PATTERNS OF RESIDENTIAL OCCUPANCY

by

B.M. Johnson

PREFACE

The study of household activity patterns was undertaken to provide basic data on internal heat gains in homes. As such it was part of the Division of Building Research's continuing effort to provide information to the Canadian construction industry to aid in the designing of energy efficient housing.

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The changing structure of Canadian households is seldom considered in housing design.[1,2] These changes are not only ignored in relation to house form, but also to service requirements. Heating load calculations have been based on an assumed composition of the traditional working father and child-minding mother.[3,4,5] If household size and occupancy patterns have changed significantly these changes should be reflected in internal heat gains and should be recognized in design and analysis. This paper describes the findings of a pilot survey by the Division of Building Research to determine residential occupancy patterns with particular emphasis on energy use.

The objective of the study was to collect specific data on current household activity patterns. The requirement for this data came from scepticism about both the validity and usefulness of current design data. The American Society of

Heating, Refrigerating and Air-Conditioning Engineers produces a guidebook remarkable for its thoroughness on most topics, however, internal heat gains for residences are incorporated in the factor (C_D) for the modified degree day procedure for determining energy consumption during the heating season. However, the ASHRAE guide states, "It is important to remember that the wide variation in occupant living habits and the assumption inherent in this procedure may result in a variation of ±20 per cent from actual fuel use on an annual basis."[3] This estimate is based on a study that compared the theoretical energy consumption with actual energy consumption to derive a value for internal heat gains.[5]

The British researcher J.K. Page gives a simplistic as well as sophisticated method of utilizing heat gain.[4] In the simplistic method the mean indoor-outdoor temperature difference is reduced by 5.5 to 8.4°C for dwellings to account for internal and solar heat gains. The sophisticated method uses a value of 0.0205 kW/m^2 based on values attributed by Page[4] to N.S. Billington. These values are for the heat gain from occupants, lighting, hot water systems, T.V., electrical appliances and sunshine. If all equipment is electrical, then the electrical usage is 950 kWh per month in Britain which is substantially more than the 675 kWh quoted in ASHRAE from an Edison Electric Institute report.

METHOD OF STUDY

To collect the desired data a structured interview was chosen as the survey instrument after a pilot study found questionnaires to be too complicated. The interviews posed questions on the activities of each household member for a typical work or week day and the two non-work days (i.e., Saturday and Sunday). Parents answered for children who could not comprehend the questions.† In conducting the interviews, the questions were rearranged to the patterns of the individual and occasionally phrased in a leading fashion to avoid appearing unresponsive to previous answers. Always one interviewer asked the questions while the other recorded the answers. Each interview team consisted of a male and a female who alternated the interviewing task. The questions (see Appendix A) tried to construct a time budget of household activities as well as the frequency of use of specific equipment. Questions on other issues such as annoyance of odours and patterns of window openings were also asked.

With the exception of the pilot survey all the households were chosen from two housing projects, one 21-storey apartment building and one low-rise medium density (50 dwelling units/ha) cooperative housing project (Figures 1

† Michelson[6] did not survey children under eight years of age. DBR interviewers, however, found that children as young as five were able to answer competently and sometimes even to correct their parents.

to 4). Project organizations were used to give official support for the study to improve residents' willingness to participate. This apparently helped because the response rate was high enough that no additional selection had to be undertaken apart from the original ten per cent random sampling. The interviews were at the residents' convenience during four weeks in early 1978. The small size of the sample meant that for most analysis the two projects were considered as being from one population. Analysis of certain occupant characteristics, discussed later, was done by separating the projects (Appendix B). Six household types were identified for the sample, those listed in Table 1 provide a basis for the analysis of the energy inputs.

Based on existing literature[7,8] an estimate was made of the energy produced by the occupants depending on the level of activity of the person as well as some other factors. The derivation of the values chosen for analysis is given in Appendix C. The combined latent and sensible heat produced was assumed

for an adult to be,	light activity	100 W
	moderate activity	230 W
	heavy activity	375 W
for a child to be,	minimal activity	75 W
	moderate activity	170 W
	heavy activity	280 W

ANALYSIS

Five sources of energy input can be considered in addition to the heating system: occupants, lighting, hot water, electrical equipment (including T.V.) and solar gain. The data relate to all these except solar gain.

Occupants

From the data it was possible to approximate the daily energy input from the occupants according to household composition (Table 2). Billington, referred to by Page[4], had assumed a value of 0.2 kW from the occupants.

Lighting

The interview technique of the survey did not allow a reliable method of determining the patterns of use for artificial lighting. During the evening interviews, however, an informal record was kept suggesting that the more people there were in the home the more lights would be in use, but the relationship was non-linear and depended also upon the activity level of the occupants. Assuming that a single person has three 60-watt lights for a total of 0.18 kW, then 0.10 kW for other occupants might be valid for non-daylight periods of occupancy.

EQUIPMENT

The use of most equipment is relatively predictable, e.g., a kettle or electric razor in the morning. Television sets, however, are a significant yet unpredictable energy input. Billington, through Page[4], assumes six hours of daily use, other estimates are approximately three hours, the difference is almost 1 kWh per day. Table 3 gives the mean and standard deviation of reported television use from the DBR study for the day indicated. The precision of these values exceeds their accuracy because a good deal of interpretation was done to extract this information from the interview responses.

For children (aged 10 to 17) watching television Farley[9] gives mean values of approximately 1.75 hours for week days and 1.5 hours for Sunday.[9] These lower values may reflect different weather conditions between Toronto and Ottawa (some of Farley's data were collected in the summer).

The use of other equipment was also noted for week days Saturdays and Sundays although only in terms of frequency not duration of use. For example, the week day use of toasters had a mean of 1.3 uses. If each use was three minutes long the daily use would be 4.9 minutes or 0.1 kWh (based on a rated value of 1200 W), however, only 21 of the 25 households surveyed reported using the toaster so this value must be reduced by 21/25 to 0.08. Admittedly this introduces an error if the interviews did not bring up this topic. Table 4 gives the mean usage for each of the noted devices for three different days, these are compared to the values given by Canada Mortgage and Housing Corporation.[10] Again, the quoted precision of this data exceeds its accuracy.

Because of the increased use of electrical appliances these values may increase over time, however, most new types of equipment use technology such as solid state circuitry that minimizes energy use. The installation of computer terminals at home (or even micro-computers) may cause sudden jumps in energy consumption, e.g., of the persons interviewed two had computer terminals. At 750 watts each these could be significant contributors to heat gain.

A basal rate of about 3 kWh per day was assumed for the running of refrigerators and humidifiers.

Hot Water

Although questions were asked about the frequency of bathing, dishwashing, etc., not enough data were gained to give accurate information about hot water consumption. Failure to account for the prevalent habit of daily baths or showers might lead to an underestimate of hot water consumption. It is probably counter-balanced, however, by the equally prevalent habit of only doing dishes once a day and the low rates for doing laundry, as observed in the survey. The input from two baths, one warm clothes wash, and one dishwash would use approximately 2 kWh of which 50 per cent may be retained to give a 1 kWh energy input. For the following analysis a value of 1.5 kWh was used for total daily energy input based on a three-person household.

TOTAL ENERGY INPUT

The DBR data, when supplemented with information from other sources, can help construct a total energy picture. To do this based on this data base is really premature but it does give an indication of the range of values being dealt with. Table 5 gives the input for all sources for each household type after values for lighting, hot water and equipment use have been prorated by household size (the mean household size was 2.5 persons).

