, most tenants were able to control their comfort levels by the use of radiators and window opening and closing. On the other hand, some tenants may have been reluctant to voice any complaints about their

Table 8. Tenant Attitudes Concerning Energy and Program

	Pine Street	Ellis Street	Total
Belief That Tenant Is Able To Save More Energy:			
Able to Save	9	2	11
	23.1%	5.1%	14.1%
Already Using Minimal Amount	30	37	67
	76.9%	94.9%	85.9%
Refuse to save more	0	0	0
	0%	0%	0%
Column	39	39	78
Total	50.0%	50.0%	100.0%
	Difference of Proportions $Z = 2.3$	Prob. $< .01$	
Energy Is Important Compared To Other Problems:			
Yes	19	13	32
	50.0%	33.3%	41.6%
Don't Know	4	5	9
	10.5%	12.8%	11.7%
No	15	21	36
	39.5%	53.8%	46.8%
Column	38	39	77
Total	49.4%	50.6%	100.0%
	Gamma	0.3	
Individual Efforts Will Affect Building Consumption:			
Yes	14	15	29
	36.8%	38.5%	37.7%
Don't Know	16	21	37
	42.1%	53.8%	48.1%
No	8	3	11
	21.1%	7.7%	14.3%
Column	38	39	77
Total	49.4%	50.6%	100.0%
	Gamma	0.2	

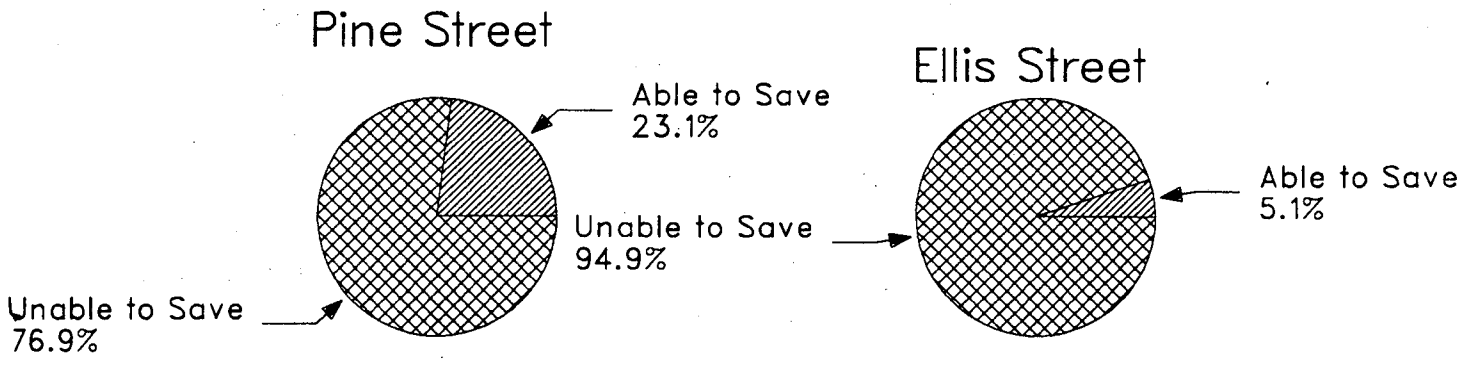
Table 8 cont. Tenant Attitudes Concerning Energy and Program

	Pine Street	Ellis Street	Total
Belief That Others Are Saving Energy:			
Yes	6	1	7
	15.8%	2.6%	9.1%
Don't Know	28	30	58
	73.7%	76.9%	75.3%
No	4	8	12
	10.5%	20.5%	15.6%
Column Total	38	39	77
	49.4%	50.6%	100.0%
	Gamma	0.5	
Apartment Is Too Cold In Winter:			
Yes	9	11	20
	23.7%	28.2%	26.0%
No	29	28	57
	76.3%	71.8%	74.0%
Column Total	38	39	77
	49.4%	50.6%	100.0%
	Difference of Proportions $Z = 0.45$	Prob. $> .05$	
Apartment Is Too Warm In Summer:			
Yes	22	27	49
	57.9%	69.2%	63.6%
No	16	12	28
	42.1%	30.8%	36.4%
Column Total	38	39	77
	49.4%	50.6%	100.0%
	Difference of Proportions $Z = 1.03$	Prob. $> .05$	

Table 8 cont. Tenant Attitudes Concerning Energy and Program

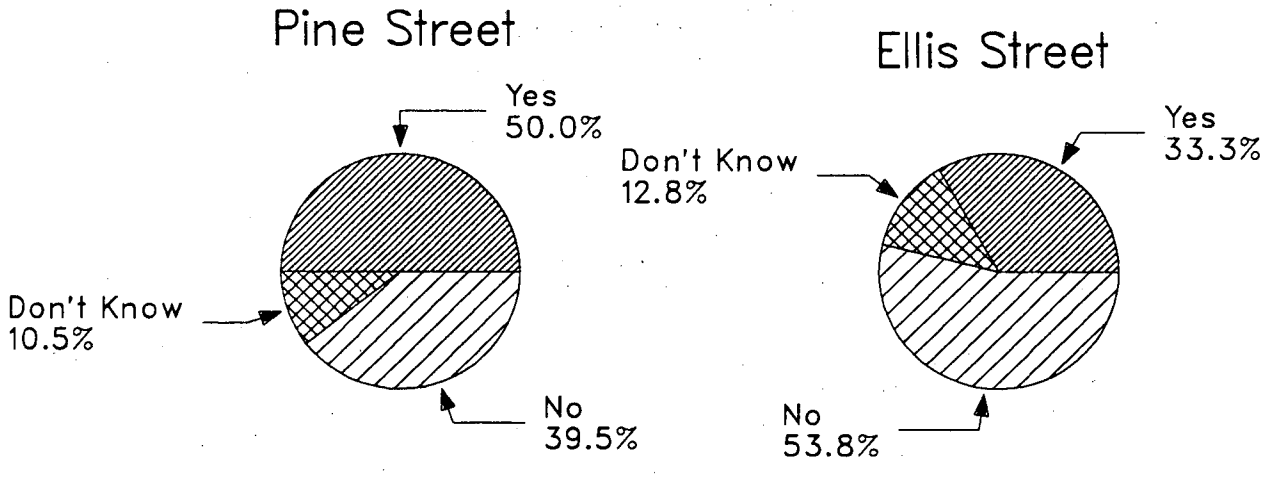
	Pine Street
Willingness To Save In Order To Get Money From Housing Authority:	Those who received payment
Agree	17 65.4%
Neutral	2 7.7%
Disagree	4 15.4%
Don't know	3 11.5%
	26 100.0%
Belief That Tenants Have Come Together To Save Energy In Order To Get Money Payments:	
Agree	11 42.3%
Neutral	3 11.5%
Disagree	3 11.5%
Don't know	9 34.6%
	26 100.0%

Figure 18. Attitudes – Belief that Responent Can Save More Energy*



* Statistically Significant at p = 0.05 level

Figure 19. Attitudes – Energy Considered Important *



* Statistically significant at p = 0.05 level

Figure 20. Attitudes – Individual Effort will Affect Building Energy Consumption

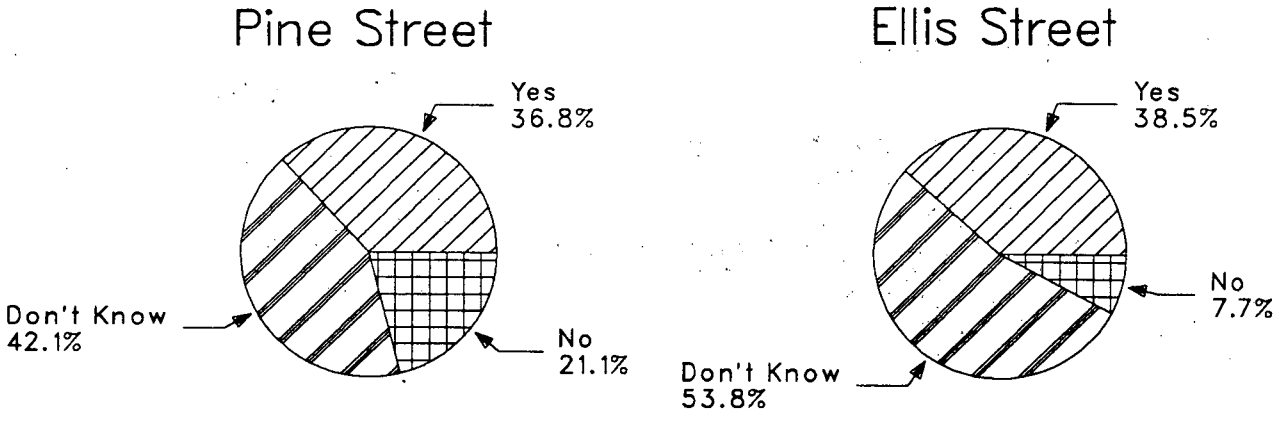
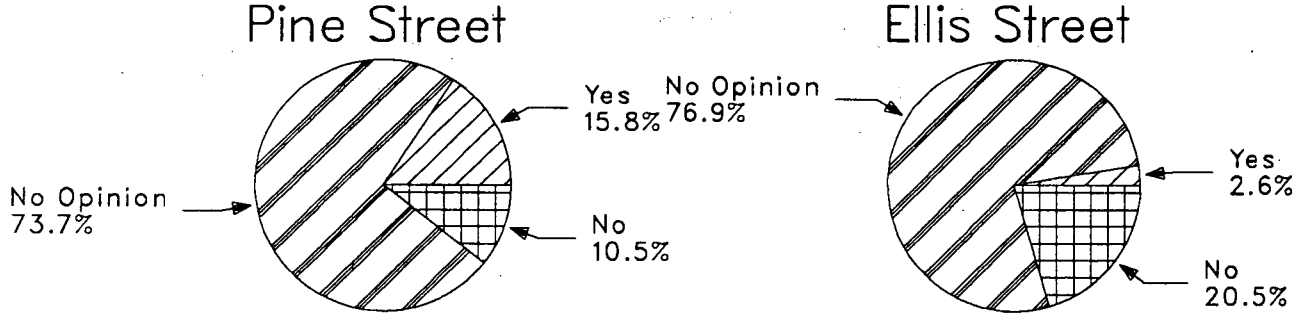


