Energy consumption of buildings and occupant behavior. An investigation in Mediterranean climatic conditions

Piero Bevilacqua - Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, Italy - piero.bevilacqua@unical.it
Cristina Carpino - Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, Italy - cristina.carpino@unical.it
Dafni Mora - Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, Italy - dafni.mora@unical.it
Marilena De Simone- Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, Italy - marilena.desimone@unical.it

Abstract

The article illustrates the results of a study regarding occupancy profiles and energy needs of residential buildings located in a Mediterranean climate (southern Italy). Different parameters are collected by using surveys: data from bills, characteristics of buildings, family composition and practices, heating, cooling and DHW systems, control strategies. The data processing is used in order to identify occupancy scenarios and representative case studies. The influence of the occupancy profiles on thermal performances of selected buildings is investigated by energy simulations comparing thermal losses and gains obtained by means of the application of Standard procedures contained in UNI/TS 11300-1 and real patterns. Heating energy needs and comfort parameters are studied considering the variables influenced by occupant behavior: set point temperature, ventilation, lighting, appliances and shading systems.

1. Introduction

An integrated building design process needs the analysis of the interactions of all building components and external factors on the energy demand: location, building envelope, heating, ventilation, air conditioning, lighting systems, appliances. In particular, it is difficult to predict the energy consumption patterns in residential buildings, considering that they depend on the cost of energy, gender, age, employment, family size, socio-cultural belonging, etc (Steemers and Yun, 2009). The effect of occupant behavior on building energy consumption was examined by many researchers. The results come to a consensus that the occupant behavior has a large influence on the indoor environment and energy demands. Studies in the USA and the Netherlands have determined that building characteristics explain only from 40 to 54% of variation in energy use (Guerra-Santin, 2010). Investigations conducted in China reveal that socio-economic and behavior variables are able to explain 28.8% of the variation in heating and cooling energy consumption (Chen et al., 2013).

The control of indoor conditions, such as ventilation and air temperature, has a strong effect on the interaction between the household and the dwelling. In fact, buildings usually do not perform as predicted, even when very sophisticated energy simulation methods are used. For this reason accurate use profiles should be introduced in energy calculations and simulation programs to deliver more accurate energy performances (Motuziene and Vilutiene, 2013). This means that use profiles of HVAC systems, domestic hot water systems and electricity have to be known. Hetus (Harmonised European Time Use Survey) provides statistical data of people’s use of time in different European countries. The data analysis shows that there are differences in time spent for different activities depending on culture. In addition, there is the dependency on the climate zone. For example, in the southern part of Europe, people spend more time eating and for leisure purposes compared to the north. In different countries, inhabitants behave differently and this aspect has to be taken into account when predicting the building energy demand by means of simulation tools. In (de Meesteret et al., 2013) the influence of family size, control of the heating system and management of the heated area on the heating loads of a standard dwelling in Belgium is investigated. Simulations of the building with different insulation levels showed that the impact of internal gains (occupant's lifestyle) on energy consumption is more significant for the case with better thermal insulation. In (Deurinck et al., 2012) the effect of building retrofit taking into account different occupancy patterns is analyzed and the gap between predicted and actually achieved energy saving is correlated to the indoor temperature take back.

The aim of this article is to investigate the influence of building occupancy on the prediction of energy needs and comfort conditions of residential buildings in Mediterranean climate conditions. The study is carried out by using data collected by surveys and energy simulation of representative case studies. The data processing is used to identify reference construction types, family compositions and occupancy profiles. The influence of occupant behavior on energy performances is investigated by simulations using DesignBuilder, which is an interface of simulation engine EnergyPlus (DesignBuilder, 2014).