If this range of energy input significantly affects heating requirements, then profiles of energy input could be used for house design. Instead of implicitly incorporating an assumed average input[11,3] a series of profiles could be used explicitly for housing designated for specific household compositions.

The Division of Building Research is currently preparing a computer program "ENCORE-Canada" to calculate annual heating requirements.[12] Within this program hourly profiles of energy consumption (input) are explicitly used, in addition to solar gain and outside temperature, to predict hourly heating/cooling requirements. Energy input profiles for two household types were used in two runs of this program to determine the consequence on the heating/cooling requirements for a given house design. The method of preparing these profiles is explained in Appendix B. Figures 5 to 8 and Table 6 show the results for week days and Sundays (holidays) for each of the two households (i.e., types 3 and 4).

The intention of the simulation was to determine the maximum difference that could result from various household types. To do this a small (90 m^2), well insulated, airtight bungalow was chosen. For mid-January the heating demand was 40 per cent higher for the two-person (both working) than the four-person (traditional) household. At other times of the year the difference would probably be greater.

HOUSEHOLD CHARACTERISTICS

Associated with the question of varying household activities is the question of when residents are at home. Figures 9, 10 and 11 show the probability of there being at least one member of the household at home week days, Saturdays and Sundays. Week days a distinct pattern emerged of high probability of occupancy from 23:00 to 7:00 h. This dropped to approximately 0.5 from 9:00 to 16:00 h in all cases where there was more than one person in the household. Two points are worthy of note: first, noon-hour return to home was almost non-existent; and second, single persons are rarely at home around 21:00 h or, as would be expected, between 9:00 to 17:00 h. Even elderly couples were often not at home during the day, which is of consequence to planners who assume that elderly persons are useful as a security measure in observing the neighbourhood. Later in this report profiles of household occupancy are given for household types 3 and 4 listed in Table 6.

To analyze further the occupancy patterns of the persons surveyed, six stereotypes were chosen. They are described in Table 7 which gives the population of each housing type and the mean time spent away from home.

Farley[9] determined that school-age children in suburban apartments spent about the same amount of time at home as those in suburban houses. From Table 7, however, it appears that activity patterns may vary between children in apartments and houses just as activity patterns for all persons may vary.

Also of interest is the variation in activity level between the housing types and the days of the week. Table 8 shows the mean time spent on week days, Saturdays and Sundays for each personality stereotype according to various activity levels based on a classification of the heat output of the activities (Appendix C).

HOUSEHOLD EQUIPMENT

In addition to the occupants' activities and use of electric lights, etc., the use of certain equipment affects internal heat gains. In the survey households were asked whether they had certain appliances or equipment. Table 9 shows the appliance possession rates for the two housing types as well as the approximate Ontario possession rate from Household Facilities and Equipment [13] where available.

The values in Table 9 show that possession rates of household equipment are higher than the Ontario average for the types of equipment appropriate to the housing type. The internal heat gains due to the use of such equipment may, therefore, be higher. This could certainly be true of clothes dryer use where 91 per cent of the surveyed households had clothes dryers compared with the Ontario figure of only 55 per cent.

Car block heaters and certain other similar equipment do not directly add to the internal heat gain and therefore the energy used needs to be subtracted from total electrical consumption. Table 10 gives the usage pattern for block heaters during the winter.

If the values of Table 10 for use by apartment households are considered in respect to the pattern of being away from home (Table 6) then the values of block heater use are very consistent for the two housing types. A figure of 10 hours of use per day could be used in total energy calculations to account for block heater consumption.

ENVIRONMENTAL QUALITY

Heating requirements are related to air quality in several ways. Table 11 gives reported values for daytime opening of windows according to the season. In the apartment building several residents stated that they were troubled by odours in the basement but not in their own units. As a point of interest, of households with air conditioning 20 per cent of the persons in the row house and 29 per cent of those in the apartment opened their windows in the summer, indicating that air quality may be a major determinant of window use as well as temperature control. It is interesting that the window opening habits of persons in the two housing types were almost identical in the winter despite the apartment dwellers' unanimous claim that they were untroubled by odours whereas 60 per cent of the residents of the row house said they were troubled by odours. In the interviews the apartment dwellers stated that they opened the windows to freshen the house either on Saturday or on arriving home at the end of the day. The suspicion that opening habits are dependent upon orientation is confirmed in Table 12. This table shows a significant correlation between south facing orientations and higher rates of window opening for the small sample size. Assuming the data are reliable and not confounded by other factors such as smoking, it could be concluded that people are actually opening the windows to reduce the air temperature in units. This may be related to stack effect. The sample was not large enough, however, to note any definite trends although there was a slight increase in window opening in the centre of the building.

The relative humidity inside the houses, if low, might trouble the occupants with static electricity or, if high, cause condensation on windows and possibly walls. As far as static electricity goes, roughly 55 per cent of the occupants of both housing types found this to be a problem. Condensation was noted more frequently in the row houses than the apartments, 55 to 35 per cent, respectively. Curiously, about 20 per cent of persons in the row houses had problems with both. Even more curious was that persons with humidifiers did not perceive static electricity to be any less of a problem than did those without humidifiers. Table 9 shows that possession rates of humidifiers was higher in the apartment than the row house; despite this, more apartment dwellers maintained they had a static problem. The subjective nature of things such as static electricity, odour and condensation is emphasized by this survey.

ACCOMMODATION AND OCCUPATION OF SAMPLE

The cooperative row house development was comprised of 3-bedroom units none of which was occupied by less than two persons. Roughly 35 per cent of the households surveyed contained two persons, and about the same percentage contained three. Households with four persons or more constituted 30 per cent of the sample. Table 13 shows household size and number of bedrooms for the apartment building. These figures show a pattern for more persons per bedroom than the national average.[13]

The occupational group of the sample is worthwhile reporting to give an indication of the effect of occupation on activities and length of time at home. Table 14 gives the occupational group according to housing type.

CONCLUDING REMARKS

The survey described herein is an attempt to provide some initial data and a measure of the significance of occupancy patterns. It indicates that the energy use consequences of housing design need to be more carefully appraised. Not only does the pattern of energy use and its effect on heating requirements need to be more intensively studied but the factors that determine this use need to be understood (e.g., the effect of master metering in multiple unit projects)[14].

The requirements of individual households for various activities and the image of the house types[15] need more extensive study to solve specific problems such as excessive energy consumption and to ensure the best possible use of limited resources.

REFERENCES

1. Charney, M. Housing in Canada - a dead-end choice. Architectural Design, No. 4, 1976, p. 202 - 206.

2. Cheseroni, W. Never-nesters - the new affluent. Builder, Oct. 2, 1978, p. 29.

3. ASHRAE Handbook: 1976 Systems. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (New York, 1976), Chapter 43.

4. Page, J.K. The optimization of building shape to conserve energy. Journal of Architectural Research, Vol. 3, No. 3, September 1974, p. 20 - 28.

5. Harris, W.S., G.Y. Anderson, C.H. Fitch and D.F. Spurling. Estimating energy requirements for residential heating. ASHRAE Journal, October 1965, p. 50 - 55.

6. Michelson, W. Environmental choice, human behavior and residential satisfaction. Oxford University Press, New York, 1977.

7. ASHRAE Handbook: 1977 Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (New York, 1977), Chapters 8 and 25.

8. Grandjean, E. Ergonomics in the home. Taylor and Francis Ltd., London, 1973.

9. Farley, J. High-rise apartment or detached house: What are the implications for children's behavior. From, New Directions in Environmental Design Research, Rogers, W., and Ittelson, W.H. ed. Environmental Design Research Association, Proceedings of EDRA 9 Conference, 1978, p. 145 - 161.

