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Energy and thermal performance of apartment buildings in Albania: the case of a post-communist country

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Abstract: This paper undertakes a comparative evaluation of the energy and thermal performance of apartment buildings in Albania built both Pre-90 and Post-91 (a year that marks the change of the political system from communism to democracy in Albania). Building surveys, occupant surveys and continuous monitoring of outdoor and indoor environmental conditions during the summer and winter to allow for seasonal variations, were conducted in 29 case study flats randomly selected to represent both periods. Electricity bills were also provided for a full year. It was found that electricity consumption has been 22% lower in flats built Pre-90 and that the average temperature in living rooms were found to be very close to 29°C in summer and 16°C in winter in both Pre-90 and Post-91. Notwithstanding that measured average temperatures were similar in the two building cohorts, higher range and variance on mean indoor temperature has been found in summer in the flats built Pre-90, which has affected the thermal sensation votes of occupants living in them. It was found that over 60% of residents living in apartment buildings built Pre-90 were feeling cold in winter and hot in summer, compared to 30-40% of residents living in apartment buildings built Post-91, who felt cold in winter and hot in summer respectively. Although the findings cannot be treated as statistical generalization, the analysis provides an in-depth contextual insight into environmental, thermal and energy performances of flats in Albania, which would help inform future energy retrofitting programmes.

Keywords: Energy performance, thermal comfort, occupant's behaviour, apartment buildings, post-communism

1. Introduction

As in many countries in Europe, improving the existing stock in Albania is considered as the highest potential contributor to the energy saving targets of the National Energy Efficiency Plan (Energy Community, 2011), given the fact that building sector is the second largest energy consumers in Albania with over 40% of total carbon emissions (Energy Community, 2015; Global Buildings Performance Network, 2015). Even more, reducing energy reduction in buildings is considered essential to increase the energy security of the country (Energy Charter Secretariat, 2013). Although Albania, as a developing country, has no obligations towards reducing any quantity of greenhouse gas emissions (United Nations Human Rights, 2015), the built area and the energy consumption in the building sector is expected to increase as a result of the continuous development of the country. Moreover, Gupta (2013) remarked that we expect people to spend more time in the buildings in the future in the developing countries, as in developed countries (90% of the time), consequently increasing the energy consumption and health issues.

Furthermore, the economic situation of Albania makes it difficult to consume the necessary amount of energy to provide the adequate thermal comfort in houses. At least 25% of the population cannot afford to pay for energy and 95% of those with access to electricity say it is too expensive to use (Fankhauser and Tepic, 2005). Today, the housing stock is in a poor condition also due to long-term lack of renovation, mainly because of lack of financing for this purpose. Therefore, it is inevitability to improve the energy performance, as well as increase the thermal comfort in the existing homes in Albania.

However, regional, social and cultural variation including differences in climatic conditions, income level, building materials and techniques have probably underestimated (Kohler, 1999) when designing energy retrofitting programmes. In line with this, in a post-communist society, where, on one hand people took control over their lives, property and economy and on the other hand, were left with feelings of weakness and powerless to self-organize because of for a long time previously being controlled by the state, it is important to know whether their expectations of the comfort that their indoor environment must provide has also changed. The last 27 years have marked many changes in Albania, not only in the built environment, but also in the way people live and respond to their environment.

In this context, this paper presents a comparative analysis of energy and thermal performance between the flats built Pre-90 and Post-91. The aim is to create an insight of energy and thermal performance of flats is Albania built during two main political periods and whether there is a correlation between how people feel in terms of thermal comfort and building period. Although flats represent only 6% of the residential buildings in Albania, they accommodate over 35% of the total households in Albania (Novikova et al., 2015). A socio-technical approach consisting of building and occupants' surveys, electricity data' collection, as well as indoor and external temperature measurements, was followed to give an overall picture of environmental, energy and thermal performance of flats across both periods. Statistical analyses have been undertaken to find correlations between them and other factors, such as, demographic, building or behavioural factors.

1.1. Apartment buildings built Pre-90 and Post-91

Most of buildings in Albania, and especially apartment buildings, have been the product of a quick and cheap construction strategy because of the housing shortage during the communist regime (Pre-90) and after, from the rapid urbanization that happened with the beginning of the democracy, which paid no intention to the quality of life of their occupants. Homes built during communist regime (53% of all apartment buildings' stock in Albania) were minimalist, demonstrating the power of the system over people's life and space. The approved standards were 4-6 m^2 per person (United Nations, 2002), causing discomfort of life related to living conditions in them. On the other hand, the size of households were large due to the fact that more than one generation shared the same dwelling (Aliaj, 1999), mainly because for cultural reasons and strong traditional values of marriage and family, as well as economic reasons. Apartment buildings constructed during this period were mainly prototype designs of low-rise blocks of flats, typically with loadbearing brick constructions or pre-fabricated concrete elements.

With the change of the political system to democracy, there was a massive and uncontrolled flow of population from rural to urban areas. Therefore, the biggest intent was to build bigger houses at a low cost, with no concern to neither the design nor energy efficiency nor thermal comfort. Apartment buildings were characterised by high-rise (above 8 floors) concrete frames structures with hollow bricks in-fill and no wall insulation.

Although the Building Code was revised in 1989, the Energy Building Code come to life in 2003, but it was never implemented. Therefore, most of the residential buildings in Albania are uninsulated and built with no concern to energy efficiency. Table 1 gives an overview of building and socio-economic characteristics of both periods considered in this paper.

Table 1: Building and socio-economic characteristics of two main construction periods in Albania

Period	Building characteristics	Socio- economic characteristics
Pre-90	• Low-rise blocks of flats (six floors max) • Typically, loadbearing brick construction or pre-fabricated elements • Prototype designs • Limited space standards • High technical standards due to the strict control • Average household size in the sample is 3.2 members • Average number of bedrooms is 1.6 • Average density is 0.054 people/m^2	• Immigration was totally controlled by the communist government • No housing markets • Big families in small flats • Low-cost buildings • Buildings of this period supported the 'collective' aspect of communism ideology: 'Let's build quickly, good and cheap' slogan
		
Post-91	• Many ground-floor flats were converted to non-residential use • Most common construction is concrete frames with hollow brick in-fill • Limited building controls • Average household size in the sample is 3.4 members • Average number of bedrooms is 1.8 • Average density is 0.049 people/m^2	• Rapid and massive free movement from rural to urban areas • Overpopulation of cities • Most of public stock was privatized • Most new housing has been produced by the private sector • Individualist society
		

2. Methodology

The analysis presented in this paper relate to 29 owner-occupied case study flats out of 49 dwellings selected to represent Albanian housing stock for an on-going research by the authors that aims to investigate the most effective retrofitting strategies for energy savings and improving thermal comfort in residential buildings in Albania. From the group of 29 flats, 13 have been built Pre-90 and 16 Post-91. The year 1990 is taken as the reference year where a massive social, economic and cultural change has happened in Albania affecting also the construction industry, as the result of the political change from the communist regime to democracy.

A socio-technical approach was used to collect quantitative and qualitative data from 29 flats in Tirana, Albania, in summer and winter, in order to have an overall picture of energy and thermal performance of the flats in the most energy consuming seasons of the year. Data collection consisting of:

Building surveys to gather information regarding the building properties and energy use. Quantitative data were collected regarding building materials and construction, orientation, floor area, appliances and lighting, which creates a detailed picture of energy use and behaviours within the flat. The survey was undertaken only once (in June-July) because the information gathered would be the same in both seasons for the same flats. Electricity bills were also obtained for 22 out of 29 flats.