2. Data collection

The study focuses on residential buildings and the sources of information are questionnaires, energy bills and statistical data. The collection activity started in 2012, the participants were the families of engineering students at the University of Calabria. The investigated area is the Calabria region located in southern Italy with a population of about 2 million. In total, 111 households were interviewed, obtaining 98 available ones, with a response rate of 88%. The survey consists of 63 questions divided in six groups of parameters: general information, energy consumptions, conditioning and DHW, appliances, occupant behaviors and renewable energy systems. With the aim of determining the characteristics of the building stock and occupancy profiles, the paper presents a partial elaboration of the entire available data, in particular of:

1) parameters describing physical characteristics of dwellings;
2) climatic conditions;
3) family information;
5) heating system;
6) daily routine about the use of heating system, windows, lighting, shutters, sunshades.

In order to know if the data set is representative of the population, it was compared with data provided by the National Institute of statistics (Istat, 2014). The average age of the respondents was 36.9 years in accordance with the average age of population of 42.9 years. The gender distribution in the data set was 46.3% males and 53.7% females, in good accordance with the regional repartition, 48.7% males and 51.3% females. 53.8% of responses stated a family income of lower than 30,000 euro, and the average regional value is €23,995. The average annual household electricity consumption is 2,509 kWh for the Calabria region comparable with 2,733 kWh of the data set.

3. Data presentation and analysis

The data regarding general information of the sample are reported in table 1.

The mean floor area of dwellings is 140.8 m^2 and the majority of respondents, 55.9%, live in an apartment, 24.3% in a detached house and 7.2% in a semi-detached house.

28.8% of buildings were built before 1980 and 44.1% before 1990. With relation to the structures, 78.4% of the buildings are made of reinforced concrete and 6.3% in stone. This last typology is traditional in the considered region. Mainly windows are classified as having double-glazing with 69.4% of responses, whereas 28.6% of buildings present single glass. Considering the national classification in climatic zones, 9.5% of the cases correspond to the climate zone B, 33.3%, 46.4% and 10.7% to the climate zones C, D and E respectively.

38% of annual income is less than €30,000, 30% between €30,000 and €70,000, 30% of people did not answer, probably related to the privacy of personal information. The mean number of family members is 3.71 and, in terms of age, 53.4% of people are younger than 30 years. Table 2 shows the results regarding heating and thermal comfort.

The type of heating generation system mostly used is a wall-mounted gas boiler: 57.6%; a fire place follows with 14.4% of the responses. In relation to the fuel, 72.5% of buildings use methane, 8.8% LPG and 11.3% biomass.

Generally, occupants are satisfied with the thermal sensation.

Table 1 – General information: building characteristics, climatic conditions, family composition. N number of cases.

Variable		Responses		N	Percentage [%]
Building	Type	1.	Single house	27	24.3
		2.	Apartment	62	55.9
		3.	Double house	8	7.2
		4.	Other	1	0.9
		5.	Don't answer	13	11.7
	Year of construction	1.	Before 1980	32	28.8
		2.	1980 - 1990	17	15.3
		3.	After 1990	49	44.1
		4.	Don't know	0	0
		5.	Don't answer	13	11.7
	Floor area (m²)	1.	Less than 69	9	8.1
		2.	70-100	22	19.8
		3.	101-149	36	32.4
		4.	More than 150	31	27.9
		5.	Don't answer	13	11.7
	Structure	1.	Reinforced concrete	87	78.4
		2.	Stone	7	6.3
		3.	Wood	0	0
		4.	Other	4	3.6
		5.	Don't answer	13	11.7
	Type of windows	1.	Double glass	68	69.4
		2.	Single glass	28	28.6
		3.	Other	2	2.0
		4.	Don't know	0	0
		5.	Don't answer	0	0
Climate	Climate zone / Heating degree day	1.	A (less than 600)	0	0
		2.	B (601-900)	8	9.5
		3.	C (901-1400)	28	33.3
		4.	D (1401-2100)	39	46.4
		5.	E (2101-3000)	9	10.7
		6.	F (more than 3000)	0	0
Family information	Age (years)	1.	Less than 30	194	53.4
		2.	30-50	33	9.1
		3.	50-65 years	120	33.1
		4.	More than 65	4	1.1
		5.	Don't answer	12	3.3
	Gender	1.	Female	182	53.7
		2.	Male	157	46.3
	Total annual income (€)	1.	Less than 30000	42	37.8
		2.	30000-70000	33	29.7
		3.	70000-10000	2	1.8
		4.	More than 100000	1	0.9
		5.	Don't answer	33	29.7

In table 3 and 4 information about occupant behavior in relation to the use of lighting and windows opening, external shutters and sunshades is shown.

