EVALUATION OF THE SIGNIFICANCE OF OCCUPANCY PATTERNS ON ENERGY PERFORMANCE

As previously mentioned in Sub-section 3.6.4, the worst-performing RTB was chosen as a base-case representative scenario development from the social housing stock of the multi-family buildings built in Northern Cyprus between the 1980s and 1990s. The three different occupancy patterns are identified according to the field survey findings, namely, low (OP1), moderate (OP2) and high (OP3) occupancy in order to represent the interviewed sample. The occupancy patterns for the summer period of the base-case representative flats were defined in order to bring more accurate information to the calibration studies undertaken in the building modelling simulation. This method is based on the analysis of the quantitative data measured in-situ (indoor air temperature) and other collected data (electricity consumption), which is compared to the qualitative data collected in the occupant surveys. In these surveys, whose answers are summarised in Tables 1–3, the occupants of the case studies were asked about their occupation habits in the summer period, when they use domestic cooling systems (mainly portable fans and wall-mounted air conditioning), when they open windows for natural ventilation and when and for how long they make use of their domestic cooling systems. One of the main reasons for gathering this information is that the occupants' patterns in energy use play a significant role in the thermal performance of the interviewed households.

Table 1. The category of occupancy pattern 1 (OP1, low occupancy) was assigned to Flat B to undertake the energy simulation analysis (summer weekdays)

FLATB*-OP1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy (man)																								
Occupancy (woman)																								
Roller blind																								
Natural ventilation																								
Portable fan																								
*Air conditioning system is not installed																								

As can be seen in Table 1, the OP1 shows the elderly occupancy profile of people who spend most of their time at home during the summer. In this case, the absence of an air conditioning system during the occupancy hours makes it more difficult to draw conclusions about the risk of overheating experienced in summer, but the survey showed the use of a portable fan in the living room between 13:00 and 18:00 and in bedroom 2 between 22:00 and 7:00, which provides more evidence of the thermally uncomfortable conditions experienced by the occupants. One of the occupants is away in the early morning and returns around 11:30, at which point the energy consumption rises, and the flat is completely occupied. This flat

is naturally ventilated throughout the occupancy hours in order to cool down the indoor air environment and reduce their reliance on portable fans in summer.

Table 2. The category of occupancy pattern 2 (OP2-moderate occupancy) was assigned to Flats C and E to undertake the energy simulation analysis (summer weekdays)

FLATSC/E-OP2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy (grandfather)																								
Occupancy (grandmother)																								
Occupancy (child 1)																								
Occupancy (child 2)																								
Roller blind																								
Natural ventilation																								
Air conditioning																								
Portable fan																								

As can be seen in Table 2, OP2 shows the multi-family occupancy profile. The flat is inhabited by a retired couple, aged between 65 and 75 years old, and there are two grandchildren who spend most of the day at home. Due to the school holiday in the summer, the two children are at home between 8:00 and 17:00 on weekdays. In this case, the relatively high indoor air temperatures in the living room indicate the use of a wall-mounted air conditioning system. It can be seen that due to the presence of children, the air conditioning system was in use between 11:00 and 17:00, both in the living room and bedroom 1. It can also be seen that the retired couple mostly use the air conditioning system between 22:00 and 4:00, and a portable fan is in operation between 4:00 and 6:00 in bedroom 2. Notably, the increase in energy consumption indicates that at midday, the two adults were involved with household activities (mainly meal preparation and cleaning), leading them to set the air conditioning system temperature at 16 °C. The operable windows were kept closed when children were present (between 8:00 and 17:00) due to safety concerns. The roller blind window systems were used on occasion and were more frequently detected between 14:00 and 17:00 to prevent incoming sun in the main living room space in summer.

Table 3. The category of occupancy pattern 3 (OP3-high occupancy) was assigned to Flats A, D and F to undertake the energy simulation analysis (summer weekdays)

FLATSA/D/F-OP3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy (father)																								
Occupancy (mother)																								
Occupancy (child 1)																								
Occupancy (child 2)																								
Occupancy (child 3)																								
Roller blind																								
Natural ventilation																								
Air conditioning																								
Portable fan																								

As can be seen in Table 3, OP3 shows the multi-family occupancy profile. The flat is inhabited by a couple aged between 45 and 50 years old; both of them work full-time, between 7:00 and 17:00 on weekdays. In this household, three children aged between 5 and 16 years old were identified. Due to the school holiday in the summer, two of the kids mostly stay at home, and the eldest son (16 years old) works between 9:00 and 16:00. In this case, the indoor air temperature measurement in the living room indicates the air conditioning is in use for 24 hours. The occupation pattern defined by the energy bill analysis is confirmed by the consumption drastically increasing in the summer, showing that the flat was fully occupied in the summer, with both portable fans and air conditioning systems in operation, but lower indoor air temperatures were rarely seen in the living room due to the deficient building envelopes. In this case, cooling appliances (located in the living room and bedrooms 1 and 2) are often used during the occupancy hours. This household ventilates the indoor occupied spaces during the late evening between 20:00 and 23:00 and makes use of solar protection during the hottest hours of the day.

To fulfil the research aim and objectives, in the DTS analysis, the six representative flats analysed belong to social housing neighbourhoods, which tend to be associated with medium to low incomes. According to the State Planning Organisation statistics in 2016, the OP1 type is a small-sized household category (1–2 members) and the OP2 and OP3 types represent a medium-sized household (3–5 members). Notably, 50% and 42% of Cypriot households belong to each of these categories. In order to represent the interviewed sample size, three different occupancy profiles were identified. The selection criteria were primarily based on the households that have similar economic conditions and which show occasional use of domestic cooling systems, despite their occupancy profiles presenting very different patterns and intensity of use of natural ventilation and solar protections to prevent

incoming sun in the south-facing RTB. This diversity aids in the building performance evaluation in the following sections examining the influence of ventilation rates, window opening schedules and the use of domestic appliances in terms of the internal heat gain factor on the energy performance of the base-case representative flats.