Occupants' survey through questionnaire-guided interviews to get insights of how and when the house has been used, as well as occupants' behaviours in their home. The study adopted the method of questionnaire-guided interviews, as the most appropriate technique for gathering of all essential information in full range and depth, as well as getting insights of occupants' behaviours. The survey included also a transverse questionnaire, with questions to assess their comfort sensation and preference in summer and winter. Only one occupant per dwelling participated in the survey, to provide consistency across the research, and a total of 29 responses for each season was gathered.

Continuous monitoring of the outdoor and indoor temperature in the living room and main bedroom of the flats in summer and winter, to assess the thermal comfort in the house.

iButtons, with accuracy of (± 0.5)°C and a measurement range of (-10)°C to (+65)°C, were used to record the indoor temperature of the main living room and bedrooms of the flats in summer and winter for 6 weeks per season at half-hourly intervals to allow for seasonal variations. Data loggers were placed by the researcher in secure places in the living rooms and bedrooms away from external walls, direct solar radiation and devices that generate heat or air conditioning, to minimise any local effects on the measurements. Outside air temperature was also measured at 30-minute interval for 6 weeks in summer and 6 weeks in winter. The decision on the instrument was made on the minimum interference and upsetting of occupants' activities and life, as well as cost.

An overview of data collected for each flat is given in Table 2:

Only the living room measurements are considered for the scope of this study and all the analysis presented in this paper has been undertaken using SPSS Statistics, Version 24.

Table 2: Data collected for each flat

	Building survey	Occupant's survey	Transverse thermal comfort survey		Continuous measurement of living room temperature		Continuous measurement of bedroom temperature		Monthly electricity data
			Summer	Winter	Summer	Winter	Summer	Winter	
F1	√	√	√	√	√	√	√	√	√
F2	√	√	√	√	√	√	√		
F3	√	√	√	√	√	√	√	√	√
F4	√	√	√	√	√	√	√	√	√
F5	√	√	√	√	√	√	√	√	√
F6	√	√	√	√	√	√	√	√	√
F7	√	√	√	√	√	√	√		
F8	√	√	√	√	√	√	√	√	√
F9	√	√	√	√	√	√	√	√	√
F10	√	√	√	√	√	√	√	√	√
F11	√	√	√	√	√	√	√	√	√
F12	√	√	√	√	√	√	√	√	√
F13	√	√	√	√	√	√	√	√	
F14	√	√	√	√	√	√	√	√	√
F15	√	√	√	√	√	√	√		
F16	√	√	√	√	√	√	√	√	
F17	√	√	√	√	√	√	√	√	√
F18	√	√	√	√	√	√	√	√	√
F19	√	√	√	√	√	√	√	√	√
F20	√	√	√	√	√	√	√	√	√
F21	√	√	√	√	√	√	√	√	√
F22	√	√	√	√	√	√	√	√	√
F23	√	√	√	√	√	√	√	√	√
F24	√	√	√	√	√	√	√	√	√
F25	√	√	√	√	√	√	√	√	√
F26	√	√	√	√	√	√	√	√	√
F27	√	√	√	√	√	√	√	√	
F28	√	√	√	√	√	√	√	√	√
F29	√	√	√	√	√	√	√	√	

Flats built pre-1990

Flats built post-1991

2.1. Survey sample

From 22171 apartment buildings in Albania, over 30% of them are in Tirana (Instat, 2012). Flats were randomly selected form various parts of Tirana, the capital of Albania. Most of them were mixed-used with shops on ground floor and residential on the others. From the sample, 13 flats are built Pre-90 and 16 flats are built Post-91.

Table 3 presents the frequency of different characteristics in the sample. Pre-fabricated concrete panels and solid brick walls were very common constructions during the communist regime of Pre-90, while insulation has only started to be applied in the last ten years or so. Date of construction ranged from 1950 to 2013. Most of the flats have 1-2 bedroom. The household size in the sample is 1-5 members and are of different ages (children to elderly members).

Table 3: Frequency of different characteristics in the sample

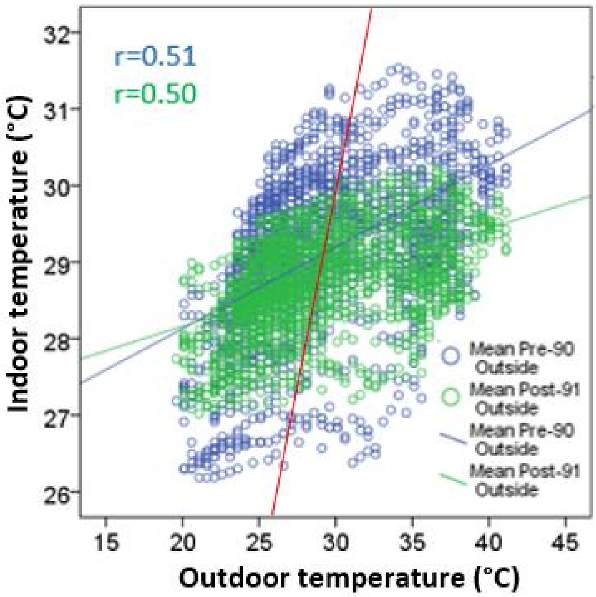
Categories		Count n	Percentage %
Period	Pre-90	13	44.8%
	Post-91	16	55.2%
Main construction material	Stone	0	0.0%
	Full brick	5	17.2%
	Hollow brick	14	48.3%
	Pre-fabricated	3	10.3%
	Hollow brick and insulation	2	6.9%
	Silicate brick	5	17.2%
How many bedrooms?	1 bedroom	10	34.5%
	2 bedrooms	17	58.6%
	3 bedrooms	2	6.9%
What is the highest education level in your household?	Elementary	0	0.0%
	High school	6	20.7%
	University	23	79.3%
Household size	1	2	6.9%
	2	6	20.7%
	3	7	24.1%
	4	9	31.0%
	5	5	17.2%
How many persons younger than 18 live in the household?	0	13	44.8%
	1	9	31.0%
	2	7	24.1%
How many persons older than 65 live in the household?	0	19	65.5%
	1	6	20.7%
	2	4	13.8%
Type of heating	No heating	0	0.0%
	Heat pumps	19	65.5%
	Electric heater	6	20.7%
	Gas heater	0	0.0%
	Wood stove	0	0.0%
	Heat pumps and electric heater	2	6.9%
	Heat pumps and gas heater	1	3.4%
	Individual central heating	1	3.4%
Type of cooling	No cooling	1	3.4%
	Air conditioning	19	65.5%
	Electric cooler	4	13.8%
	Air conditioning and electric cooler	5	17.2%

Electricity was the most commonly type of energy used for space heating mainly due to lack of infrastructure or security for using other types such as gas and wood, and air-conditioning devices are the most common heating and cooling in the flats in the sample. Almost in all dwellings, electricity consumption increases during the winter months (November-March) with its peak in January and in summer (June – August) in July, associated with heating and cooling respectively. The normalised electricity use by area has reached values from 50 to 120kWh/m^2/year in flats built both Pre-90 and Post-91, however the yearly average electricity consumption in flats built Post-91 has been found to be 22% higher than in those built Pre-90.