Figure 21. Attitudes – Belief that Others Are Saving Energy *



* Statistically significant at p = 0.05 level

Figure 22. Thermal Comfort: Apartment Too Cold in Winter

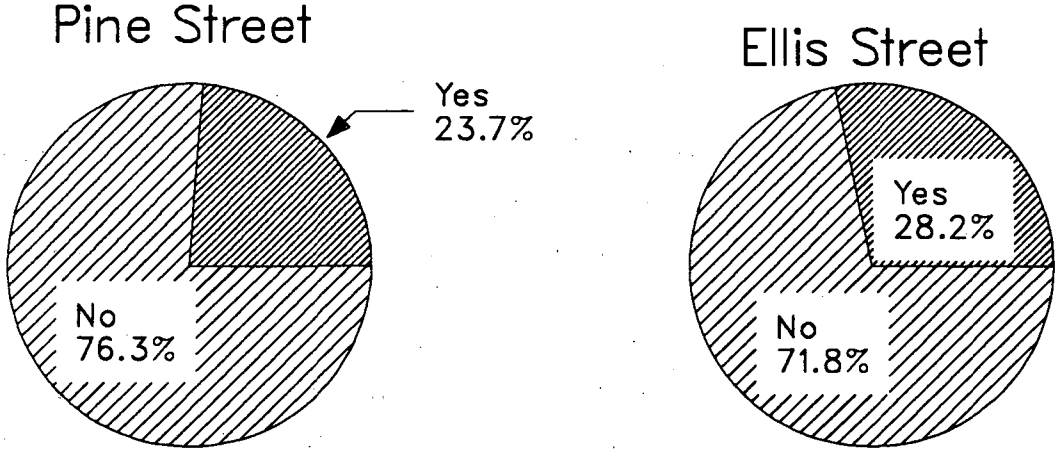
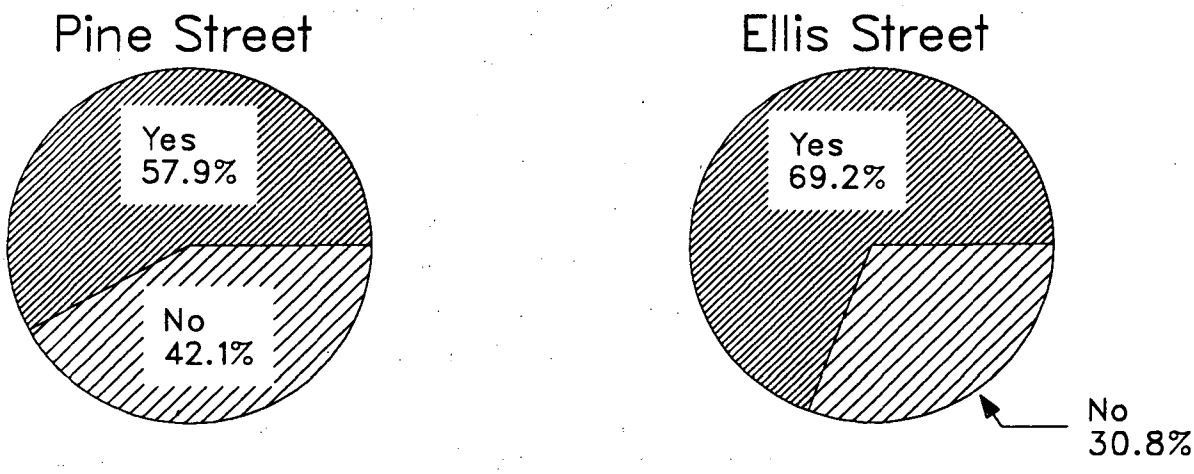


Figure 23. Thermal Comfort: Apartment Too Hot in Summer



personal comfort, either because of cultural values (see conclusions) or fear of being evicted from their apartment.

For the Pine Street residents, 65% were willing to save energy in order to get money from the Housing Authority (Fig. 24, Table 8). There was some agreement in indicating that tenants in the building have come together to save energy in order to get the incentives, but almost a third of the tenants did not know and, therefore, did not express an opinion (Fig. 25, Table 8).

INCENTIVES

We asked a few questions about incentives for those tenants receiving money (the Pine Street residents). Only 66% remembered receiving a check in the mail; 21% reported that they had not received a check, and 13% could not remember (Fig. 26, Table 9).* Most (85%) of those who remembered receiving a check reported receiving the correct amount ($30) (Fig. 27, Table 9). Those tenants who remembered receiving checks in the mail were equally divided in knowing the purpose of the incentives: 42% connected the check with the general concept of energy conservation, while 46% knew specifically that the check was for their efforts in reducing energy use in their buildings as part of the Housing Authority's demonstration program (Fig. 28, Table 9). In summary, about one-third of the Pine Street sample clearly understood the intent and nature of the project.

Approximately one-half of the Pine Street sample believed the incentives would change people's energy-conserving behavior; however, many (42%) did not know what effect the incentives would have on their behavior (Fig. 29, Table 9). Moreover, only 14% felt that the incentives changed their own behavior (Fig. 30, Table 9). Most (83%) of Pine Street tenants felt that comfort and energy savings were compatible, so that other reasons prevented tenants from saving energy (Fig. 31, Table 9).

Originally, we had wanted to include a number of questions pertaining to the incentives, particularly open-ended questions, to encourage tenant feedback as to how to make the incentive program work more effectively. However, as the results indicate, many of the tenants simply did not understand the nature of the program, so follow-up, detailed questions would have been in vain. Also, during our interviews, we found that many of

* In a follow-up phone call, the Housing Authority agreed that not everyone at Pine Street received a check for the following reasons: there were some new tenants in the building, a husband may have died and the wife did not receive the check that was mailed to her husband, or someone was divorced and the spouse would not cosign the check.

Table 9. Pine Street Incentive Program

	Frequency
Received Payment:	
Yes	26
	65.8%
No	8
	21.1%
Don't know	5
	13.2%
	39
	100.0%
Remembered Amount Received:	
$20.00	1
	3.8%
$30.00	22
	84.6%
$35.00	1
	3.8%
$50.00	1
	3.8%
Don't know	1
	3.8%
	26
	100.0%
Knew Why They Received Money:	
General Sense Connected With Energy Conservation	11
	42.3%
Knew Specifically	12
	46.2%
Don't Know	3
	11.5%
	26
	100%

Table 9 cont. Pine Street Incentive Program

	Frequency
Expectation That Incentives Will Induce Tenants To Save Energy:	
Yes	14
	53.8%
No	1
	3.8%
Don't know	11
	42.3%
	26
	100.0%
Whether Respondent Has Changed Behavior As A Result Of The Program:	
Yes	3
	14.3%
No	18
	85.7%
	21
	100.0%
Compatibility Of Comfort And Savings:	
Yes	19
	82.6%
No	4
	17.4%
	23
	100.0%