10. 100 ways to save energy and money in the home. Office of Energy Conservation, Energy, Mines and Resources Canada, March 1975.

11. Mitalas, G. Net annual heat loss factor method for estimating heat requirements of buildings. National Research Council of Canada, Division of Building Research, Building Research Note No. 117, November 1976.

12. Konrad, A., and B.T. Larsen. ENCORE-Canada: Computer program for the study of energy consumption of residential buildings in Canada. Prepared for 3rd International Symposium on the Use of Computers for Environmental Engineering Related to Buildings, Banff, Alberta, Canada, May 10 - 12, 1978.

13. Household facilities and equipment. Statistics Canada, May 1978.

14. Energy conservation implications of master metering. Midwest Research Institute, Federal Energy Administration, Washington, 1976.

15. Cahn, J.G. What single-family buyers are looking for. House and Home: Housing, Vol. 52, No. 1, July 1977, p. 74 - 79.

TABLE 1

HOUSEHOLD COMPOSITION AND SAMPLE SIZE

	Household Type	Row House	Apartment	Total
1	Single Person	0	5	5
2	Single Parent	2	1	3
3	Two Adults (under 65)	2	4	6
4	Two Adults with at Least One Pre-School Child	4	0	4
5	Two Adults with a School Aged Child	2	2	4
6	Elderly Couple (+65)	1	2	3
	TOTAL	11	14	25

TABLE 2

MEAN OCCUPANT ENERGY INPUT (kW)

	Household Composition Type*					
	1	2	3	4	5	6
Energy Input	0.06	0.22	0.15	0.35	0.25	0.2

*See TABLE 1

TABLE 3

HOURS OF TELEVISION USE (HOURS)

	Mean	Standard Deviation
Week Day	4.1	2.5
Saturday	5.8	3.0
Sunday	3.3	2.0

TABLE 4

MEAN DAILY ENERGY USE (INPUT) FOR VARIOUS EQUIPMENT (kWh)

	Saturday	Sunday	Week Day	Canada Mortgage and Housing Corporation
Clothes Dryer	1.2	0.3	0.5	2.5
Washing Machine	0.1	0.0	0.1	0.25
Oven	0.3	0.5	0.2	3.3
Range	1.2	1.3	1.3	
Dishwasher*	1.1	0.6	0.9	0.8
Kettle	0.6	0.3	0.5	0.5
Toaster	0.08	0.08	0.8	0.01
Vacuum	0.1	0.1	0.05	0.01
Iron	0.1	0	0.05	0.02
TOTAL	4.16	3.0	3.5	4.3

* Dishwasher value based on population having a dishwasher

TABLE 5

TOTAL DAILY ENERGY INPUT (kWh)

	Household Type					
Source of Input	1	2	3	4	5	6
Occupants	1.5	5.3	3.6	8.4	6.0	4.8
Lighting	1.1	4.0	2.7	6.3	4.5	3.6
Equipment	5.2	7.4	7.4	11.7	11.7	7.4
Hot Water	0.5	1.0	1.0	2.0	2.0	1.0
TOTAL	8.3	17.7	14.7	28.4	24.2	16.8

TABLE 6

ENERGY INPUT FOR "TYPICAL" HOUSEHOLDS

Household Type	Day	Source of Input	Maximum Input	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				Specific Energy Input Percentage of Maximum — Time of Day - Hours																							
3	Weekday	Occupants	300 W-hr	67	67	67	67	67	67	67	83	35	0	0	0	0	0	0	0	0	35	58	100	100	100	83	67
3	Weekday	Appliances	600 W-hr	28	28	28	28	28	28	62	62	57	28	28	28	28	28	28	28	28	37	70	70	120	103	62	28
3	Weekday	Hot Water	400 W-hr	33	0	0	0	0	0	25	100	100	0	0	0	0	0	0	0	0	0	40	31	25	25	100	81
3	Weekday	Lighting†	425 W-hr	0	0	0	0	0	0	71	47	0	0	0	0	0	0	0	0	0	24	47	94	100	100	94	61
3	Holiday	Occupants	300 W-hr	67	67	67	67	67	67	67	67	78	78	33	33	0	0	0	33	33	53	53	33	33	33	33	33
3	Holiday	Appliances	600 W-hr	28	28	28	28	28	28	28	42	58	92	92	28	28	28	28	28	42	64	92	92	92	92	92	92
3	Holiday	Hot Water	400 W-hr	25	0	0	0	0	0	0	25	25	108	108	58	25	0	0	25	50	65	65	65	65	65	65	65
3	Holiday	Lighting†	425 W-hr	0	0	0	0	0	0	0	76	38	38	38	0	0	0	24	24	47	47	47	47	47	47	47	47
4	Weekday	Occupants	730 W-hr	45	45	45	45	45	45	50	55	40	40	40	40	45	40	0	40	55	79	79	100	100	70	60	43
4	Weekday	Appliances	730 W-hr	22	22	22	22	22	22	22	60	70	115	50	70	33	33	22	33	42	60	78	78	78	78	78	22
4	Weekday	Hot Water	530 W-hr	38	0	0	0	0	0	0	38	75	75	100	11	49	25	11	11	25	87	75	38	38	49	25	75
4	Weekday	Lighting†	1260 W-hr	0	0	0	0	0	0	0	52	52	21	21	21	37	21	0	21	37	84	95	100	100	84	94	52
4	Holiday	Occupants	730 W-hr	45	45	45	45	45	45	45	45	73	73	73	73	45	18	18	18	18	45	73	73	73	45	45	45
4	Holiday	Appliances	730 W-hr	22	22	22	22	22	22	22	22	42	70	22	22	42	22	90	90	90	70	50	70	70	115	115	90
4	Holiday	Hot Water	530 W-hr	38	0	0	0	0	0	0	0	38	75	175	38	38	44	44	44	44	75	162	75	75	75	38	75
4	Holiday	Lighting†	1260 W-hr	0	0	0	0	0	0	0	0	63	48	32	32	32	10	29	29	29	37	37	79	79	63	63	32
Thermostat Setting (All Days)				60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60

†rough estimate only

Use conversion factor 1 W = 3.412 14 Btu/h

TABLE 7

TIME SPENT AWAY FROM HOME FOR VARIOUS PERSONS (HOURS)

	Personality Stereotypes	Row House: Number Surveyed	Row House: Time Away From Home: Week Day	Sat.	Sun.	Apartment: Number Surveyed	Apartment: Time Away From Home: Week Day	Sat.	Sun.
i	Pre-School Child	5	1.0	1.0	1.3	-	-	-	-
ii	School Aged Child	7	7.8	3.9	4.3	5	8.6	6.4	3.3
iii	House Wife	5	1.8	3.1	2.5	-	-	-	-
iv	5-day Work Week	13	9.6	4.4	3.8	14	11.1	7.3	5.4
v	6-day Work Week	1	11.8	7.5	1.3	6	12.1	11.6	8.9
vi	Retired	2	0.9	1.5	1.8	3	1.0	0.8	4.0