3. Temperature distribution and thermal comfort during the summer

The indoor temperature of 29 living rooms and 26 main bedrooms were monitored from 30 June to 12 August 2016 at half-hourly intervals, to cover the hottest season of the year in the Albanian climate. The outdoor temperature ranged between 19.6°C to 41.1°C, while the indoor temperature ranged from 23°C to 36.5°C (mean 29.1°C) and 24.5°C to 35.5°C (mean 28.7°C) in living rooms of flats built before and after 1990 respectively.

Figure 1 gives temperature distribution of the whole set of the indoor (living rooms) and outdoor temperature recordings during the summer for both flats built Pre-90 and Post-91, followed by a descriptive analysis of the mean indoor temperature. Each dot represents the average of the recorded temperature of all flats built Pre-90 (blue) and Post-91 (green) every 30 minutes, against the recorded outdoor temperature. It is found a wider range (5.4°C) and larger variance (1.1°C) in the indoor temperatures in flats built Pre-90 compared with flats built Post-91 with range and variance of 3.2°C and 0.4°C respectively.



Descriptive analysis	Average of flats Pre-90	Average of flats Post-91
N	2047	2047
Minimum (°C)	26.2	27.0
Maximum (°C)	31.5	30.2
Mean (°C)	29.1	28.7
Std. Deviation	1.0	0.6
Range	5.4	3.2
Variance	1.1	0.4

Figure 1: Average of recorded indoor temperature of flats built both Pre-90 (blue) and Post-91 (green) plotted against recorded external temperature. The red line shows where the indoor and outdoor temperatures are equal. The table presents the descriptive analysis of the recorded indoor temperatures averaged for flats built in both cohorts

Indeed, there is a higher proportion of indoor temperatures experienced towards the hot end of the spectrum in the flats built Pre-90, as shown in the population pyramid given in Figure 2. The average of the recorded indoor temperature has a wider variance in flats built Pre-90, but it has a higher concentration around 29°C in flats built Post-91.

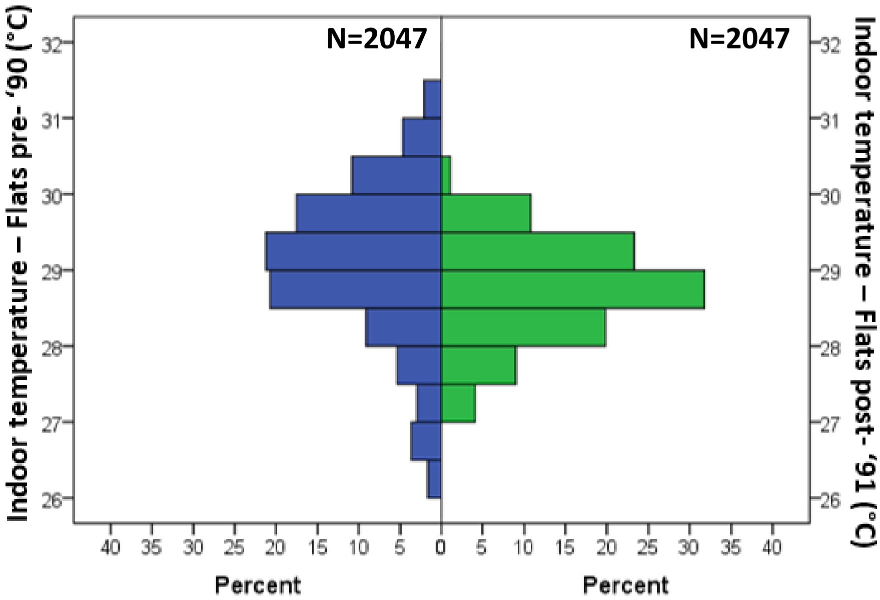


Figure 2: Comparison of indoor averaged indoor temperature distribution in summer between flats built Pre-90 and Post-91

Looking at the running daily mean temperature during the monitoring period (See Figure 3) there are found recorded indoor temperatures above 25°C almost all the time in all the flats, being well above the recommended figures from the guidelines (23°C -25°C) (CIBSE, 2006). Notwithstanding that most of them have the ease with which indoor temperatures can be lowered by adjusting the air conditioning system, indoor temperatures up to 31°C have been found very common in summer. Furthermore, the daily mean temperatures have been up to 1°C higher in flats built pre-1990.

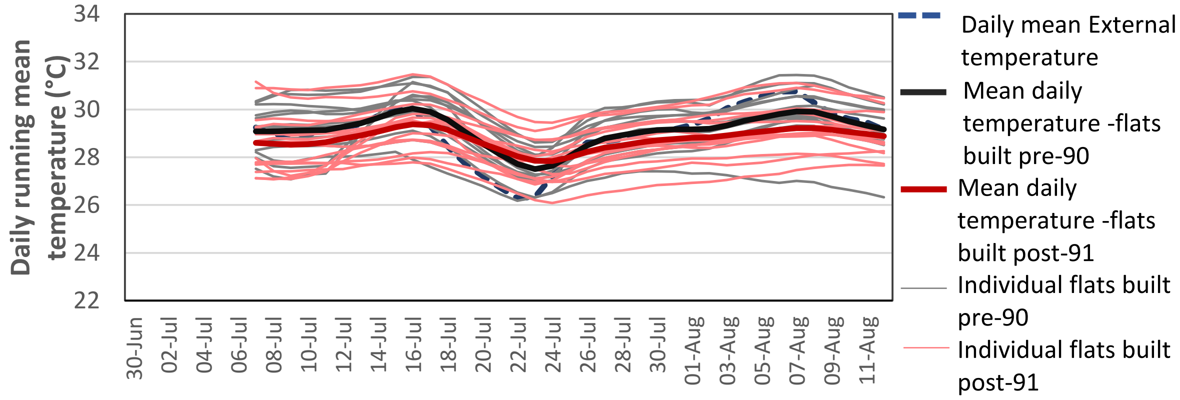
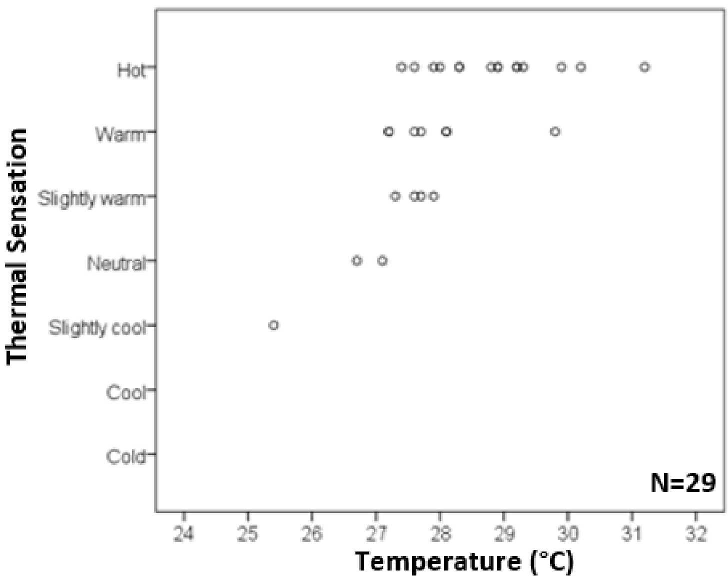


Figure 3: Daily running mean indoor temperatures in summer for each flat and averaged for flats built Pre-90 and Post-91