Figure 24. Incentives – Willingness to Save

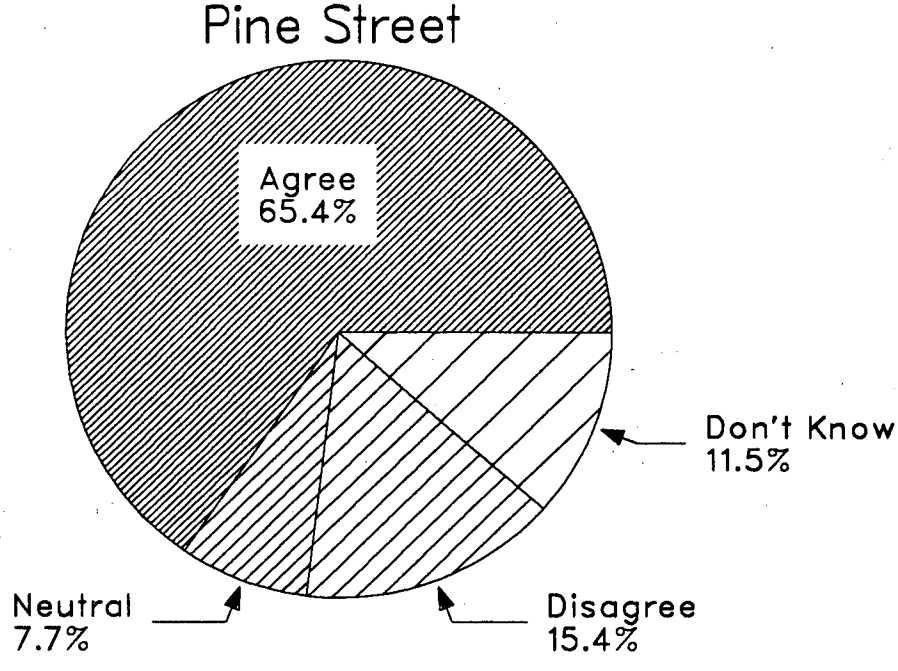


Figure 25. Incentives – Tenants Acting Cooperatively to Save

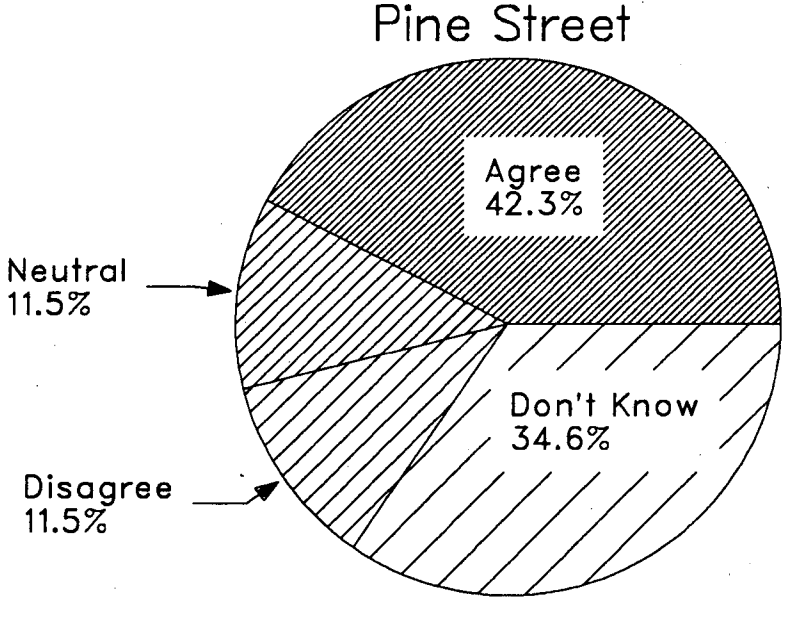


Figure 26. Incentives – Those Receiving Payments

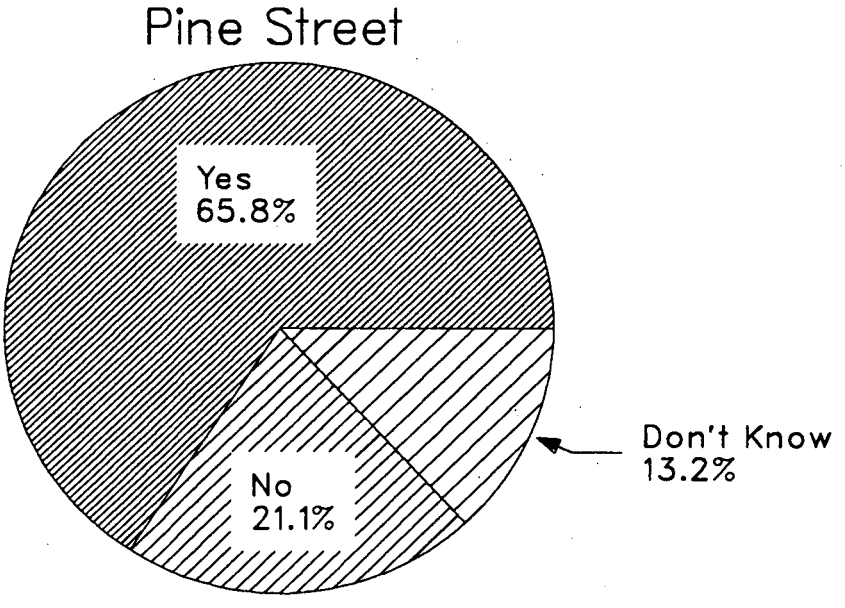


Figure 27. Incentives – Amount Remembered Received

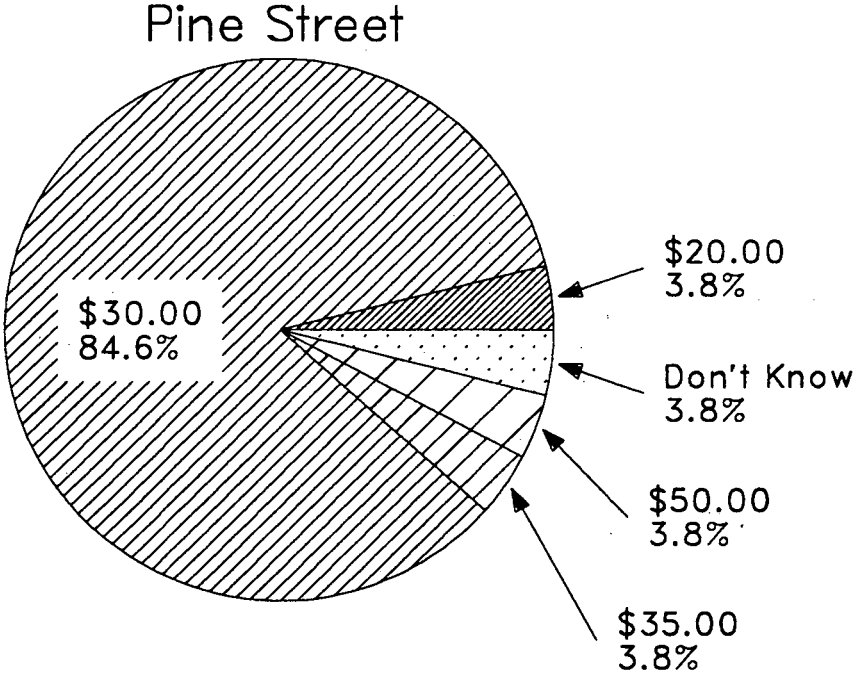


Figure 28. Incentives – Know Why Money Received

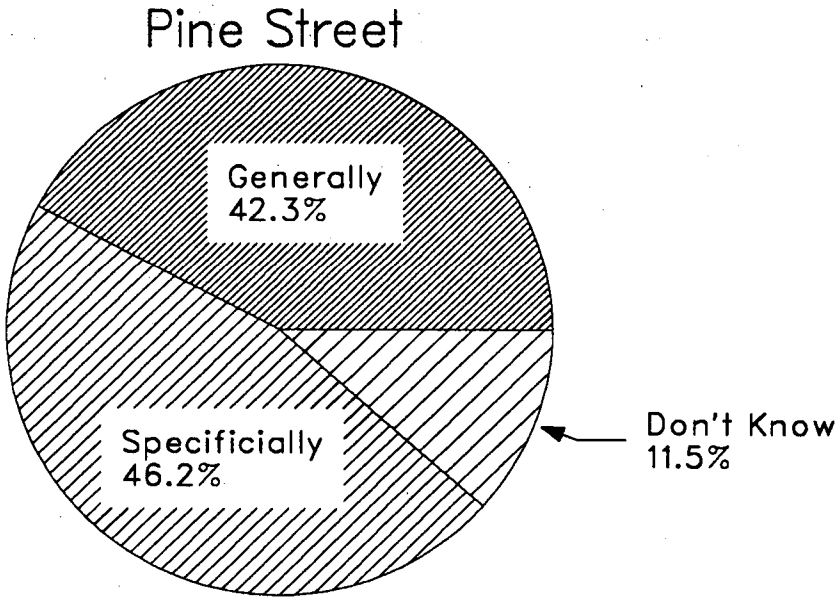


Figure 29. Incentives – Expectation That Incentives Will Induce Tenant to Save Energy

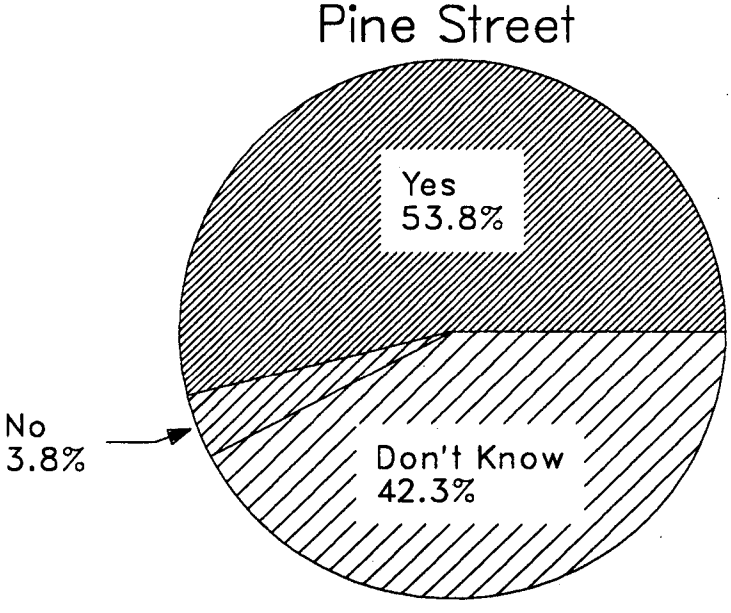


Figure 30. Incentives – Changed Respondent's Behavior

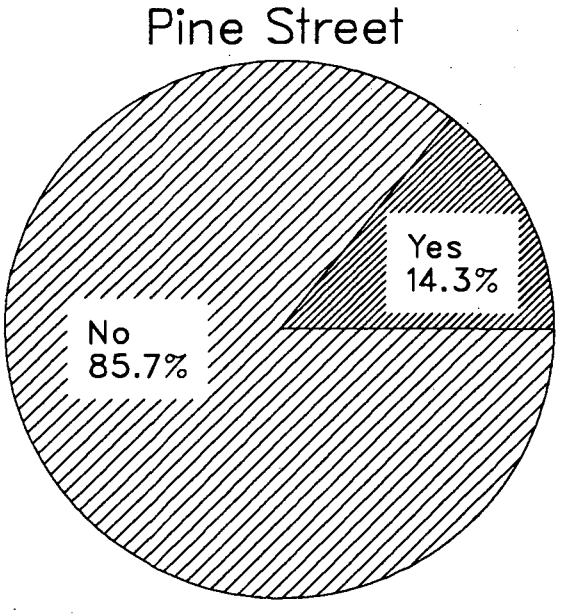
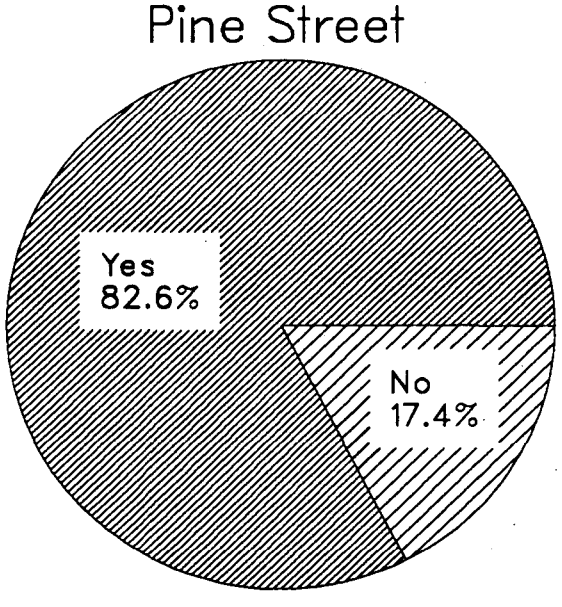


Figure 31. Incentives – Comfort and Savings Compatible



the tenants assumed they were receiving the money as a result of their past conserving behavior, not as part of an experiment to see if their behavior would change with the promise of future monetary rewards. The Housing Authority attached to the check a cover note explaining that the money was not only for past energy conservation but for encouraging future energy conservation. This message, however, was not clearly presented in that note. Also, the note was printed only in English, so that those tenants unable to read English were unclear on why they received this money.