Data reveal that 27% of houses have energy saving lamps, 52.3% partially use energy saving lamps. Occupants switch lamps on when it is too dark in both the living room and bedroom and open windows at a fixed time in the morning.

The majority of buildings have external shutters used following different methods: 26.1% always open and 13.5% open at a fixed time in the living room, 18% always open and 15.3% always closed or open at a fixed time in bedrooms.

Table 2 – Heating system and thermal comfort conditions. N number of cases.

Variable		Survey responses		N	Percentage [%]
Heating	Generation system	1.	Air source heat pump	3	2.5
		2.	Electricity	10	8.5
		3.	Wall-mounted gas boiler	68	57.6
		4.	Fireplace	17	14.4
		5.	Pellet	1	0.8
		6.	Other	6	5.1
		7.	No answer	13	11.0
	Fuel	1.	Methane	58	72.5
		2.	LPG	7	8.8
		3.	Diesel	1	1.3
		4.	Biomass	9	11.3
		5.	other	1	1.3
		6.	No answer	4	5
	Thermal sensation	1.	Very satisfied	22	19.8
		2.	It doesn't matter	12	10.8
		3.	Satisfied	42	37.8
		4.	Not satisfied	17	15.3
		5.	No answer	18	16.2

Sunshades are not used diffusely and they are adopted both in summer and winter.

Table 3 – Daily routine of occupants, lighting and windows opening. N number of cases.

Variables		Survey responses		N	Percentage [%]
Lighting	Type of lighting	1.	All are energy saving	30	27.0
		2.	Some are energy saving	58	52.3
		3.	No energy saving lamps	8	7.2
		4.	No answer	15	13.5
	Switch lamp - Living room	1.	Always switch on as long as entering the room	9	8.1
		2.	When too dark	82	73.9
		3.	Other	4	3.6
		4.	No answer	16	14.4
	Switch lamp – Bedroom	1.	Always switch on as long as entering the room	8	7.2
		2.	When too dark	82	73.9
		3.	Other	5	4.5
		4.	No answer	16	14.4
Windows	Opening – Living room	1.	Always open	18	16.2
		2.	Always closed	7	6.3
		3.	Open at fixed time	31	27.9
		4.	Other	35	31.5
		5.	No answer	20	18.0
	Time of the day it is open – Living room	1.	Morning	16	69.6
		2.	Afternoon	4	17.4
		3.	All day	3	13.0
	Opening – Bedroom	1.	Always open	11	9.9
		2.	Always closed	2	1.8
		3.	Open at fixed time	41	36.9
		4.	Other	36	32.4
		5.	No answer	21	18.9
	Time of the day it is open –Bedroom	1.	Morning	27	84.4
		2.	Afternoon	2	6.3
		3.	All day	3	9.4

4. Occupancy profiles and cases study

The data processing evidences the characteristics of the analyzed building stock in terms of building types, climatic conditions, family composition and heating system.

In addition, representative occupants' behaviors in managing windows and lighting are shown.

In order to investigate the importance of the use of real occupancy profiles in determining energy needs by simulation, two cases study were chosen according to the results of data analysis. For both cases, dynamic calculations of heating energy need are carried out considering input data provided by the Standard UNI/TS 11300-1, with reference to the most common situation in which occupant behavior is not available, and introducing as input real modalities about occupancy, ventilation, appliances, lighting, windows components. This last analysis is possible when an accurate investigation is used.