3.1. Thermal comfort in summer

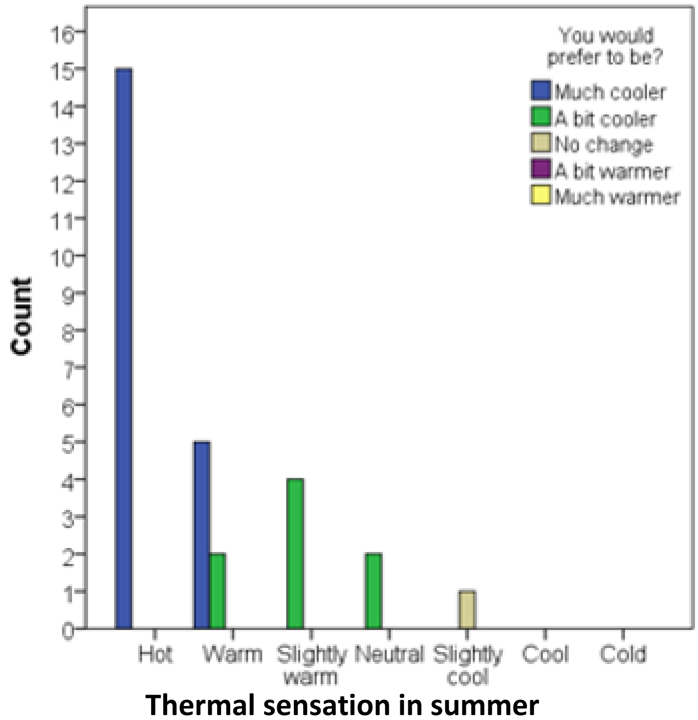
Subjective evaluation of the thermal environment was provided using a 7-point ASHRAE scale for the thermal sensation evaluation and a 5-point scale for thermal preference (ASHRAE, 1992). From the thermal sensation vote distribution given in Figure 4, followed by a descriptive analysis, it is shown that about 90% of the participants reported feeling warmer than neutral during the summer, from which over 50% of them were feeling hot, for a mean temperature of 28.9°C (SD=1.0). Only two occupants were feeling neutral for mean temperature of 26.9°C (SD=0.3) and one slightly cool for mean temperature of 25.4°C.



n	Mean (°C)	s.d. (°C)	Min (°C)	Max (°C)
15	28.9	1.0	27.4	31.2
7	28.0	0.9	27.2	29.8
4	27.6	0.3	27.3	27.9
2	26.9	0.3	26.7	27.1
1	25.4	.	25.4	25.4
0	.	.	.	.
0	.	.	.	.

Figure 4: Total thermal sensation votes in summer and descriptive statistics for each scale

In Figure 5 are shown the thermal preferences votes corresponding with each thermal sensation votes reported during the survey in summer. All the participants that were feeling hot (T=28.9°C) and most of them that were feeling warm (T=28.0°C), wanted to feel much cooler. All the others (T=26.9-28.0°C) wanted to feel a bit cooler, except the person that was feeling slightly cool who wanted no change (T=25.4°C)



N=29

	Much cooler	A bit cooler	No change	Total
Hot	15	0	0	15
Warm	5	2	0	7
Slightly warm	0	4	0	4
Neutral	0	2	0	2
Slightly cool	0	0	1	1
Cool	0	0	0	0
Cold	0	0	0	0
Total	20	8	1	29

Figure 5: Thermal sensation votes reported in summer and crosstabulation with thermal preference votes

Comparing thermal sensation votes of participants living in flats built Pre-90 and Post-91 (Figure 6), it was found that the proportion of people feeling hot was higher in the flats built Pre-90 (70%) than those living in flats built Post-91 (44%). However, the mean temperature was also higher in those flats. Only two persons reported feeling neutral in flats built Post-91 for a mean temperature of 26.9°C.

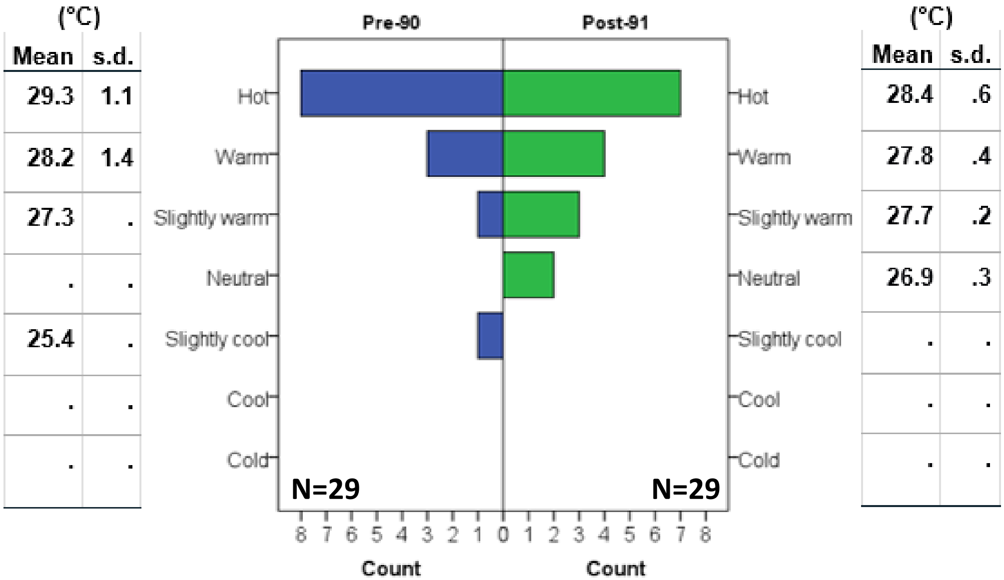


Figure 6: Comparison of thermal sensation votes in summer for flats built Pre-90 and Post-91, together with descriptive statistics of indoor temperature for each ASHRAE thermal sensation scale

A descriptive analysis is given in Table 4, comparing indoor temperature and thermal sensation votes in flats built both Pre-90 and Post-91, for several variables. Interestingly, mean indoor temperature and thermal sensation votes are not affected by the size of the household in both periods.

The presence of children and elder members in the household is higher in the flats built Post-91 and the mean indoor temperature was generally lower in those flats compare to the indoor temperature in flats built Pre-90. However, the thermal sensation in households with children and elder members were higher in flats built Post-91 than those built Pre-90. Over 80% of the flats were air conditioned, however mean indoor temperatures have been over 28°C. There were only three flats where air conditioning was on all day, while most of them were cooled for a few hours mainly in afternoon and evening. Windows were left open for the rest of the time. However, six of the participants reported to open windows and doors all day, even when the cooling was on.

Higher thermal sensation votes and higher mean indoor temperatures (0.5-1°C higher) have been found in air-conditioned flats built Pre-90 compared with flats built Post-91. Interestingly, higher mean indoor temperatures and thermal sensation votes have been found in insulated flats built Post-91 compared to uninsulated ones.