ENERGY-CONSERVING BEHAVIOR

For all the tenants in the two buildings, we asked about a number of energy-conserving behaviors that had been described at the workshops. For those receiving incentives, follow-up questions were asked to see if their energy-conserving behavior was a result of the money they received during the demonstration program. There was a statistically significant difference in the two buildings on how the tenants kept their room temperatures (Fig. 32, Table 10). Over 65% of the Pine Street tenants reported that they kept their room temperatures at 70°F or lower while only 14% of the Ellis Street tenants reported this behavior. This difference might be attributed to the problem of overheating at the Ellis Street building. The incentive did not have any change on this behavior: the Pine Street tenants were practicing this behavior before the incentives.

About 50% of the tenants reported that they wore thicker and more clothing in the winter to stay warm, and there was no statistically significant difference between the two buildings (Fig. 33, Table 10). Again, the incentives made no difference on the behavior of the tenants at Pine Street.

Only a small percentage (12%) of tenants cleaned the coils of their refrigerator as recommended in the workshops (Fig. 34, Table 10), and while there was no statistically significant difference between the buildings, a few of the Pine Street tenants reported that they practiced this behavior because of the incentives. There was a statistically significant difference between the buildings in the way tenants heated their apartments. Over 60% of the tenants at Pine Street closed their windows before turning on the radiator; in contrast, only 29% of the tenants at Ellis Street practiced this behavior (Fig. 35, Table 10). Again, this difference might be attributed to the problem of overheating and poor ventilation at Ellis Steet, forcing many tenants to keep their windows open, whether the radiator was on or off, with the poor accessibility of the radiator valve as a contributing factor. Four of the Pine Street residents reported they changed their behavior as a result of the incentives.

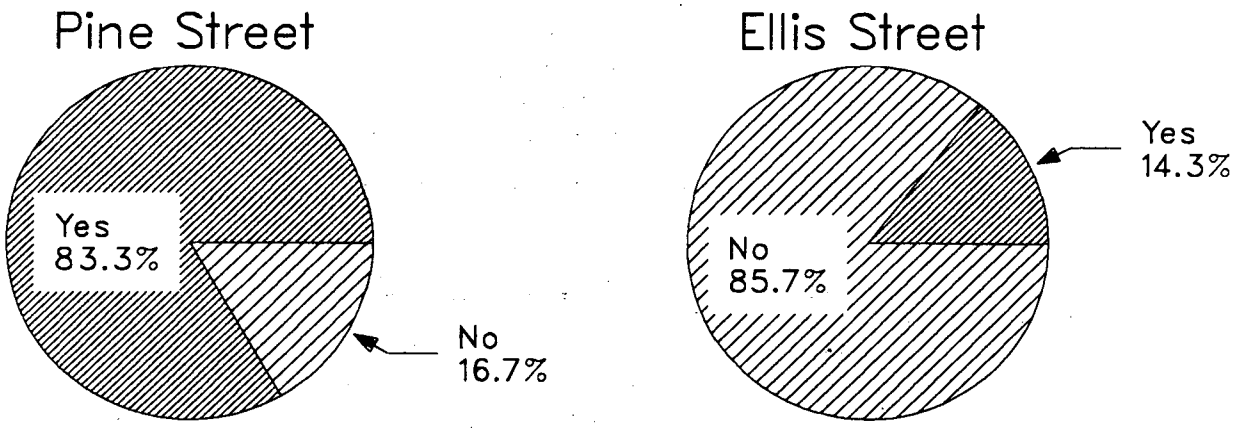
Table 10. Energy-Conserving Behavior and Effect of Incentive

	Pine Street	Ellis Street	Total
Room Temperature Kept At 70 ° F Or Lower:			
Yes	15	3	18
	68.2%	14.3%	41.9%
No	7	18	25
	31.8%	85.7%	58.1%
Column	22	21	43
Total	51.2%	48.8%	100.0%
	Difference of Proportions		
	Z = 3.6	Prob.<0.01	
Effect of Incentive:			
None	9		
	60.0%		
Don't Know	6		
	40.0%		
	15		
	100.0%		
Wears Thicker And More Clothing In Winter:			
Yes	16	20	36
	42.1%	52.6%	47.4%
No	22	18	40
	57.9%	47.4%	52.6%
Column	38	38	76
Total	50.0%	50.0%	100.0%
	Difference of Proportions		
	Z = 1.1	Prob.>.05	
Effect of Incentive:			
None	11		
	68.8%		
Don't Know	5		
	31.2%		
	16		
	100.0%		

Table 10 cont. Energy-Conserving Behavior and Effect of Incentive

	Pine Street	Ellis Street	Total
Refrigerator Coils Cleaned:			
Yes	4	5	9
	11.1%	13.5%	12.3%
No	32	32	64
	88.9%	86.5%	87.7%
Column	36	37	73
Total	49.3%	50.7%	100.0%
	Difference of Proportions		
	Z = .39	Prob. > .05	
Effect of Incentive:			
Yes	4		
	100.0%		
Window Closed Before Radiator Opened:			
Yes	20	8	28
	62.5%	28.6%	46.7%
No	12	20	32
	37.5%	71.4%	53.3%
Column	32	28	60
Total	53.3%	46.7%	100.0%
	Difference of Proportions		
	Z = 2.6	Prob. < .01	
Effect of Incentive:			
None	8		
	40.0%		
Yes	4		
	20.0		
Don't Know	8		
	40%		
	20		
	100.0%		

Figure 32. Behavior – Room Kept at 70 Degrees or Lower *



* Statistically significant at p = 0.05 level

Figure 33. Behavior – Thicker and More Clothing in Winter

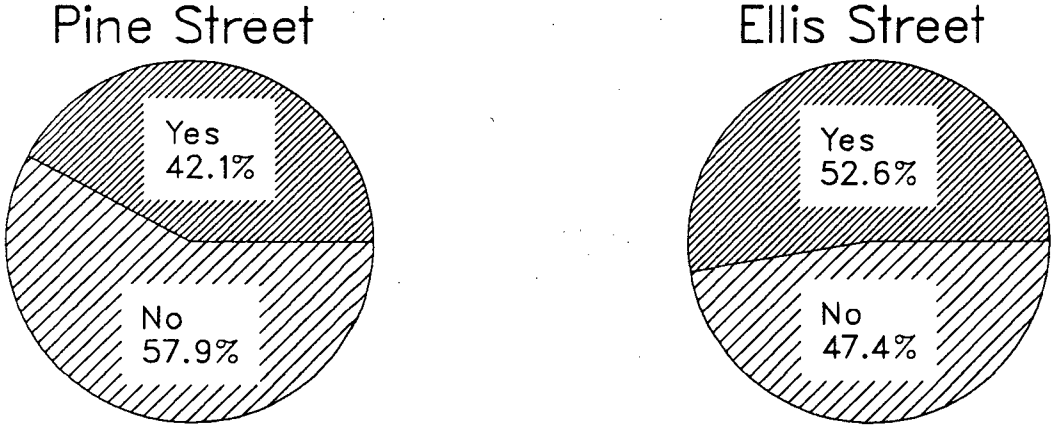


Figure 34. Behavior – Refrigerator Coils Cleaned

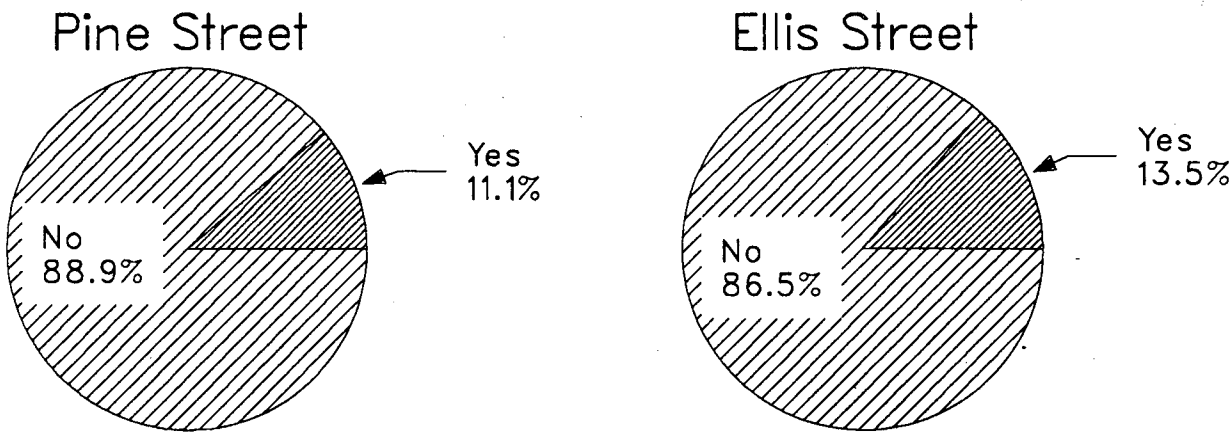
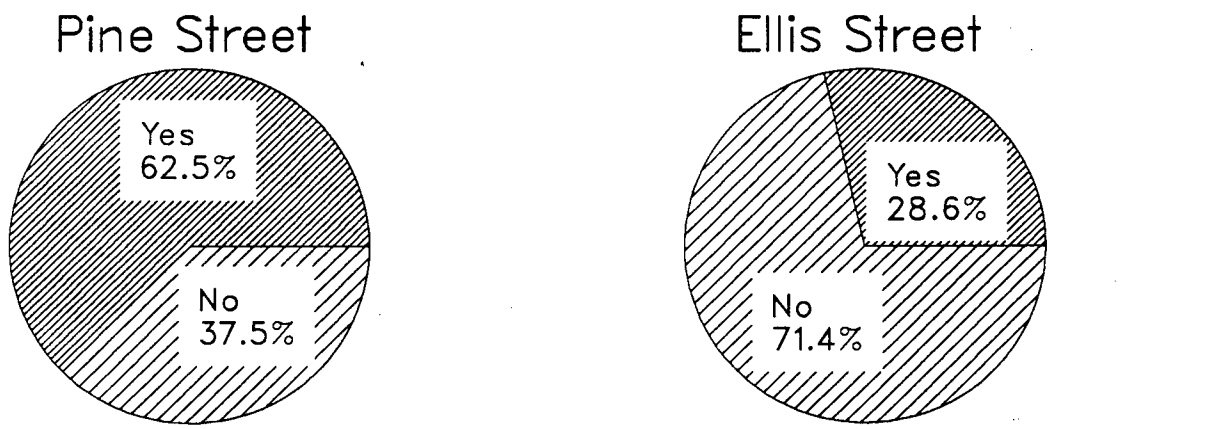