In particular, a single-family house and an apartment were analyzed.

The study was carried out by comparing the results obtained adopting the Standard procedure and those based on real occupancy profiles achieved by interview.

Table 4 – Daily routine of occupants, shutters and sunshades use. N number of cases.

Variables		Survey responses		N	Percentage [%]
Shutters	Have shutters	1.	Yes	69	62.2
		2.	No	24	21.6
		3.	No answer	18	16.2
	Opening – Living Room	1.	Always open	29	26.1
		2.	Always closed	12	10.8
		3.	Open at fixed time	15	13.5
		4.	Other	13	11.7
		5.	Don't have	24	21.6
		6.	No answer	18	16.2
	Opening – Bedroom	1.	Always open	20	18.0
		2.	Always closed	17	15.3
		3.	Open at fixed time	17	15.3
		4.	Other	12	10.8
		5.	Don't have	24	21.6
		6.	No answer	21	18.9
Sunshades	Have sunshades	1.	Yes	23	28.8
		2.	No	40	50.0
		3.	No answer	17	21.3
	Position related to the glazed system	1.	External	19	23.8
		2.	Interpane	1	1.3
		3.	Internal	3	3.8
		4.	Don't have	40	50.0
		5.	No answer	17	21.6
	Type	1.	Awning	4	5.0
		2.	Venetian blind	4	5.0
		3.	Brise-soleil	0	0
		4.	Screen	2	2.5
		5.	Shutter	12	15.0
		6.	Pleated curtain	1	1.3
		7.	Don't have	40	50.0
		8.	No answer	17	21.3
	Seasonal use	1.	Only during the summer	3	3.8
		2.	Only during the winter	0	0
		3.	In winter and summer	20	25.0
		4.	Don't have	40	50.0
		5.	No answer	17	21.3

4.1 Description of dwellings

The considered houses are situated in the climate zone C, the heating period is from 15 November to 31 March.

The climate file used for dynamic simulations was created from the data reported in the Standard UNI 10349 for the city of Cosenza (UNI 10349, 1994).

The single-family household is represented in figure 1. It was built in 1978, the external walls are in masonry without thermal insulation and the thermal transmittance is equal to 1 W/m²K.

The building consists of two floors with a net area of 134 m².

Transparent surfaces have single glazing, the frames are made of wood. The family is compose of three people and inhabited zones are located on the first floor.

Fig.1 – Single family house.

The house has seven rooms, see fig. 2, five of which are heated (living room, two bedrooms, bathroom and utility room); in the kitchen and hallway there is no control of the internal conditions.

The generator system is a wood-burning boiler fireplace and the internal air temperature is controlled by a thermostat.

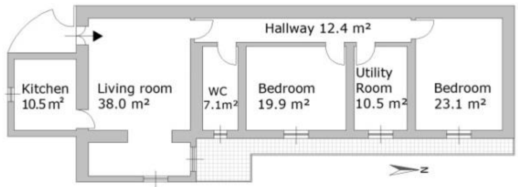

Fig. 2 – Map of the single family house.

The second case study is an apartment of 80 m², built in 2008 in reinforced concrete (see fig. 3).

Fig. 3 – Apartment in condominium.

The insulated walls have thermal transmittance of 0.6 W/m²K, windows assemble double glazing and frame with thermal break. The apartment is located on the second floor and there is one inhabitant, the heated zones are shown in fig. 4. The heating system is autonomous with a zone thermostat and gas boiler.

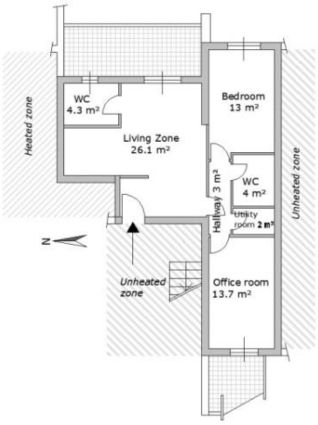

Fig. 4 – Map of the apartment.