TABLE 8

MEAN TIME SPENT IN ACTIVITIES BY DAY OF WEEK AND PERSONALITY STEREOTYPE (HOURS)+

Day of Week	*Personality and House Type		Activity Level: Light A	Light B	Moderate C	High D	High E
Week Day	i	Row	13.3	3.1	3.9	2.6	0.1
		Apartment	-	-	-	-	-
	ii	Row	11.2	2.5	1.1	0.9	0.1
		Apartment	10.3	3.7	0.8	0.3	0
	iii	Row	8.6	6	3.3	0.5	0
		Apartment	-	-	-	-	-
	iv	Row	9.6	2.4	0.8	0.2	0
		Apartment	9.8	2.8	0.5	0.1	0.1
	v	Row	9.8	1.5	0	0	0.1
		Apartment	9.1	2.4	0.2	0.1	0
	vi	Row	13.5	4.5	3.1	0.1	0
		Apartment	15.1	5.2	0.3	0.1	0
Saturday	i	Row	12.8	2.9	4.6	3.0	0.1
		Apartment	-	-	-	-	-
	ii	Row	13.9	2.4	2.3	1.0	0.2
		Apartment	12.4	2.4	1.4	0.1	0.1
	iii	Row	12.1	3.7	1.4	0.1	0.1
		Apartment	-	-	-	-	-
	iv	Row	12.3	3.9	2.3	0.1	0.1
		Apartment	10.8	2.8	2.1	0.3	0
	v	Row	11	2.5	0	0	0.1
		Apartment	10.2	1.8	0.5	0.1	0.1
	vi	Row	17	5.8	2.5	0.1	0
		Apartment	14.2	4.1	2.0	0.1	0
Sunday	i	Row	12.5	3.4	4.5	3.5	0.1
		Apartment	-	-	-	-	-
	ii	Row	13.9	2.3	-	0.9	0.1
		Apartment	12.0	2.5	2.8	0.2	0.1
	iii	Row	12.5	3.1	1.4	0.1	0
		Apartment	-	-	-	-	-
	iv	Row	12.8	3.9	1.9	0.1	0
		Apartment	12.0	2.7	2.4	0.1	0
	v	Row	15.0	3.0	4	0.5	0
		Apartment	11.4	2.2	0.7	0.1	0
	vi	Row	17.0	5.3	2	0.1	0
		Apartment	13.4	3.5	3.2	0.1	0

† Due to the averaging process, the values of Table 8, when added to the appropriate values of Table 7, will not necessarily add to 24 hours

* As in Table 7

TABLE 9

POSSESSION RATES OF HOUSEHOLD EQUIPMENT (%)

Equipment	Apartment	Row House	Ontario Average
Washing Machine	100	100	71
Clothes Dryer	100	91	55
Dishwasher	50	18	20
Home Freezer	7	36	47
Humidifier	57	36	23
Lawnmower	-	10	40
Air Conditioner	7	36	19

TABLE 10

PATTERN OF BLOCK HEATER USE (% OF POPULATION)

	Never Used	Only When Very Cold	Every Night 8 - 12 hours	Always
Row House	27	18	36	18
Apartment	28	14	50	7

TABLE 11

PATTERN OF WINDOW OPENING (%)*

Pattern of Opening	Season: Summer		Winter		Fall/Spring	
Often (at least 3 times a week)	Apartment	21	Apartment	21	Apartment	33
	Row	70	Row	18	Row	10
Seldom	Apartment	7	Apartment	21	Apartment	25
	Row	20	Row	18	Row	70
Never	Apartment	71	Apartment	57	Apartment	42
	Row	10	Row	64	Row	20

* Population only of persons in housing for at least one year

TABLE 12

WINDOW OPENING HABITS AND ORIENTATION

Orientation	Window Opening Habits		
	Often	Seldom	Never
Facing North	2	1	3
Facing South	2	3	1

TABLE 13

HOUSEHOLD SIZE VERSUS NUMBER OF BEDROOMS (%)

Bedrooms	Household Size				
	1	2	3	4	Total
1 Bedroom	100	-	-	-	100
2 Bedroom	45	45	10	-	100
3 Bedroom	-	50	-	50	100

TABLE 14

OCCUPANCY GROUP ACCORDING TO HOUSING TYPE

	Row House	Apartment
Pre-School	4	0
Student	8	5
Clerical/Sales/Craftsman	4	2
Public Services/Technical	8	6
Professional/Managerial	2	8
House Persons	5	0
Retired/Unemployed	1	3
Civil Servants	1	3
Military	0	1