Figure 35. Behavior – Window Closed Before Radiator Opened *



* Statistically Significant at p = 0.05 level

WORKSHOPS

Workshops were held at both buildings to educate tenants on the importance of energy conservation and on energy-conserving behaviors they could take to save energy. Two workshops were conducted in each of these buildings: one in 1985 and the other in 1986. A little more than 60% of the tenants remembered that a workshop was held in their building, and about one-half of the respondents reported attending the workshops (Figs. 36 and 37, Table 11). Because of the amount of time that passed between the workshops and the survey, we did not ask any other workshop-related questions since too much time had transpired for tenants to remember the workshops and recognize the impact of these meetings on their behavior.

Table 11. P.G.& E./Public Housing Authority Workshop Attendance

	Pine Street	Ellis Street	Total
Remembered Meeting Being Held:			
Yes	23	25	48
	62.2%	64.1%	63.2%
Don't Know	1	0	1
	2.7%	0.0%	1.3%
No	13	14	27
	35.1%	35.9%	35.5%
Column	37	39	76
Total	48.7%	51.3%	100.0%
	Gamma	0.0	
Attended Meeting:			
Yes	17	18	35
	45.9%	47.4%	46.7%
Don't Know	2	1	3
	5.4%	2.6%	4.0%
No	18	19	37
	48.6%	50.0%	9.3%
Column	37	38	75
Total	49.3%	50.7%	100.0%
	Gamma	0.0	

Figure 36. Workshops – Remember Meeting

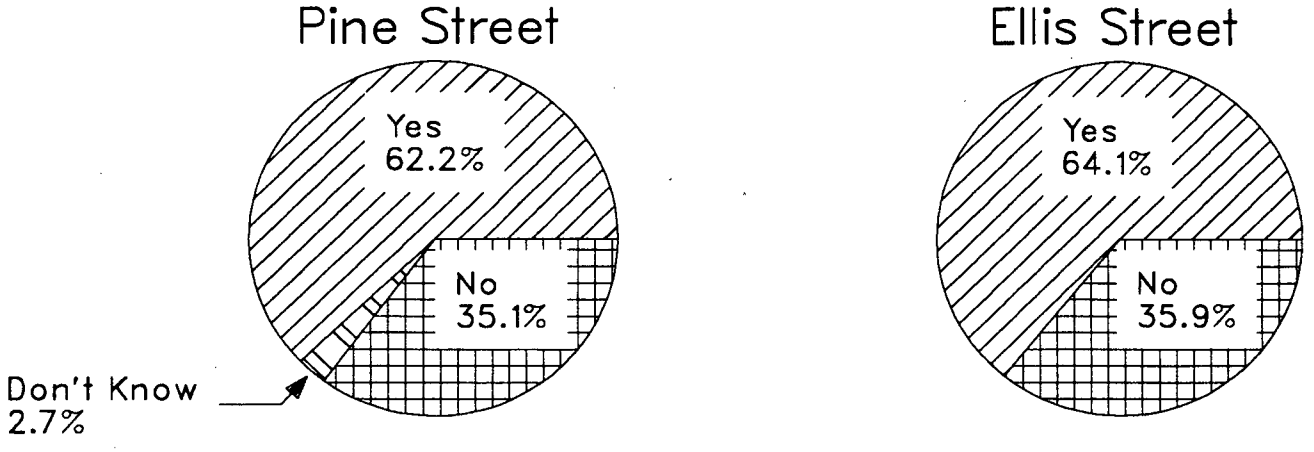
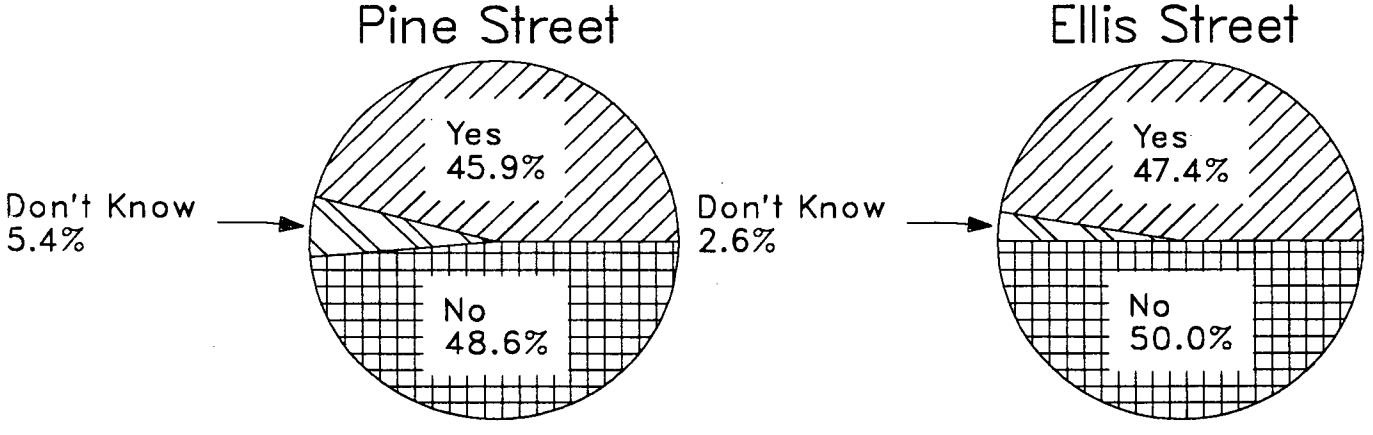


Figure 37. Workshops – Attended Meeting



ENERGY ANALYSIS

A comprehensive evaluation of tenant incentive programs — or any other energy conservation program — is based on measured energy data (utility bills). Once normalized for changes in occupancy rates and for deviations of actual-year weather from long-term normals, the difference between pre- and post-incentive data provides a ready estimate of energy savings. Inclusion of a control building makes it possible to adjust for decreases (or increases) in energy use that result from factors other than the conservation programs.

In this study, several years of pre-incentive utility data were available for the surveyed treatment and control senior buildings (1880 Pine and 350 Ellis, respectively). Although the tenant workshops were conducted in November of 1985, distribution of the incentives was delayed for 13 months. As a result of this delay, our energy savings evaluation is based on only three months of post-incentive data. Fortunately, these three months embrace the 1987 heating season and thus span a period when most of the savings can be expected to have occurred.

METHODOLOGY

We applied three methods for viewing changes in gas use following distribution of the incentives: simple heating degree-day scaling and two applications of a widely used regression technique. Pre- and post-incentive occupancy data were unavailable and, hence, it was not possible to correct for changes in gas or electricity use due to changes in occupancy rates.

- *Method I: Simple heating degree-day scaling.* Gas use was summed for the three-month, 1987 post-incentive period and the same three months during 1985 (mid-November through mid-March). A fraction of this total consumption (40%) was assumed for space heating. The result was multiplied by the ratio of heating degree-days in the pre-incentive period to those in the post-incentive period. By "inflating" usage for the relatively warm post-incentive winter, this method provides an estimate of what post-incentive heating use would have been were weather conditions in 1987 identical to those in 1985.

- *Method II: Regression.* We used the Princeton Scorekeeping Method (PRISM) to adjust the heating fuel (gas) use at Ellis and Pine for variations in monthly weather conditions. PRISM uses utility bills to determine a weather-adjusted index of annual energy use called normalized annual consumption, NAC (Fels, 1986). The PRISM method produces several other energy-use indicators: weather-independent daily base load energy use (α), the heating rate or the amount of energy used per

heating degree-day (β), and the reference temperature (τ) from which the heating degree-days are computed. Together, the last three parameters provide a simple linear model of energy use as a function of weather:

$$NAC = (365 \text{ days} \times \alpha) + 365 \text{ days} (\beta \times HDD_{\tau})$$

where α has the units of energy per day (kBtu/day), β has the units of energy per heating degree-day (kBtu/°F-day), and the heating degree-days are calculated to the base τ selected by PRISM as the most representative of the building being analyzed. The parameter τ is found as that value which maximizes the fit of the model, as indicated by the R^2 statistic (Fels, 1986).

We used the simple linear model generated by PRISM to identify the α, β, and τ parameters for the pre-incentive period. Using the above equation, these parameters—in combination with the number of post-incentive days and heating degree days—were used to derive an estimate of gas use following the incentives. This estimate represents what gas use should have been *in lieu* of the incentives. In this way, savings are estimated by subtracting the actual post-incentive gas use from the use predicted by the model.