Table 4: The mean and standard deviation of the indoor temperature, and thermal sensation votes for flats built Pre-90 and Post-91, for different variables in summer

	Pre-90						Post-91					
	Temperature (°C)			ASHRAE*			Temperature (°C)			ASHRAE*		
	n	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.
Household size												
1	1	29.8	.	1	3.00	.	1	30.3	.	1	3.00	.
2	3	28.7	.5	3	2.33	.58	3	27.9	.4	3	2.33	.58
3	3	29.1	.9	3	3.00	.00	4	28.8	.4	4	1.50	.58
4	5	29.2	1.2	5	2.00	1.73	4	28.5	.3	4	1.75	1.50
5	1	29.0	.	1	1.00	.	4	29.1	1.4	4	2.25	1.50
How many persons younger than 18 live in the household?												
0	6	29.1	.7	6	2.67	.52	7	28.6	.9	7	1.86	1.07
1	3	28.4	1.2	3	1.67	2.31	6	29.0	1.1	6	2.00	1.26
2	4	29.6	.6	4	2.25	.96	3	28.5	.4	3	2.33	1.15
How many persons older than 65 live in the household?												
0	6	29.5	.7	6	2.67	.52	13	28.8	.9	13	1.85	1.14
1	5	28.9	1.0	5	1.80	1.79	1	27.3	.	1	3.00	.
2	2	28.4	.2	2	2.50	.71	2	29.0	.9	2	2.50	.71
Type of cooling												
No cooling	1	28.6	.	1	2.00	.	0	.	.	0	.	.
Air conditioning	7	29.2	1.0	7	2.14	1.46	12	28.7	.7	12	2.00	1.13
Electric cooler	2	29.2	1.3	2	3.00	.00	2	29.9	.9	2	2.00	1.41
Air conditioning and electric cooler	3	29.0	.7	3	2.33	1.15	2	28.0	1.0	2	2.00	1.41
Are the walls being insulated?												
No	13	29.1	.8	13	2.31	1.18	11	28.7	.8	11	1.82	1.17
Yes	0	.	.	0	.	.	5	28.9	1.1	5	2.40	.89
Have you got double glazing?												
No	11	29.2	.7	11	2.55	.69	7	28.8	1.0	7	2.14	1.21
Yes	2	28.5	1.8	2	1.00	2.83	9	28.7	.8	9	1.89	1.05
When do you switch the cooling on during the day?												
No cooling	0	.	.	0	.	.	2	29.9	.9	2	2.00	1.41
Afternoon	6	29.2	.8	6	2.67	.52	3	28.7	.9	3	2.33	.58
Evening	1	29.3	.	1	2.00	.	1	28.6	.	1	.00	.
Afternoon + evening	4	29.1	.6	4	2.50	1.00	9	28.7	.7	9	2.00	1.12
All day	2	28.6	2.0	2	1.00	2.83	1	27.3	.	1	3.00	.
Do you cool the house during the night?												
No	10	29.2	.7	10	2.70	.48	11	28.8	.7	11	2.00	1.00
Yes	3	28.7	1.4	3	1.00	2.00	5	28.5	1.2	5	2.00	1.41
When do you open the windows in summer?												
Afternoon	1	28.9	.	1	3.00	.	1	28.7	.	1	1.00	.
Evening	0	.	.	0	.	.	1	30.3	.	1	3.00	.
During the night	1	27.2	.	1	-1.00	.	0	.	.	0	.	.
Morning + evening	4	29.5	.2	4	2.75	.50	7	28.6	.5	7	1.43	1.27
All day	3	29.1	.9	3	2.33	1.15	3	29.0	.6	3	2.67	.58
All day and night	3	29.5	.9	3	2.33	.58	1	30.5	.	1	3.00	.
Evening and night	1	28.4	.	1	3.00	.	3	27.8	.6	3	2.33	.58

*ASHRAE seven-point scale: Hot=3; Warm=2; Slightly warm=1; Neutral=0; Slightly cool=-1; Cool=-2; Cold=-3

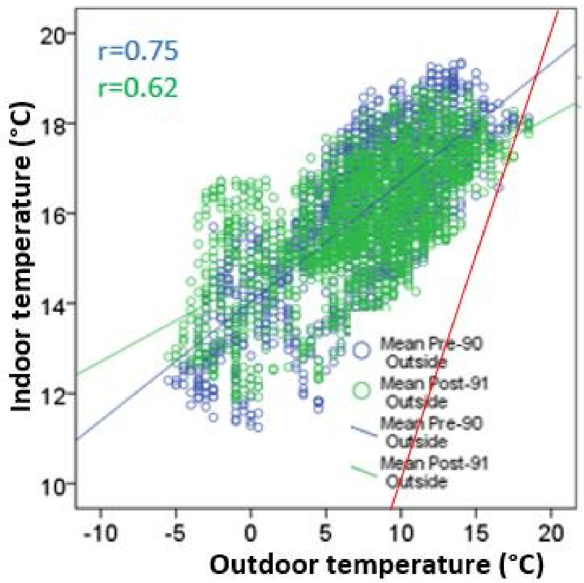
On the other hand, the presence of double glazing might have affected the indoor temperatures and thermal sensation votes, as they were higher for flats with single glazing compared to those with double glazing. Expectable, flats that had cooling on all day, had lower indoor temperatures, compared to those that had cooling on only for some hours a day. Notwithstanding that indoor temperature has been lower in the flat built Post-91 that had cooling on all day, the occupant participating in the survey reported to feel hot. From 29 flats (13 built Pre-90 and 16 built Post-91), most of them have been not cooled during the night in summer and the thermal sensation votes have been higher in flats built Pre-90 compared to those built Post-91. Opening the windows all day, have caused the indoor temperature to be higher, associated with higher thermal sensation votes, in both cohorts. In the other hand, opening the windows only during the night has resulted in lower indoor temperatures and thermal sensation votes.

4. Temperature distribution and thermal comfort during the winter

The indoor temperature of 29 living rooms have been monitored from 5 January to 16 February 2017 at half-hourly intervals, to cover the cold season. The outdoor temperature ranged between -5.5°C to 18.5°C, while the indoor temperature ranged from 4.5°C to 28°C (mean 16.1°C) and 2.5°C to 27.5°C (mean 15.9°C) in living rooms of flats built Pre-90 and Post-91 respectively.

The same analysis approach as per summer is taken also for the data collected during the winter survey. Figure 7 gives temperature distribution of the whole set of the indoor and outdoor temperature recordings during the winter for both flats built Pre-90 and Post-91, followed by a descriptive analysis of the mean indoor temperature.

Notwithstanding that there has been found a very close mean indoor temperature to 16°C for flats built in both cohorts, there is a wider range and variance of the mean indoor temperatures of flats built Pre-90 (8.1°C and 2.7°C respectively) compared to the range and variance of flats built Post-91 (7°C and 1.8°C respectively).



Descriptive analysis	Average of flats Pre-90	Average of flats Post-91
N	2048	2048
Minimum (°C)	11.3	11.9
Maximum (°C)	19.4	18.8
Mean (°C)	16.1	15.9
Std. Deviation	1.6	1.4
Range	8.1	7.0
Variance	2.7	1.8

Figure 7: Average of recorded indoor temperature of flats built both Pre-90 (blue) and Post-91 (green) plotted against recorded external temperature. The red line shows where the indoor and outdoor temperatures are equal. The table presents the descriptive analysis of the recorded indoor temperatures averaged for flats built in both cohorts during the winter

The correlation r between the indoor and the outdoor temperature is noticeably higher in winter than in the summer. This suggests that the indoor temperature is more influenced by the outdoor temperature in winter than in summer. The similarity in temperature distribution is also illustrated in the population pyramid shown in Figure 8. The mean indoor temperatures are between 14°C and 18°C for most of the time in flats of cohorts.