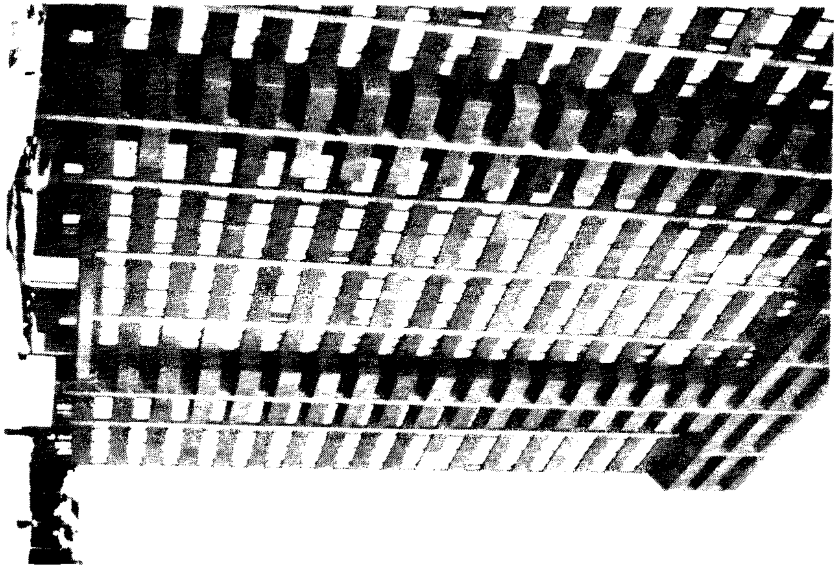

Figure 1. Apartment Building

Figure 3. Row House Development

Figure 2. Row House Development

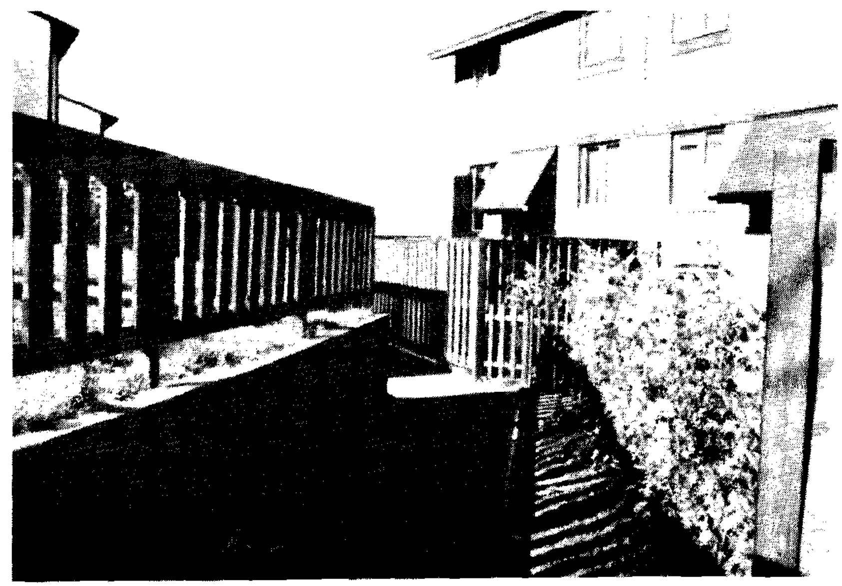

Figure 4. Row House Development

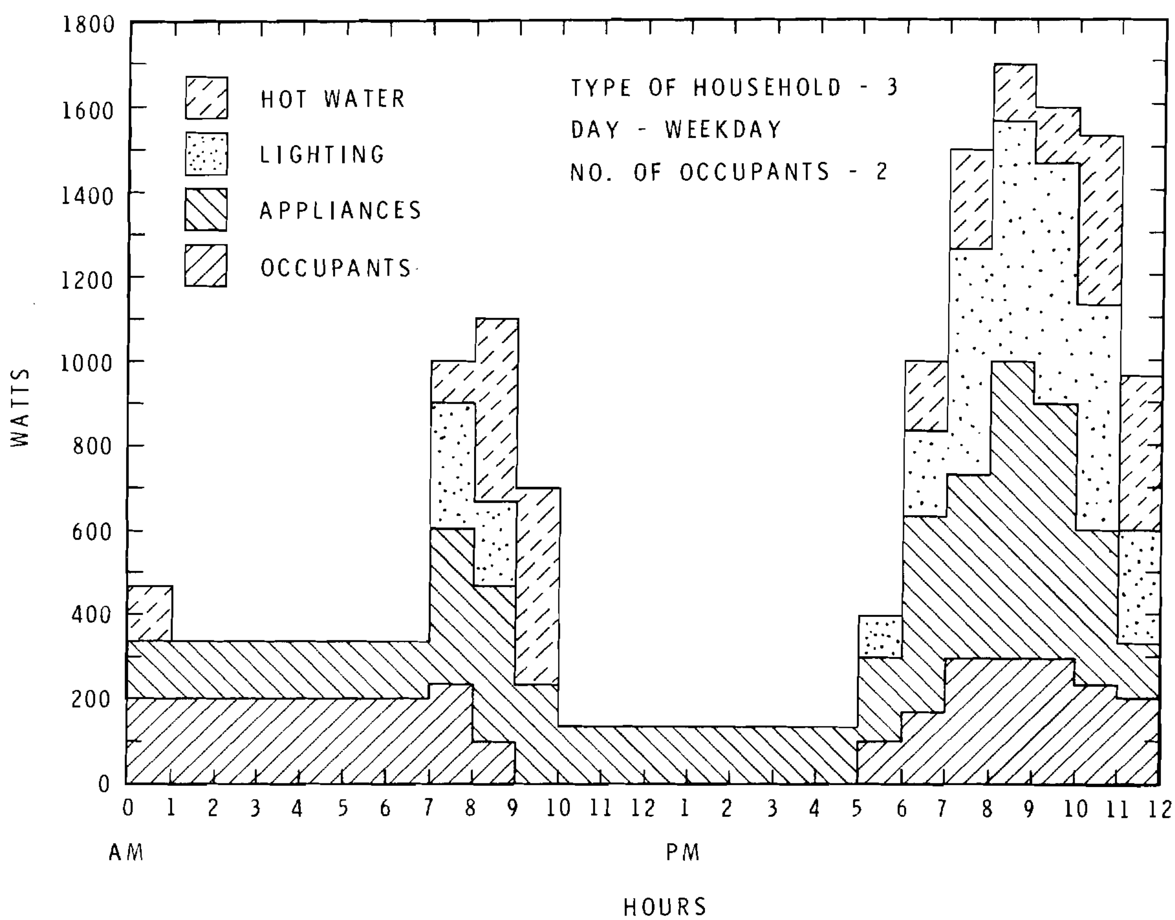

Figure 5. Energy Input vs Time of Day

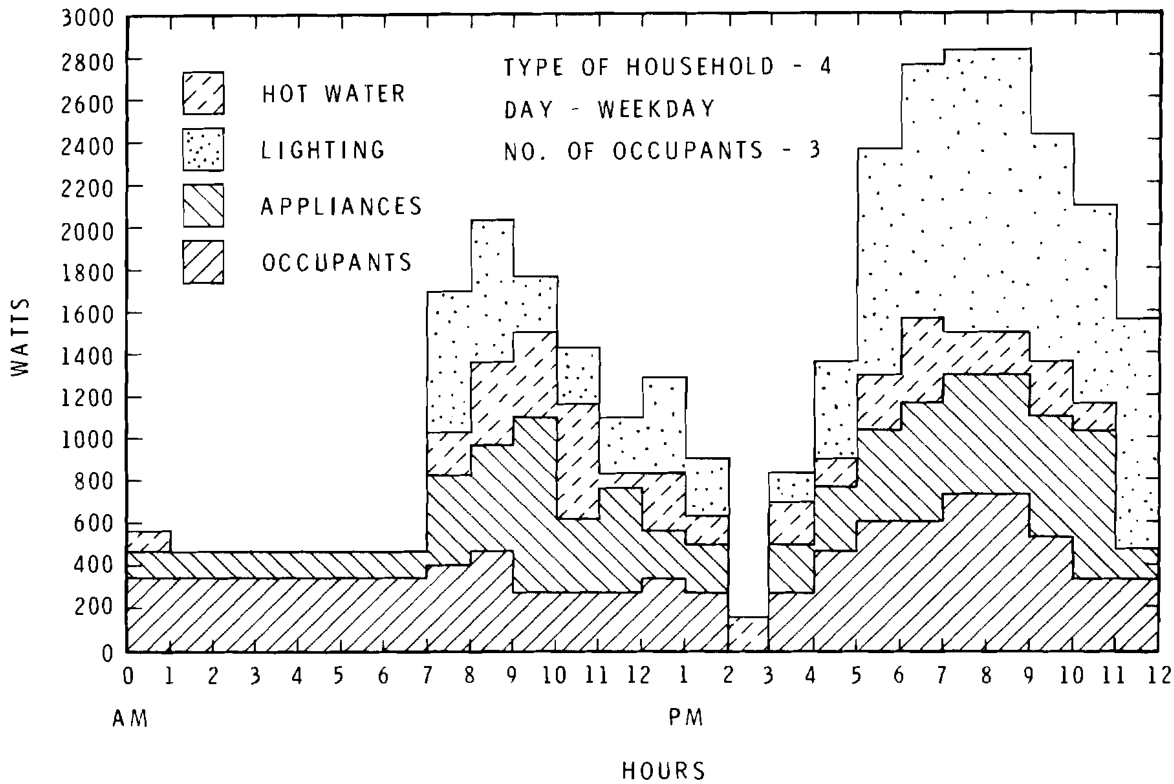

Figure 6. Energy Input vs Time of Day

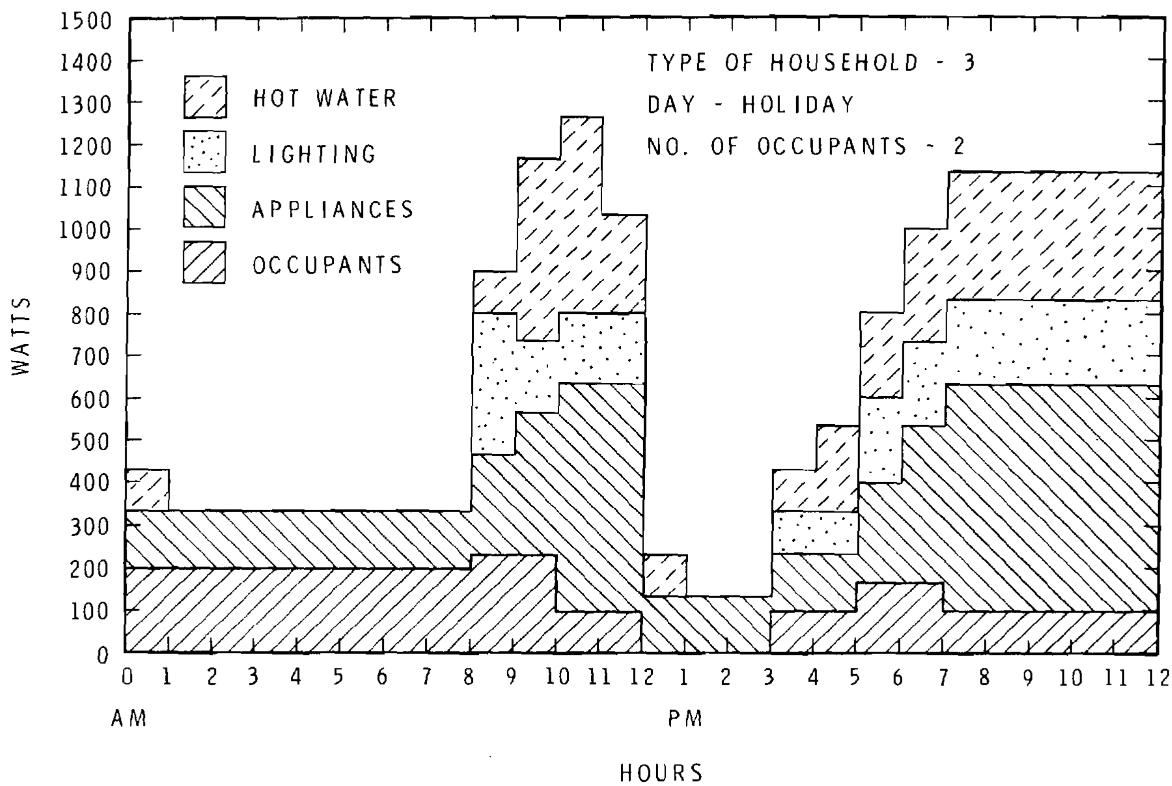

Figure 7. Energy Input vs Time of Day

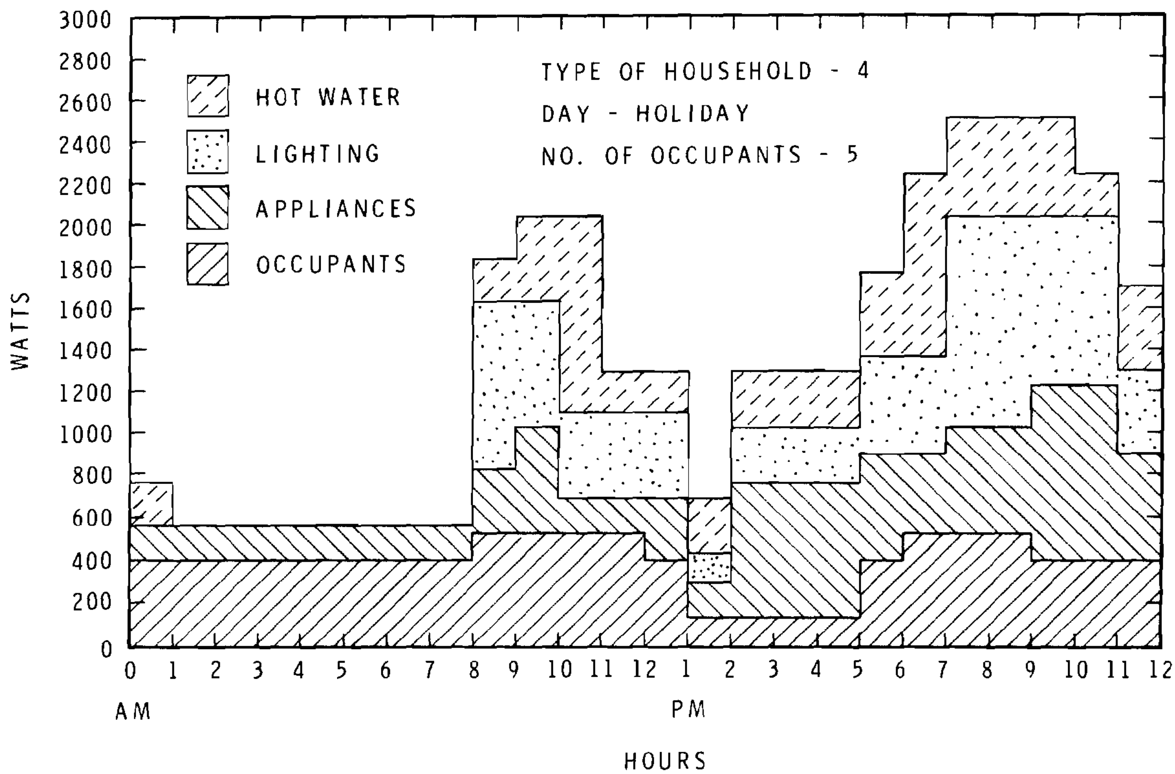

Figure 8. Energy Input vs Time of Day

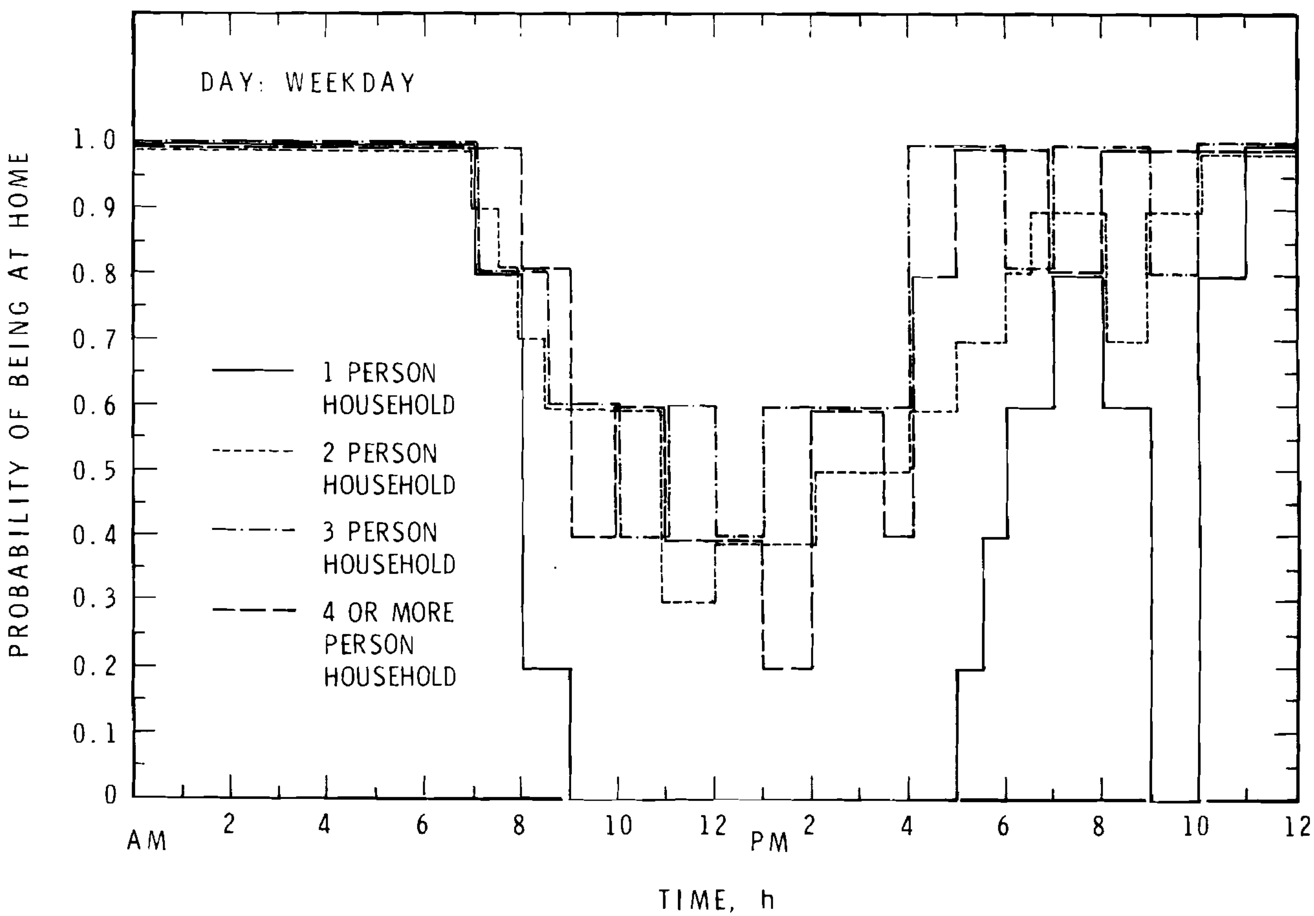

FIGURE 9

PROBABILITY OF SOMEONE AT HOME VS TIME OF DAY

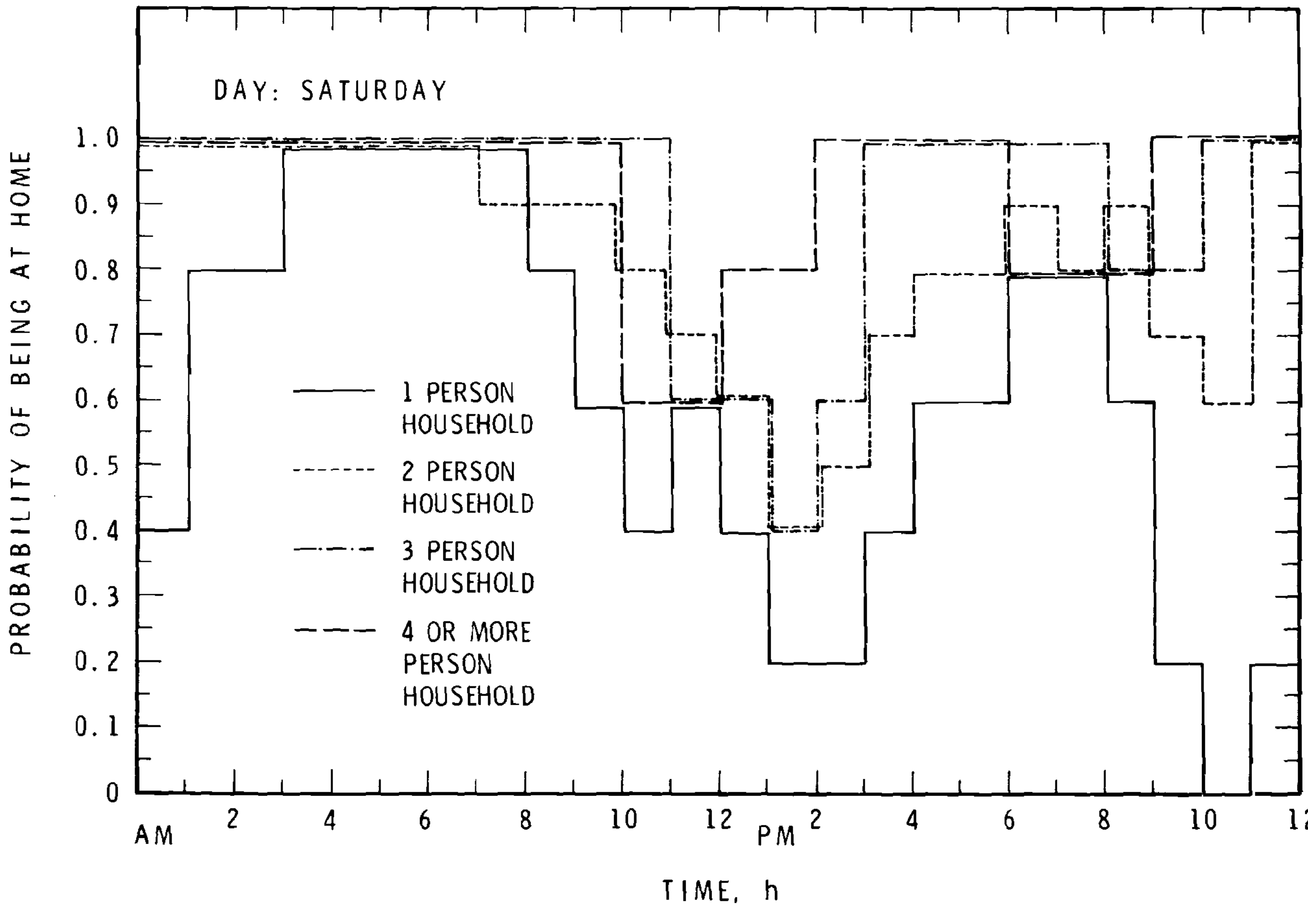

FIGURE 10

PROBABILITY OF SOMEONE AT HOME VS TIME OF DAY

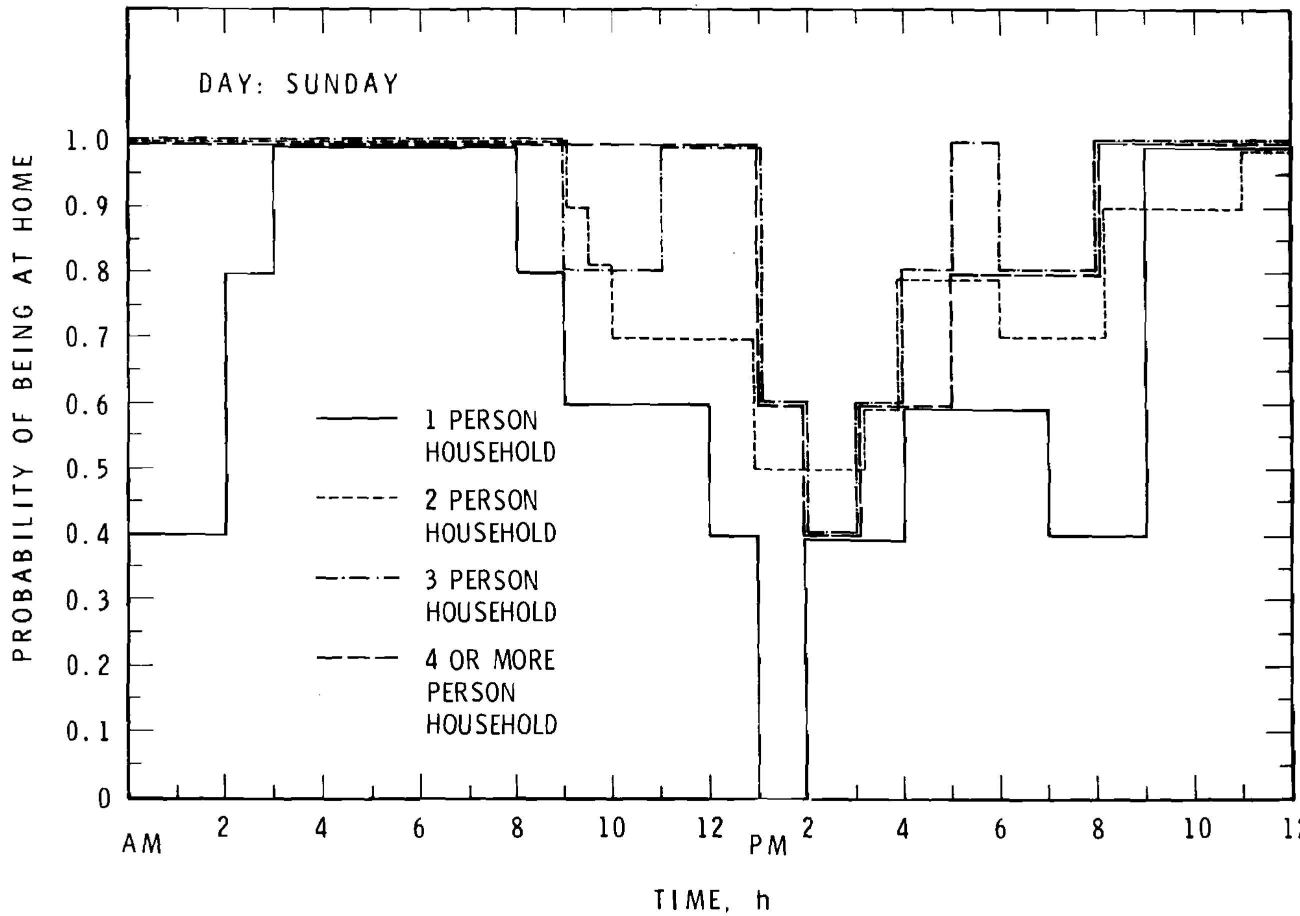

FIGURE 11

PROBABILITY OF SOMEONE AT HOME VS TIME OF DAY

Interview No.

HOUSEHOLD OCCUPANCY PATTERNS

Address ____________________

Date __________ Type of Dwelling __________ Exposure: N S E W

QUESTIONS	COMMENTS

1. a) No. of Bedrooms ______
   No. of Bathrooms ______
   Total in Dwelling ______

2. Have you a:

	Yes	No
a) Washing Machine		
b) Clothes Dryer		
c) Dishwasher		
d) Home Freezer		
e) Humidifier		
f) Portable Electric Heater		
g) Elec.Snowblower		
h) Elec.Lawnmower		
i) Air-conditioner		
j) Smoke Detector		
k) Special Equipment		

3. If you have a car plug-in, how does the weather determine your use of it?

____

____

4. a) Do you find that condensation tends to show on windows?

   ____

   If yes, what do you do about it?

   ____

   b) Do you find that static electricity is generated in your home? __________

   c) How often is a window opened in your home?

	Day	Night