- *Method III: NAC "window" analysis.* This method follows variations in the NAC over time. We determined the normalized annual consumption for a twelve-month period beginning in 1984. This twelve-month "window" was then moved ahead three months at a time until the post-incentive period was fully incorporated. The resulting history of changes in NAC provides an indication of energy-use trends.

A secondary objective of the tenant incentives program was to achieve electricity conservation by encouraging tenants to turn off lights and to slightly raise the temperatures of their refrigerators. To evaluate changes in electricity use, we simply compared consumption per apartment, per day, for the mid-November to mid-March periods beginning in 1984 and 1987.

ENERGY RESULTS

Gas

Raw gas use per occupied apartment (unadjusted for weather differences) for the period September 1983 to March 1987 is shown for both Pine and Ellis in Fig. 38. This figure also includes a plot of the monthly heating degree-days (HDD) during this time period. Seasonal variations in consumption are very similar for the two buildings, and winter peaks correspond well with heating degree-days. Note that peak use in March 1987 — following the distribution of incentives — is slightly less than that in the winter of 1986, even though the 1987 winter was somewhat colder.

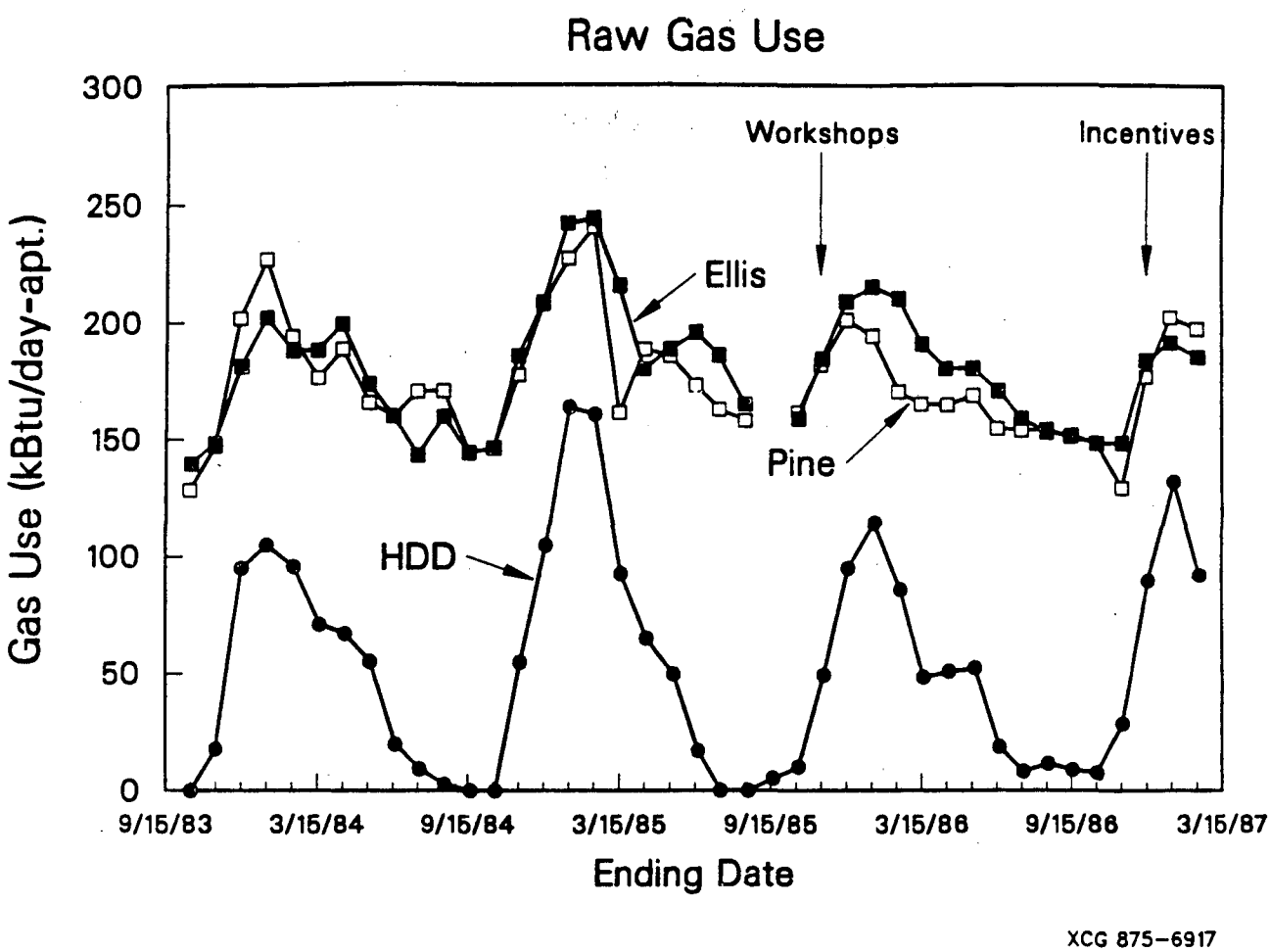


Figure 38. Raw gas consumption and heating degree-days at the Ellis and Pine.

It is important to note that since the 1983-1984 heating season, several changes — in addition to distribution of the incentives — have occurred at the buildings that might affect energy use. At Pine, low-flow showerheads were installed in 1984 and no full-time building manager was present between June 1986 and March 1987. At Ellis, low-flow showerheads were installed in 1984, and the building manager changed in 1986.

Using the simple heating degree-day analysis, described in Method I above, we estimate an *increase* in gas use at both buildings (Table 12). After the workshops, which occurred between the 1985 and 1987 heating seasons, heating energy use at the control building (Ellis) increased 22% whereas use at the treatment building (Pine) increased by only 5%.

We obtained different results using the other two methods. According to the regression technique (Method II), gas savings of 20% occurred at Pine and 11% savings at Ellis. The results obtained using Method III ("window analysis") are shown in Fig. 39. Throughout the period from October 1984 to March 1987, gas use was slightly higher (3 to 7 percent) at Ellis (control building) than at Pine. Consumption started to drop at *both* properties beginning in 1986. Although this small change in consumption occurred following the tenant workshops, the differences are generally not greater than the error estimates for each year's NAC and do not come close to the estimated savings generated by Method II.

Electricity

Our analysis of changes in electricity use per apartment, per day (no weather correction) showed a 2% decline at 1880 Pine and a 17% decline at 350 Ellis. This is somewhat surprising since the tenants at Ellis did not receive incentives.

ENERGY SUMMARY

The three methods for gas use analysis yield markedly different results. We are more confident in Method I (heating degree-day scaling) because it employs the simplest correction technique and is, hence, less prone to estimation error. Method II is highly sensitive to various parameters — especially when employed over only a three-month period — and yields questionable results at the Ping Yuen properties. In addition, due to effects specific to the San Francisco climate, the R^2 statistic is rather poor in some cases. The fact that Method II predicts greater savings at the control building also suggests the possibility of error with the regression technique. Method III provides only a qualitative indication of savings as it is too soon to compute a complete annual post-

Table 12. Results From Heating Degree-Day Scaling Analysis[†]

PROJECT	GAS SAVINGS[*] (Therms/apt)	(%)	ELECTRICITY SAVINGS (kWh/apt/day)	(%)
350 ELLIS	-18	-22	3	17
1880 PINE	-5	-5	1	2

[†] Three family buildings (Ping Yuen A (control), B (control) and C (treatment)) participated in the tenant incentive program, but were not surveyed. However, we did collect and analyze energy data in these buildings, and the methods of analysis were identical to the ones used for the senior buildings. We found the following results:
(1). Based on Method I, gas use increased 32% at Ping Yuen A, 27% at Ping Yuen B, and 34% at Ping Yuen C.
(2). Based on Method II, gas use declined at Ping Yuen A by 6%, whereas gas use increased by 38% and 43% at Ping Yuen B and Ping Yuen C, respectively.
(3). Electricity use declined by 4% to 8% at the control buildings and 2% at the treatment building.

[*] The analysis normalizes energy use to heating degree-days (base 61 °F) in the pre-incentive year. Normal-year heating degree-days were not used due to data unavailability. Positive values correspond to savings; negative values correspond to increases in energy use.