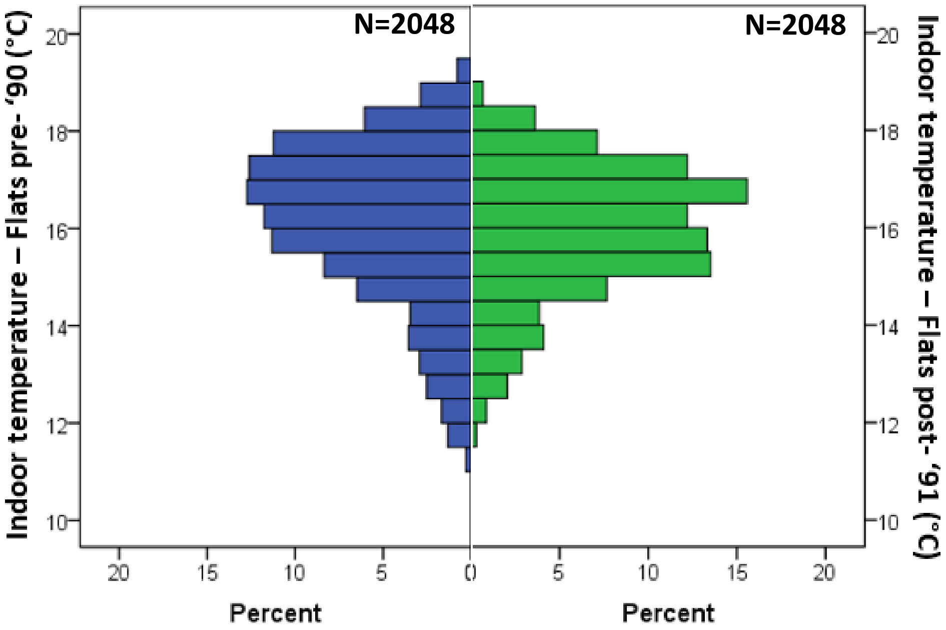


Figure 8: Comparison of indoor temperature distribution in winter between flats built Pre-90 and Post-91

Figure 9 give a line graph of recorded temperature of each flat distinguished by line colours representing flats built Pre-90 and Post-91. Generally, indoor temperature recorded in flats built Pre-90 reach lower values than the flats built Post-91, except two flats built Post-91 that have recorded very low indoor temperatures throughout the monitoring period. The flats were occupied by working couples that typically returned home in evenings.

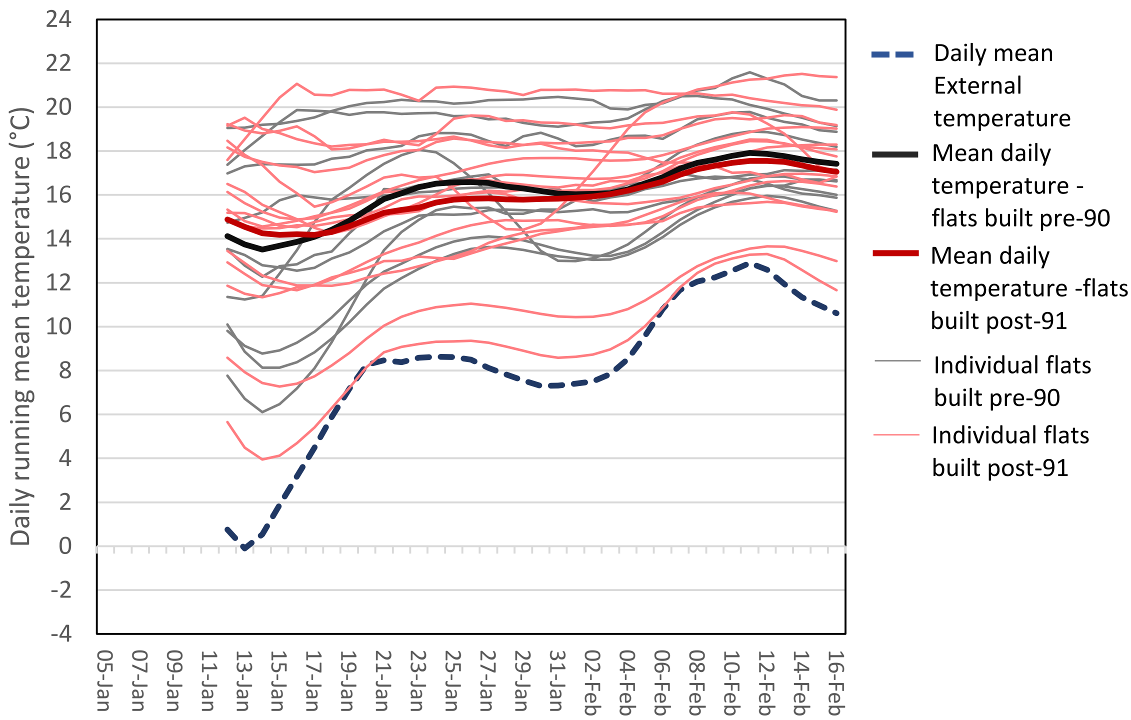
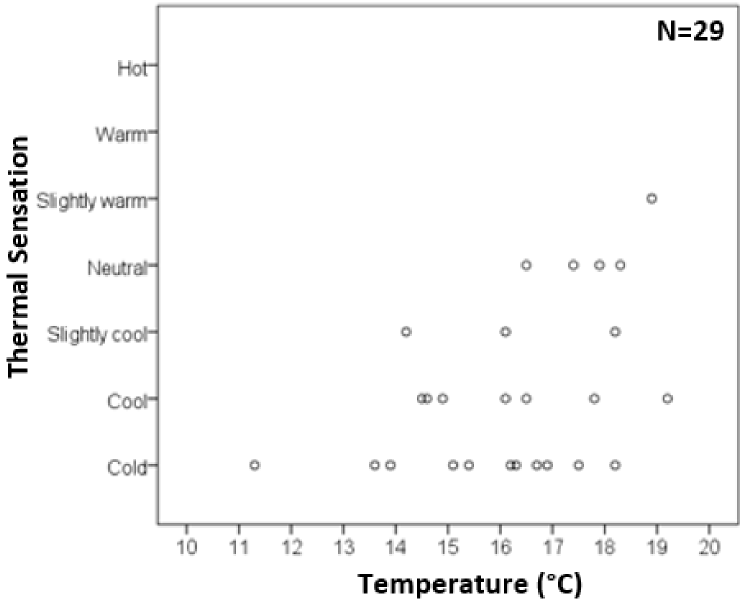


Figure 9: Daily running mean indoor temperatures in winter for each flat and averaged for flats built Pre-90 and Post-91