Winter		
Summer		
Fall/Spring		

   d) Are you bothered by odours in the building? __________

5. For each person living in this household:

Sex	Age	Occupation

Interview No.

Imagine a Typical.....	Weekday	Saturday	Sunday
1.a) What time would you wake up? b) Would you bathe/shower then? c) Would you eat breakfast prepare breakfast (others) wash dishes, other activity? d) Would you then leave the house? (return at what time)?			
2.MORNING AT HOME: Would you do the following (in- clude time): a) Household tasks b) Engage in leisure activities c) Supervise children d) Make short trip(s) to stores, visit friends, classes e) Engage in exercise or other heavy activity?			
3.NOON: a) Are you at home around noon? b) Would you eat lunch prepare lunch wash dishes other activity?			
4.AFTERNOON AT HOME: (Time) Would you: a) Do household tasks b) Engage in leisure activities c) Supervise children d) Make short trip(s) to stores, classes, visit friends e) Engage in exercise or other heavy activity? f) What do you do just before supper?			
5.DINNER/SUPPER TIME (Time) a) Do you eat evening meal at home? b) Make the evening meal? c) Wash dishes? d) Would you be home in the evening (percentage)?			
6.EVENING AT HOME: (Time) a) Would you do household tasks b) Engage in leisure activi- ties c) Supervise children d) Make short trip(s) to stores, classes, visit friends? e) What time would you go to sleep?			

APPENDIX B

USE OF ENCORE PROGRAM