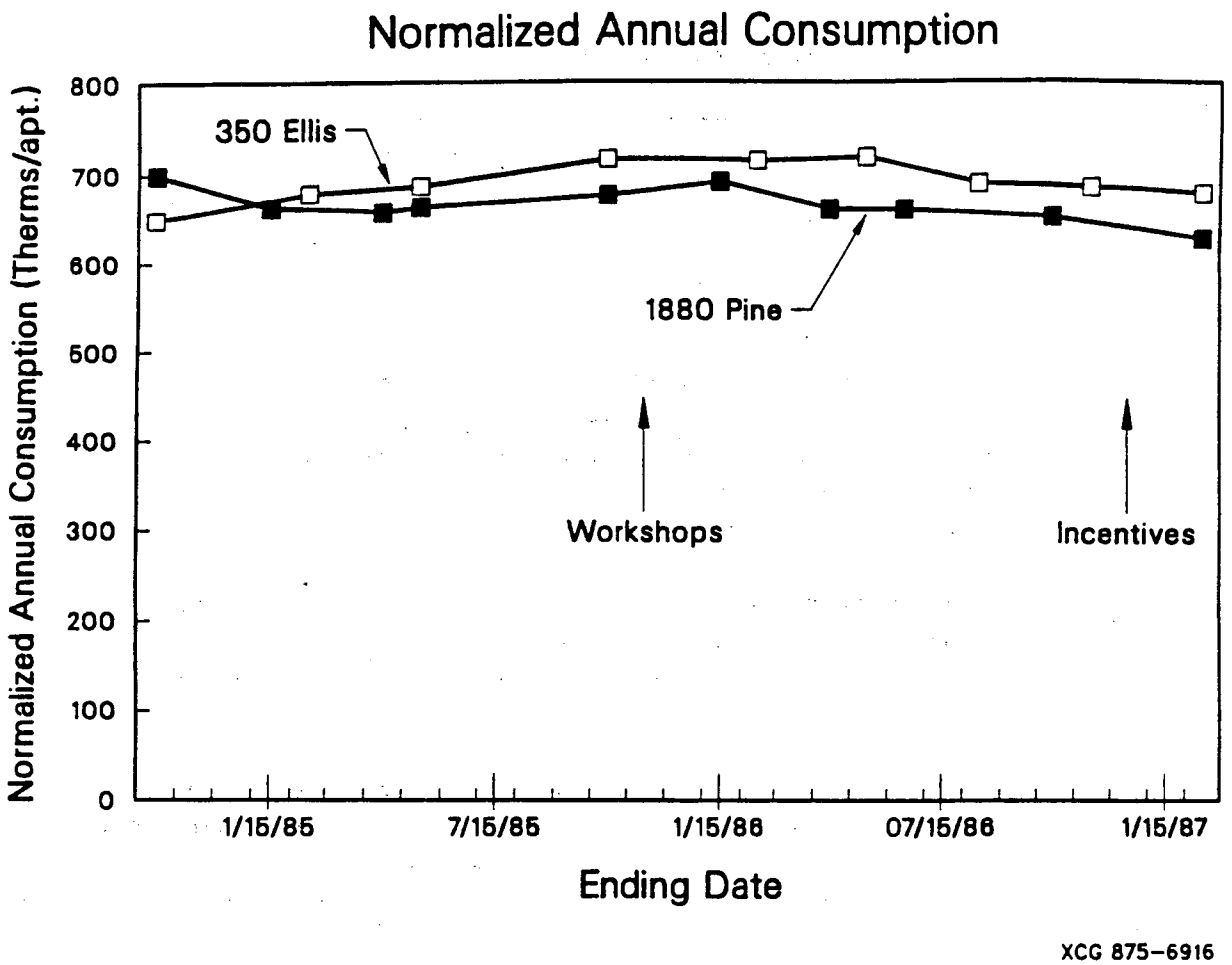


Figure 39. Gas consumption at the two projects using the PRISM "window" analysis technique.

incentive NAC.

In summary, given the limited post-incentive utility data, it is too soon to provide a definitive estimate of changes in gas or electricity use. Gas use appears to increase at all five projects while electricity use declines, showing little correlation with the receipt of incentives except perhaps at 1880 Pine where the increase in gas use was less than at the Ellis. Savings in electricity were greater at the control building than at the treatment building. The small changes suggested by the data may be due to factors other than the workshops or incentives. Changes in building managers and incomplete records of occupancy are likely explanations. The suggested non-response to the incentives is not surprising in light of the poor workshop attendance, delays between the workshop and distribution of incentives, distribution of English-language instructions to non-English-speaking tenants, and counterproductive tenant perceptions described elsewhere in this report. Finally, we probably should not have expected to find significant changes in gas consumption during the course of this study because the tenants in these buildings really had few ways to control their usage. In addition, small changes in space heating consumption are difficult to isolate from the ordinary "background" fluctuations in mild climates like San Francisco (Goldman and Ritschard, 1986).

DISCUSSION AND CONCLUSIONS

In 1985, the City of San Francisco initiated a tenant incentive demonstration project in public housing to stimulate energy conservation behavior among its tenants. The goals of the incentive demonstration project were to demonstrate energy savings and to measure the effectiveness of financial incentives in public housing. Two buildings for the elderly were selected to participate in the program (1880 Pine and 350 Ellis). Energy conservation workshops were held at both buildings; however, only the tenants at 1880 Pine received the incentives. This approach to energy conservation in rental housing has not been documented in the literature.

We found that elderly tenants thought they were already using a minimal amount of energy, and several barriers prevented other tenants from reducing their heating use:

- The age and physical condition of tenants prevented many of them from bending down and adjusting radiator valves for controlling the amount of heat during the winter.
- The physical design of apartments at Ellis Street resulted in radiators being located behind large, heavy pieces of furniture (e.g., beds and bookshelves), preventing easy access to the radiator controls.
- The design of the buildings and hot water distribution systems (in particular, at Ellis Street) led to overheating and poor ventilation, forcing many tenants to keep their windows open during the day and at night in order to maintain comfortable indoor temperatures and "fresh air".
- Many tenants reported that their room radiators were broken or heating controls were inoperable: the radiator valve was missing, "frozen," or broken so that no heating adjustments could be made. Window opening and closing was the principal means of controlling the thermal environment in these buildings, and any suggestions for saving energy by regulating radiator valves were easily dismissed by the tenants.

Other factors were important in limiting the amount of energy conservation in these buildings:

- These tenants did not pay for energy costs and assumed the Housing Authority would continue to pay for these costs without burdening the tenants, so that energy would continue to have a negligible impact on their household budget. The absence of a monthly utility bill also resulted in the lack of feedback indicating to tenants how much energy they used each month.

- For at least one-half of the tenants, energy was not an important issue, compared to other problems they were facing.
- Most of the tenants believed their personal efficacy was low: they did not think their efforts in saving energy would have any impact on the total energy consumption of the entire building.
- Monetary rewards (incentives) were not considered to be adequate incentives for people who felt they already were using minimal amounts of energy, though the money itself was greatly appreciated by the tenants.
- There was very little effort in promoting the energy conservation ethic in public housing buildings at a group or community level. There was little communication among tenants, so that no one knew how many others were trying to conserve energy. The communication problem was exacerbated in these buildings due to the heterogeneity of the tenant population: many of the residents were from foreign countries and were unable to read and speak English, further isolating themselves from the rest of the tenants. Furthermore, a number of the racial minorities were organized into groups in each of the buildings, were actively involved in tenant organizations, and were very reluctant (if not hostile) in participating with other minorities in any programs, limiting the potential of cooperative efforts. Consequently, tenants in these buildings practiced energy conservation by themselves without knowing the effects of their actions and of others in their building.
- The Housing Authority, in particular, was seen by many tenants as not being responsive to tenants' complaints. A number of tenants mentioned that they had contacted the Housing Authority a number of times for repair work, but to no avail. Also, during one period of the program, there were no building managers in the buildings; as a result, in one building, the furnace failed several times, including one four-day period, leaving the tenants without heat. This negative perspective was undoubtedly a motivating factor for some tenants to not participate in the demonstration program.
- The demonstration program itself had a number of problems during its implementation. For example, there was an extended period of time (over one year) between the time of the first workshop and the mailing of the incentives that resulted in some tenants losing interest and/or weakening their belief in the integrity of the program. Also, the cover letter accompanying the incentive did not sufficiently explain the purpose of the program and the check: many tenants thought the money was solely for their previous low energy usage and did not associate it with a need to change their energy conservation behavior in the future.

We found few statistically significant differences in energy-conserving behavior between the experimental and control buildings. Specifically, we found Pine Street tenants, in contrast to those at Ellis Street, reporting that they are able to save energy, close windows before turning on their radiator, and keep their room temperature at 70 ° F or lower in the winter. These differences occurred before the incentive program was introduced. In fact, the demonstration program did not alter energy behavior in any of the buildings.

Preliminary analysis of the energy data before and after the implementation of the incentive program supports the general survey findings. Increased gas use occurred in both experimental and control buildings after the incentive money was distributed. Electricity consumption declined, although negligibly. However, more monthly data are needed before any definitive statements about the overall effectiveness of the program can be made.

Nevertheless, we do not expect many elderly tenants in these public housing buildings to use less energy than they presently are consuming because of the problems described above. Individual and social conditions prevent these tenants from responding to energy conservation programs. Consequently, we expect future attempts at saving energy in these buildings to occur at the Housing Authority level, rather than at the tenant level: for example, further improvements to the supply and distribution of heat and to the thermal integrity of the building shell (e.g., wall insulation and reduced infiltration).

It is important to note that energy-related comfort problems may be more serious than those reported in the survey. Some of the tenants were reluctant to complain, either because of their for fear of being evicted, or of their own cultural values. Tenants do not want to be labelled "complainers" for fear of being forced to leave their apartment by the Housing Authority, and, therefore, they adapt to their living conditions without asking for help from authorities (e.g., the Housing Authority and PG&E). This may be especially true for low-income and elderly tenants. Also, as noted by one historian of California culture, Asians have a stoic acceptance of life ("it cannot be helped, it must be endured") that enables them to "carry their load" without complaining (Houston, 1985). We suspect that a number of Asians in the public housing buildings embraced this philosophy. Accordingly, we suspect that tenants may be more uncomfortable with their indoor environment than actually reported to us.

We believe that many of our comments also apply to the other buildings participating in San Francisco's incentives demonstration program. Although we did not survey tenants in the family units, we did attend one workshop at one of the family buildings

and heard similar comments about their apartments by the three people who attended: broken pipes, no heat and hot water for a three-week period (they needed to use the oven to heat their water and keep their apartment warm), and inoperable radiators. We suspect that their response to saving energy would be similar to the experience at the senior buildings.

On the other hand, it may be difficult to extrapolate our findings from this study to other public housing buildings in San Francisco or around the country. The two buildings selected in our study did not represent a random sample of public housing buildings, since they were chosen as a matched pair. However, Pine Street residents were different from those at Ellis Street: in particular, they were judged to be more knowledgable about the energy conservation program. Consequently, there was a built-in bias for favoring greater energy savings at Pine Street. If the incentives had been targeted to residents at Ellis Street, we would expect different results.

The Housing Authority's political environment during the implementation of the incentives program was volatile. For example, as reported in the local newspapers, the San Francisco Housing Authority owed $1.6 million in overdue utility bills to their local utility (PG&E) for its public housing projects, had a $80,000 per month operating deficit, was charged with cutting back on maintenance at its projects, had suffered heating and hot water shut offs for days at a time at some of the projects during renovation, and had a drug-trafficing problem at some of its buildings. Due to these problems, we are not sure how generalizable our findings are for other incentive programs at other public housing sites around the country; however, we would expect some of the same problems and results.