4.1. Thermal comfort in winter

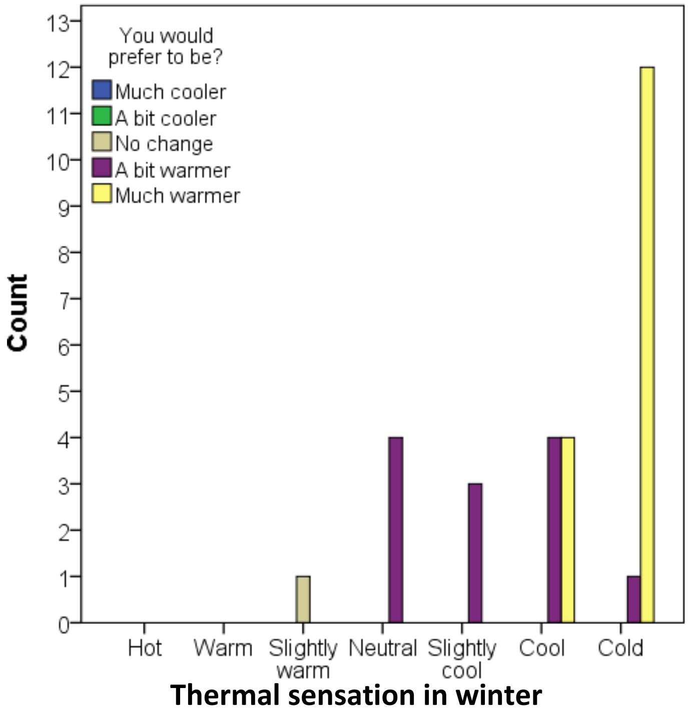
Subjective evaluation of the thermal environment was provided using the 7-point ASHRAE scale for the thermal sensation evaluation and a 5-point scale for thermal preference. From the thermal sensation vote distribution given in Figure 10, followed by a descriptive analysis, it is shown that over 80% of the households reported to feel colder than neutral during the winter, from which about 45% of them were feeling cold, for a mean temperature of 15.6°C (SD=2.0). Only four occupants were feeling neutral for mean temperature of 17.5°C (SD=0.8) and one slightly warm for mean temperature of 18.9°C.



		(°C)		
n	Mean	s.d.	Min	Max
0	.	.	.	.
0	.	.	.	.
1	18.9	.	18.9	18.9
4	17.5	.8	16.5	18.3
3	16.2	2.0	14.2	18.2
8	16.2	1.8	14.5	19.2
13	15.6	2.0	11.3	18.2

Figure 10: Total thermal sensation votes in winter and descriptive statistics for each scale

Thermal preferences votes corresponding with each thermal sensation votes reported during the survey in winter are shown in Figure 11. Only one of the participants was feeling cold (T=15.6°C) and wanted to feel a bit warmer, while all the others wanted to feel much warmer. On the other hand, the participant that was feeling slightly warm (T=18.9°C), wanted no change. Half of the respondents feeling cool (T=16.2°C) wanted to be much warmer, while all other respondents wanted to feel a bit warmer.



N=29

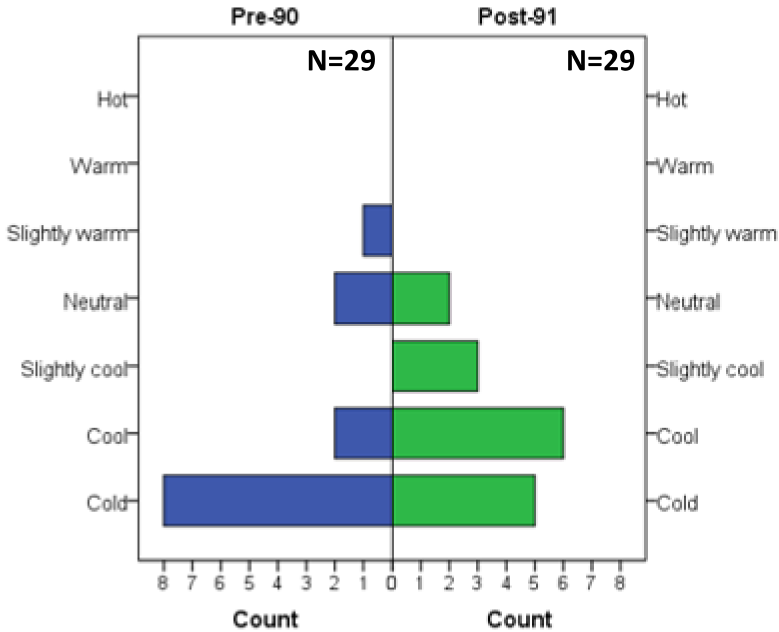
	No change	A bit warmer	Much warmer	Total
Hot	0	0	0	0
Warm	0	0	0	0
Slightly warm	1	0	0	1
Neutral	0	4	0	4
Slightly cool	0	3	0	3
Cool	0	4	4	8
Cold	0	1	12	13
Total	20	8	1	29

Figure 11: Thermal sensation votes reported in winter and crosstabulation with thermal preference votes

Comparing thermal sensation votes of participants living in flats built Pre-90 and Post-91 (Figure 12), it was found that the proportion of people feeling cold was higher in the flats built Pre-90 (62%) than those living in flats built Post-91 (31%), even though, the mean temperature corresponding to the thermal sensation vote (cold) was one degree higher in flats built Pre-90 (T=16°C) than in flats built Post-91 (T=15°C). Only two persons in each cohort reported to feel neutral, and the neutral temperature was slightly higher in flats built Post-91 that those Pre-90.

(°C)

Mean	s.d.
.	.
.	.
18.9	
17.2	1.0
.	.
14.6	1
16.0	2.5



(°C)

Mean	s.d.
.	.
.	.
.	.
17.9	0.6
16.2	2.0
16.9	1.7
15.0	1.3

Figure 12: Comparison of thermal sensation votes in winter for flats built Pre-90 and Post-91, together with descriptive statistics of indoor temperature for each scale

A descriptive analysis is given in Table 5, comparing indoor temperature and thermal sensation votes in both flats built Pre-90 and Post-91, affected by several variables. Most of the households are made of three or more members. The mean indoor temperature is correlated in opposite directions with the household size for flats built Pre-90 and Post-91. It decreases with larger households in flats built Pre-90 and increases in flats built Post-91. However, the thermal sensation votes increase from cold to cool (-3 to -2) for larger households in both flats built Pre-90 and Post-91. For larger households, the mean indoor temperature is lower in flats built Pre-90 and higher in flats built Post-91. Interestingly, the mean indoor temperature is higher (19.2°C) in households made of three members compared to smaller and larger households built Pre-90. Commonly, these families are made of two parents and a child, and tend to create more comfortable thermal conditions than in the other flats. In fact, the presence of children in the household shows to affect the indoor temperatures, but the same cannot be said for the presence of the elder person. Out of 29 households, 16 had a least one child and ten of them had at least one elder member. The mean indoor temperature shows a decrease for their presence. Moreover, there is a lower thermal sensation vote from the households made of children and elder persons.

All flats used convective heating using air conditioning and electric heater devices to heat the space in winter. Even the flat that had individual central heating, was fuelled by electricity. The mean indoor temperature in dwelling that used air conditioning devices has been 1°C lower in flats built Pre-90 (T=15.9°C) compared to those built Post-91 (T=16.9°C) and they had the same thermal sensation vote (-2).

There have been almost the same mean indoor temperature and thermal sensation votes for flats without wall insulation in flats of both cohorts. However, has been a higher mean indoor temperature (T=16.5°C) for flats with wall insulation and higher thermal sensation vote (-1.8). the presence of double glazing has possibly highly affected the mean indoor temperature in flats built Post-91 (T=17°C), compared to mean indoor temperature of 24.8°C in flats with single glazing of the same cohort. In the contrary, a difference of only one degree is found in the mean indoor temperature of flats with (T=16.8°C) and without (T=15.9°C) double glazing in flats built Pre-90. In flats built both Pre-90 and Post-91, the thermal sensation votes are higher for the presence of double glazing.