4.2 Calculation of heating energy needs according to UNI/TS 11300-1

The heating requirement is calculated according to the type of evaluation A2 Standard (AssetRating), which allows to determine conventional energy needs, useful for comparing buildings in their actual use (UNI/TS 11300-1, 2014).

This method assumes the operation of the heating system in continuous regime and a fixed set point temperature of 20 °C. The internal heat loads are obtained by the sum of sensible contribution, calculated in relation of the floor area or equal to 450 W/m² for dwellings with floor area greater than 120 m², and latent contribution evaluated using the relation:

$$Q_{wv,int} = \frac{h_{wv} \times (G_{wv,Oc} + G_{wv,A}) \times t}{3600} \quad (1)$$

where h_{wv} is the specific enthalpy of water vapor, conventionally set equal to 2544 J/gr; $(G_{wv,Oc} + G_{wv,A})$ is the flow rate of water vapor due to the presence of people and equipment, mediated on time, set equal to 250 gr/h for dwellings. The total value of internal loads amounts to 4.7 W/m² for the single house and 8.1W/m² for the apartment. In DesignBuilder the "Lumped" mode was used according to which all internal gains including occupancy, equipment miscellaneous, catering process and lighting are grouped into a single value. Regarding ventilation, the Standard assumes a constant air change that includes both the effect of infiltrations, due to air permeability of the envelope, and external flow rate provided for environmental comfort.

The air flow rate $q_{ve,k,mn}$is calculated according to the procedureof the "Ventilation flow in reference conditions", using the equation:

$$q_{ve,k,mn} = q_{ve,O,k} \times f_{ve,t,k} \quad (2)$$

where $q_{ve,O,k}$ is the minimum amount of outdoor air, in m³/s;$f_{ve,t,k}$is a correction factor representing the fraction of time in which the k-th air flow takes place and which considers the use profile and infiltrations that occur even when the ventilation is not operating. Its value is set at 0.60 for both the cases of study, $q_{ve,O,k}$ is evaluated using the relation:

$$q_{ve,0,k} = n \times {}^{V}/_{3600} \quad (3)$$

where n is the air change for hour and V is the net volume of the thermal zone, including kitchens, bathrooms, hallways and utility rooms.The flow rate obtained is equal to 0.3 ach.

In DesignBuilder the "Scheduled Natural Ventilation" mode with the outside air definition method "By zone" was adopted, which allows us to set the air changes per hour.

Table 5 summarizes the terms of the energy balance influenced by occupant behaviors and the heating energy need obtained by simulation.

In particular, thermal losses through glazed surfaces, the heat lost by natural ventilation, solar and internal gains are considered in order to quantify in a detailed way the effects of user profiles.

Table 5 – Standard procedure application. Seasonal energy contributions and heating need.

	Glazing [kWh/m²]	Natural Ventilation [kWh/m²]	Solar gains [kWh/m²]	Internal loads [kWh/m²]	Heating [kWh/m²]
Single house	-13.4	-9.2	10.3	14.2	48.4
Apartment	-8.0	-9.7	7.0	26.6	16.5

For the single house, the thermal losses through the windows represent the main negative contribution, solar gains and internal loads are comparable. The heating energy need is 48.4 kWh/m².

For the apartment, the evaluated energy performance is 16.5 kWh/m²and is influenced in a large amount by the internal loads that are about triple if compared with the other energy inputs.

4.3 Heating energy needs according to the actual use of dwellings

In the single house, the heating system is switched on from 8:00 to 23:00 during the day and the set point temperature is 20°C.

Internal gains of occupants, equipment and lighting were defined by schedules in order to specify use time-profiles in each zone.