To test the effects of occupancy rate on total annual energy demand the ENCORE computer program was used for two different household types. Types 3 and 4 were chosen as they represented the extremes of energy input suitable to a single detached house. For each household a typical occupancy profile was taken (Table 8) as appropriate, then the activities of these households were converted into energy values (Btu's). These values were grouped according to whether the input came from the occupants, appliances, hot water or lighting. This was only done for week days and holidays as the ENCORE program does not accept values for Saturdays. This together with thermostat settings provided the data for the occupancy sections of the ENCORE program. For the analysis, the hot water consumption was converted back into gallons used.

APPENDIX C

DETERMINATION OF ENERGY INPUT FROM OCCUPANTS

Values of metabolic rate were taken from ASHRAE[1] and converted into energy units for the following activities:

Sleeping	70 W
Reclining	80
Seated	100
Carpentry	200 - 640
House Cleaning	200 - 340
Cooking	160 - 200
Washing, Ironing	200 - 360
Calisthenics	300 - 400
Dancing	240 - 440

These were incorporated into a more comprehensive list from Grandjean.[2] After the survey, additional activities were found that neither reference had provided values for. Consequently, an estimate was made of the energy input from these activities and a complete listing of the activities prepared under three broad headings.

Low Energy Activities (to 200 W)

A - resting, sleeping, sitting, kneeling, squatting, standing, stooping

B - sewing, knitting, peeling potatoes, ironing, writing, washing-up, reaching for objects about eye level, bathing, showering, eating

Moderate Energy Activities (200 to 300 W)

C - walking, sweeping, dusting, cleaning floors (standing), hanging out clothes, playing piano, playing quietly, sit-down games, building blocks, entertaining, hobbies (i.e., photography), mixing food