Higher mean indoor temperatures and thermal sensation votes are associated with flats that are heated in evenings. Two flats built Pre-90 heat the space all day and this is also reflected in higher mean indoor temperatures (18.5) and thermal sensation votes (-1).

Table 5: The mean and standard deviation of the indoor temperature, and thermal sensation votes for flats built Pre-90 and Post-91, for different variables in winter

	Pre-90						Post-91					
	Temperature (°C)			ASHRAE*			Temperature (°C)			ASHRAE*		
	n	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.
Household size												
1	1	16.6	.	1	-3.00	.	1	.	.	1	-2.00	.
2	3	15.3	.4	3	-2.33	.58	3	14.9	1.3	3	-1.67	.58
3	3	19.2	.9	3	-2.00	1.73	4	15.7	4.4	4	-1.50	1.29
4	5	14.6	1.7	5	-2.20	1.79	4	16.3	4.0	4	-2.50	1.00
5	1	13.4	.	1	.00	.	4	16.7	1.8	4	-1.75	1.26
How many persons younger than 18 live in the household?												
0	6	17.3	2.3	6	-2.17	1.17	7	15.9	1.6	7	-1.86	1.07
1	3	17.7	1.1	3	-1.67	2.31	6	15.9	3.6	6	-1.67	1.03
2	4	13.7	.7	4	-2.25	1.50	3	16.4	4.9	3	-2.33	1.15
How many persons older than 65 live in the household?												
0	6	15.9	2.8	6	-2.83	.41	13	15.9	3.3	13	-1.77	1.09
1	5	16.5	2.4	5	-1.00	1.87	1	16.8	.	1	-3.00	.
2	2	15.0	.	2	-2.50	.71	2	15.9	2.2	2	-2.00	.00
Type of heating												
No heating	0	.	.	0	.	.	0	.	.	0	.	.
Air conditioning	8	15.9	2.3	8	-2.00	1.60	11	16.9	2.7	11	-2.00	1.00
Electric heater	4	17.2	2.6	4	-2.75	.50	2	11.8	3.5	2	-1.50	.71
Gas heater	0	.	.	0	.	.	0	.	.	0	.	.
Wood stove	0	.	.	0	.	.	0	.	.	0	.	.
AC + electric heater	1	13.4	.	1	.00	.	1	16.3	.	1	.00	.
AC + gas heater	0	.	.	0	.	.	1	16.8	.	1	-3.00	.
Central heating	0	.	.	0	.	.	1	14.0	.	1	-2.00	.
Are the walls being insulated?												
No	13	16.1	2.4	13	-2.08	1.44	11	15.8	3.2	11	-1.91	1.22
Yes	0	.	.	0	.	.	5	16.5	2.9	5	-1.80	.45
Have you got double glazing?												
No	11	15.9	2.6	11	-2.27	1.19	7	14.8	3.6	7	-2.57	.79
Yes	2	16.8	.2	2	-1.00	2.83	9	17.0	2.2	9	-1.33	.87
When do you switch the heating on during the day?												
Morning	1	16.6	.	1	-3.00	.	0	.	.	0	.	.
Afternoon	1	19.2	.	1	.00	.	2	12.8	4.9	2	-.50	.71
Evening	2	16.7	2.4	2	-2.50	.71	5	15.2	1.1	5	-2.00	.71
Morning and evening	4	13.6	.8	4	-2.25	1.50	5	18.8	.8	5	-1.80	1.30
All day	2	18.5	2.3	2	-1.00	2.83	0	.	.	0	.	.
Afternoon and evening	3	14.8	1.1	3	-2.67	.58	4	14.8	3.0	4	-2.50	.58
Do you heat the house during the night?												
No	12	15.7	2.1	12	-2.00	1.48	12	16.4	2.6	12	-2.00	.95
Yes	1	20.1	.	1	-3.00	.	4	14.7	4.0	4	-1.50	1.29
When and for how long do you open the windows in winter?												
Morning	12	16.2	2.5	12	-2.08	1.51	15	15.8	3.1	15	-1.80	1.01
All day	1	15.0	.	1	-2.00	.	0	.	.	0	.	.
When it is too hot	0	.	.	0	.	.	1	18.3	.	1	-3.00	.

*ASHRAE seven-point scale: Hot=3; Warm=2; Slightly warm=1; Neutral=0; Slightly cool=-1; Cool=-2; Cold=-3

5. Discussion

First of all, the analysis undertaken in this study has demonstrated the 'bad' environmental performance of flats in Albania, regardless the construction cohort. Very high indoor temperatures were recorded during the summer reaching 36.5°C and very low indoor temperature down to 2.5°C in winter. However, it was found that the indoor temperatures in flats built Pre-90 had an elevated temperature range and variation, especially in summer. The flats were constantly overheated, with indoor temperatures over 25°C all the time in summer. A better picture is in winter, where the mean indoor temperatures in most of the flats were above 15°C. The low range and variance of the indoor temperatures during the summer have probably affected the lower proportion of participants feeling hot during the summer in flats built Post-91 (44%) compared to those built Pre-90 (70%). Moreover, the occupants were feeling neutral for indoor temperature close to 27°C. The same thermal performance has been found in winter in flats built Pre-90, where 60% of the participants reported to feel cold. In contrary, only 30% of them were feeling cold in flats built Post-91.

Interestingly, the mean of normalised electricity use by floor area was found non-statistically significance different in flats built in both cohorts, even though the average yearly electricity consumption has been found to be 22% higher in flats built Post-91.

Therefore, what makes the flats built Pre-90 perform worse that those built Post-91 in terms of environmental and thermal performance?

Firstly, the deteriorated conditions of flats built Pre-90, the lack of wall insulation and lack of double glazing have made their contribution in their indoor environmental and thermal performance.

Secondly, seven out of 13 flats (46%) in the sample built Pre-90 were occupied by the same family since they were constructed and had at least one elder member. Usually they wear heavier clothing in summer than younger persons, probably causing thermal discomfort. Furthermore, the clothing norms have changed over the years. Younger people might wear only a sleeveless vest when are indoors, while this could be different for elder people.

Thirdly, the indoor temperature is higher in summer and lower in winter in flats built Pre-90 than in flats built Post-91 because of the shorter time of cooling and heating the space respectively. This is also reflected in considerably lower electricity bills (22%) compared to flats built Post-91.

6. Conclusions

It has been acknowledged that behavioural and social factors affect home energy consumption by as much as ±50% (Gill et al., 2010). Therefore, understanding the context is important not only for more accurate energy reductions by the proposed energy retrofits, but also to indicate the ways people adapt their environment (Nicol and Roaf, 2017). The analysis in this paper was focused on two main periods of Albanian political, economic and social life, that have inevitably affected also the construction industry and typology. Although the number of cases is relatively small, and the findings cannot be treated as statistical generalization, the analysis provides an in-depth contextual insight into environmental, thermal and energy performances of flats in Albania, and discusses the factors affecting them. However, conducting a study with a sample that can be statistically representative of the population would be needed to create a body of evidence on the energy and environmental performance of apartment buildings in Albania, which would help inform future energy retrofitting programmes. Furthermore, a detailed field study of thermal comfort would be essential to determine the range of temperature that people find comfortable in homes in Albania.

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