The presence of occupants was detailed considering the sensible and latent thermal loadsrelated to the specific activity (AICARR, 2005). Table 6 shows the occupancy profiles set in Design Builder.

Knowing the electrical power of each appliance, the corresponding thermal power and the hourly usage, the thermal power per unit area was calculated. Table 7 shows the equipment schedule.

Also for the lighting, operating schedules were created and its thermal input was calculated taking into account that 75% of the electric power is converted into thermal power (see table 8).

Table 6 – Occupancy profile for the single-family house.

Room	Hours	Occupants	Occupant density [person/m²]	Thermal load [W/person]
Kitchen	3 1 2 18	3 2 1 0	0.28 0.19 0.09 0	132
Living room	2 1 21	3 2 0	0.08 0.05 0	116
Bathroom	3 21	1 0	0.14 0	132
Bedroom	18 6	1 0	0.05 0	97
Bedroom	8 1 15	2 1 0	0.09 0.04 0	97

Table 7 – Equipment schedule for the single-family house.

Room	Appliance	Electric power [W]	Thermal Power [W]	Days of operation per week	Hours of operation per day	Average hourly power [W/m²h]
Kitchen	Refrigerator	180	90	7	24	8.5
	Freezer	110	55	7	24	5.2
Living room	Tv	87	78	7	4	0.34
Bathroom	Washing machine	800	160	1	1	0.94
	Boiler	1200	240	1	1	1.42
Bedroom	Pc	65	58	7	8	0.97
Utility room	Iron	800	400	1	0.3	0.45

Table 8 – Lighting schedulefor the single-family house.

Room	Usage per day [h]	Electric power [W]	Thermal power [W/m²]
kitchen	1	36	2.6
Living room	0	92	1.8
Bathroom	2	44	4.7
Bedroom	1	27	0.9
Utility room	1	18	1.3

Air changes were treated by adopting the “Calculated Natural Ventilation” mode that allows us to determine the airflow between internal and external environment, according to the building orientation and wind exposure, envelope air permeability and windows openings.

Generally, windows are opened every morning from 8:00 to 9:00 and one hour after midday. External shutters operate during the night in order to reduce heat losses.

A similar approach was used in order to create using profiles for the apartment.

Tables 9–11 summarize occupancy, equipment and lighting schedules.

Table 9 – Occupancy profile for the apartment.

Room	Hours	Occupants	Occupant density [person/m²]	Thermal load [W/person]
Living zone	5	1	0.04	116
Bathroom 1	2	1	0.25	132
Bedroom	9.5	1	0.08	97
Utility room	0.5	1	0.50	116
Office room	0.5	1	0.07	116
Hallway	0.5	1	0.33	116
Bathroom 2	0	1	0.00	0

Table 10 – Equipment schedule for the apartment.

Room	Appliance	Electric power [W]	Thermal Power [W]	Days of operation per week	Hours of operation per day	Average hourly power [W/m²h]
Living zone	Microwave	1200	600	7	0.5	0.48
	Refrigerator	180	90	7	24	3.44
	TV	150	135	7	2	0.43
	DVD	40	36	1	2	0.02
	Iron	800	400	1	1	0.09
Bathroom 1	Hairdryer	2000	1900	2	0.5	1.41
Utility room	Washing machine	1850	370	1	3	3.30
Office room	PC	55	49.5	2	2	0.04

Table 11 – Lighting schedule for the apartment.

Room	Usage per day [h]	Electric power [W]	Thermal power [W/m²]
Living zone	4	142,5	5.45
Bathroom 1	2	18,75	4.69
Bedroom	1	60	4.62
Utility room	0,5	52,5	26.25
Office room	0,5	60	4.37
Hallway	0,5	30	10.00

The heating system operates from 18:00 to 23:00 and the indoor air temperature is set to 22°C.