High Energy Activities (over 300 W)

D - walking (loaded), washing/polishing floor, making beds, holding objects, cleaning stair carpets, cleaning windows, dancing, carpentry, playing with friends

E - walking (heavily loaded), climbing stairs, lifting heavy loads, playing boisterously, calisthenics, skipping, weight lifting

The energy values for these activities are the total energy output for an averaged sized adult. Tables C-1 and C-2 give, for the three categories of activity, the energy produced in the form of sensible and latent heat for adults and children respectively, from ASHRAE Table 25-16.[3] The total values for adults and children were used to prepare occupant energy input graphs. The graphs, if of interest to the reader, can be seen by contacting the Building Performance Section of the Division.

In the preparation of Table C-1 the metabolic rate of adult women was used as that was the usual person at home.

REFERENCES

1. ASHRAE Handbook: 1977 Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (New York, 1977), Chapters 8 and 25.

2. Grandjean, E. Ergonomics in the home. Taylor and Francis Ltd., London, 1973.

3. ASHRAE Handbook: 1976 Systems. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (New York, 1976), Chapter 43.

Table C-1

Energy Input of Adults (Watts)

	Sensible	Latent	Total
Low Energy Activity	60	40	100
Moderate Activity	100	130	230
High Energy Activity	120	255	375

Table C-2

Energy Input of Children (Watts)

	Sensible	Latent	Total
Low Energy Activity	45	35	75
Moderate Activity	95	75	170
High Energy Activity	100	180	280