In conclusion, we offer the following suggestions for those individuals and organizations planning a tenant incentive program:

- Programs should be targeted first to tenants who pay for some, if not all, of their utilities. Tenants who do not pay for utilities do not have the economic incentive for saving energy.
- All maintenance concerns need to be addressed regularly before an incentive program is introduced. Maintenance staff should respond to requests for repair within a day or two (Cranz et al., 1977). In particular, if energy-related maintenance problems remain, tenants will not look favorably upon a program that encourages tenants to save energy.

- Tenants should understand how they can control energy-related equipment. Workshops and apartment visits are necessary to enforce this understanding.
- Target *all* groups in the public housing sector. Because the populations in these buildings are heterogeneous, educational and informational materials must be prepared in different languages so that everyone can understand the purpose of the program and help endorse and promote the program.
- Provide feedback mechanisms to tenants as part of the program: for example, room thermostats to measure indoor temperature and graphs of monthly utility bills (by building and, if possible, by apartment) to chart energy use over the lifetime of the program.
- Make sure incentives occur soon after information workshops are conducted so that the continuity of the program is maintained. Similarly, monthly payments are the preferred type of payment in order to maintain interest in the program. The payments provide essential monthly feedback to the tenants on how well they are saving energy.

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APPENDIX A

SAN FRANCISCO PUBLIC HOUSING SURVEY

SENIORS-1987

PART I

I.D. Number	_____	**1:1-3**
Card Number	_____	**1:4**
Building Address	_____	**1:5**
Apartment Number	_____	**1:6-9**
Interviewer	_____	**1:10**
Start Time	_____	
Finish Time	_____	
Length of Interview	_____	**1:11-12**
Date	_____	

ID:_____

SAN FRANCISCO PUBLIC HOUSING SURVEY

SENIORS-1987

MAIN FORM

I. First, I would like to ask you some background information

How many years have you lived in this building?

enter number of years_____ 1:13-14

88. don't know

99. no response

During the last year have you left your apartment vacant for one week or more?

1. yes 1:15

2. no

8. don't know

9. no response

IF YES:

Number of times:_____ 1:16

Please specify: week_____month_____year_____ 1:17-21

Please specify: week_____month_____year_____ 1:22-26

Please specify: week_____month_____year_____ 1:27-31

II. I'd like to ask some questions about your radiator.

Does the valve on your room radiator work?

1. yes 1:32

2. no (Why not?)_____

8. don't know

9. no response

IF "YES" CONTINUE, OTHERWISE GO TO QUESTION AA

During the winter, what is the setting of your room radiator valve?

	always closed	sometimes open	always open	don't know	no response	
when someone is home and awake?	1	2	3	8	9	1:33
when everyone is asleep?	1	2	3	8	9	1:34
when everyone is away?	1	2	3	8	9	1:35

QUESTION AA: Do you use an electric fan to cool the apartment on hot summer days?

1. yes — 1:36
2. no
8. don't know
9. no response

IF "YES" CONTINUE, OTHERWISE GO TO QUESTION BB

How often do you use your electric fan on hot summer days?

1. often — 1:37
2. sometimes
8. don't know
9. no response

QUESTION BB: In the winter, do you generally keep your windows open during the day or during the night?

	open	sometimes open	closed	don't know	no response	
day	1	2	3	8	9	1:38
night	1	2	3	8	9	1:39

What is your refrigerator setting?

enter setting_____ 1:40-41

88. don't know

99. no response

What is your freezer setting?

enter setting_____ 1:42-43

88. don't know

99. no response

III. Now, I have a few questions about how you use hot water.

On the average, how many baths and showers are taken in your house each day, **counting everyone who lives here?**

number of showers per day_____ 1:44-45

number of baths per day_____ 1:46-47

88. don't know

99. no response

IF SHOWER CONTINUE, OTHERWISE GO TO QUESTION IV

On the average, how long does each person shower?

1. less than or equal to 5 mins.
2. 6-10 mins.
3. 11-15 mins.
4. more than 15 mins.
8. don't know
9. no response

1:48

IV. Now, I'd like to ask you some energy related questions.

	yes	no	don't know	
Do you think if you save energy it will affect the building's energy consumption?	1	2	8	1:49
Compared to other problems, is the energy problem important to you?	1	2	8	1:50
Do you suspect that other people in this building are saving energy?	1	2	8	1:51
Is your apartment too cold in the winter?	1	2	8	1:52
Is your apartment too warm in the summer?	1	2	8	1:53

Do you think you are able to save energy in your apartment?

1. Yes 1:54

How:

_____ 1:55

_____ 1:56

_____ 1:57

2. Only Minimum Use of Energy, though as conserving as possible

Explanation:

_____ 1:58

_____ 1:59

_____ 1:60

3. No

Why Not:

_____ 1:61

_____ 1:62

_____ 1:63

Do you remember an energy conservation meeting that was conducted in this building last year by the Housing Authority and PG&E?

1. yes 1:64
2. no
8. don't know
9. no response

Did you or anybody in the household attend this energy conservation meeting?

1. yes
2. no
8. don't know
9. no response

1:65

V. I have a few questions about yourself and your household.
You don't have to answer these questions if you don't want to.

How old are you?

enter age_____
88. don't know
99. no response

1:66-67

PLEASE RECORD SEX OF RESPONDENT

1. male
2. female

1:68

Are you married?

1. single
2. married
3. other (specify_____)
9. no response

1:69

PLEASE RECORD ETHNICITY OF RESPONDENT

1. Caucasian
2. Black
3. Asian
4. Hispanic
5. Other (specify_____)
9. no response

1:70

IF RESPONDENT IS OBVIOUSLY FOREIGN:

How long have you lived in the United States?

enter number of years_____ | 1:71-72

How many people live in this apartment and how old is each person?
Please count all members living in the household including yourself whether they are related to you or not.

	number	
people under 6 years old		1:73
people 6 to 17 years old		1:74
people who are 18 to 65 years old		1:75
people over 65 years old		1:76

How many years of education have you completed?

1. no formal education
2. elementary school
3. some high school
4. high school graduate
5. some college
6. college graduate
7. advanced degree
8. don't know
9. no response

1:77

Blank 1:78-80

I.D. 2:1-3

Card 2 2:4

SAN FRANCISCO PUBLIC HOUSING SURVEY

SENIORS-1987

FINANCING FORM

PART II

Did you receive some money from the Housing Authority/PG&E at the end of last year?

1. yes
2. no
8. don't know
9. no response

2:5

IF "NO" GO TO PART III.

How much money did you get (dollars)?

enter amount_____

8888. don't know

9999. no response

2:6-9

Do you know why they gave you this money? Why?

[Check (1) if they only know generally that it has to do with energy, and (2) if they seem to understand that it has to do with their energy consuming behavior.]

1. yes, [generally]
2. yes, [specifically]
3. no
8. don't know
9. no response

2:10

The Housing Authority pays a very large utility bill for energy used in these buildings. In hoping to reduce this utility bill, they are experimenting with giving people money in exchange for being more careful with how much electricity and gas they use. If the amount of electricity and gas in the building as a whole decreases, then the incentive payments will continue, but if there is no change in energy use, the incentives will cease. Thus, the money was given to you as an incentive to save energy in your apartment.

Do you think the money will help get people to reduce their energy use?

1. yes
2. no
8. don't know
9. no response

2:11

IF "YES" CONTINUE, OTHERWISE GO TO QUESTION AA.

Have you changed the way you use energy as a result of this program?

1. yes
2. no
8. don't know
9. no response

2:12

IF "NO" CONTINUE, OTHERWISE GO TO QUESTION BB.

If we wanted you to change your energy use in the next month, how much money would you want?

enter monthly amount_____

8. don't know
9. no response

2:13-16

QUESTION AA: Why do you think money will not change the way people use energy?

_____

_____

2:17-18

QUESTION BB:

What else besides money could help people save energy in their apartment?

2:19-20

Do you think it's possible to save energy without being uncomfortable in your apartment?

1. yes
2. no
8. don't know
9. no response

2:21

I.D. 3:1-3

Card 3 3:4

SAN FRANCISCO PUBLIC HOUSING SURVEY

SENIORS-1987

PART III

I HAVE SOME FINAL QUESTIONS FOR YOU.

	yes	no	don't know	no response	
Do you keep your room temperature at 70 degrees or lower in the winter?	1	2	8	9	3:5
• IF YES Were you doing this before receiving the money? (Only if receiving money)	1	2	8	9	3:6
Inside your apartment, do you wear thicker or more clothes in winter, especially in the evening.	1	2	8	9	3:7
• IF YES Were you doing this before the money?	1	2	8	9	3:8
Do you clean your refrigerator coils?	1	2	8	9	3:9
• IF YES Were you doing this before receiving the money?	1	2	8	9	3:10

	yes	no	don't know	no response	
In the winter, before opening the window, do you turn the radiator off?	1	2	8	9	3:11
• IF YES Were you doing this before receiving the money?	1	2	8	9	3:12

II. ONLY IF RECEIVING MONEY

I have some other questions about the money you received in this program. Please tell me if you agree or disagree with the following statements.

	agree	neutral	disagree	don't know	
I am willing to save energy so that I can get some money from the Housing Authority.	1	2	3	8	3:13
The money payments have brought tenants in this building together to save energy.	1	2	3	8	3:14

INTERVIEWERS RATING

The following rating is for the interviewer to make themselves, subjectively. It is mean to provide information about health factors, which may be important in the analysis of the data. Seeing that we are sampling the elderly, (and some of the respondents may be very old), we need to have some basic information on their ability to comprehend the nature of the incentives program as well as the meaning of our survey questions.

Health of occupants:	Irrelevant to Study	May have Consequences	Important Needs Affecting Consumption	
	1	2	3	3:15
Ability to comprehend program:	Reasonable Understanding	Resisting Survey	Can't Follow	
	1	2	3	3:16

Blank 3:17-8

Please note nature of health problem affecting energy consumption, if any:

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