Windows are opened in the living room and bedroom for one hour in the morning, sunshades are activated in the bedroom and office room all day. In table 12, the results obtained by energy simulation of both the cases study are summarized. The use of real occupancy profiles for the single house determines a substantial increase in the energy need, equal to 61%, with respect to the value obtained by application of the Standard calculation. Fundamentally, this result is a consequence of the considerable increment of the thermal losses by natural ventilation.

In fact, the adoption of real scenarios in windows opening increases the air changes from 0.3 ach to 1.28 ach.

Table 12 – Real occupancy profile application. Seasonal energy contributions and heating need.

	Glazing [kWh/m^2]	Natural Ventilation [kWh/m^2]	Solar gains [kWh/m^2]	Internal loads [kWh/m^2]		
				Lighting	Equipment	Occupancy
Single house	-11.4	-46.3	10.3	0.8	5.9	6.8
					13.5	
Apartment	-6.2	-8.0	5.7	1.5	6.2	3.1
					10.7	
Heating [kWh/m^2]						
Single house	77.8					
Apartment	20.9					

The application of actual schedules regarding shutter use and internal loads determines moderate changes in comparison to the results provided by the Standard.

The heat losses through the windows record a reduction of 15%, for internal loads the reduction is 5%. Occupancy contributes for 50% to the internal gains.

For the apartment, the heating energy need is subjected to an increase of 27% due to a significant reduction of internal loads equal to 60%.

In this dwelling, equipment contributes for the most part to internal gains. The usage of sunshades determines a reduction of 23% in heat losses and of 19% in solar gains through the glazed surfaces.

Air changes increase from 0.3 ach to 0.33 ach, but thermal losses by ventilation report a reduction as window opening takes place when the heating system is switched off.

Occupant behavior influences both energy needs and the quality of indoor environments.

In tables 13 and 14 the thermal comfort conditions for the single house and the apartment respectively are shown.

Discomfort time represent the percentage of time when both the humidity ratio and operative temperature do not respect the ASHRAE 55 comfort criteria.

Furthermore, discomfort time percentage calculated with respect to the occupation time is marked for each room.

Table 13 – Single house, predicted mean vote (PMV)and discomfort hours for the occupied periods.

Zone	PMV	Discomfort (h)	Discomfort time (%)
Bedroom	-1.76	2210.3	90
Bathroom	-0.31	343.7	84
Double room	-1.92	1141.1	93
Kitchen	-0.91	715.9	88
Living Room	-0.90	387.6	95

Table 14 – Apartment, predicted mean vote (PMV) and discomfort hours for the occupied periods.

Zone	PMV	Discomfort (h)	Discomfort time (%)
Bathroom 1	-0.69	137.5	51
Hall way	-1.10	30.8	45
Bedroom	-2.64	1009	78
Utility room	-1.07	30.0	44
Office room	-1.11	35.0	51
Living Room	-1.47	369.7	54

For the single house, 90% of the time spent in the bedroom is characterized by discomfort conditions and thermal sensations of cool, in the apartment the hours of discomfort are 78% of the total. For both the cases of study, the comfort analysis reveals a thermal sensation of slightly cool in the majority of the heated zones.

5. Conclusions

Data collected by surveys were processed in order to identify the main characteristics of residential buildings located in southern Italy. Two representative cases study were selected and the influence of occupancy profiles on energy simulation results was analyzed.

In particular heating energy needs have been obtained by DesignBuilder using the calculation procedure of the UNI/TS 11300-1 Standard regarding occupancy and ventilation and by application of real use profiles summarized in schedules.

The results of the energy simulation show the importance of occupancy contribution on the final thermal performance of dwellings.

For the single-family house, window opening has the most important role and determines an increase of 61% in energy demand when real profiles are applied.

The application of the standard procedure for the apartment causes the overestimation of internal loads and the energy need increases of 27% in actual usage conditions.

In addition, internal comfort quality is related to daily routine of inhabitants. For both the cases under study, thermal sensations of slightly cool are reported in the heated zones.

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