LIGHTING STYLE AND ELECTRIC CONSUMPTION IN APARTMENTS

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ABSTRACT

Questionnaire survey of lighting use and electric bill was carried out for more than three hundred family type apartments in Osaka to compare electric energy consumption against daytime and night time lighting styles. Lighting use in daytime and nighttime, electric bill in natural ventilation season, and basic attributes of apartments, family rooms and respondents were asked. Results show the followings: 1) 74.5 % had more than two lighting devices in family rooms. Two were 50.5 % and dominant. But only 8-15 % used them for nighttime local lighting. 2) 49.7 % rarely used daytime artificial lighting, whether 14.6 % used daytime lighting during family rooms stay. Frequency of nighttime local lighting use was lower for behaviors of eating, reading and working. 3) Electric bill of 'rarely daytime lighting' apartments was 12.0 % lower than that of 'almost lighting during stay' apartments. 4) Electric bill of night time 'single lighting' apartments was lower than other night time lighting style apartments, if lighting was used during stay. This tendency was true regardless of the stay duration. On the other hand, electric bill on night time 'single lighting' apartments was the highest, if daytime lighting was rarely used and if stay duration was shorter. 5) If daytime lighting was rarely used and if stay duration was longer, electric bill depended on the behaviours when local lighting was used. It was highest for relaxing and lowest for eating.

Keywords: multiple lighting arrangement, single lighting, local lighting, electric consumption

1. INTRODUCTION

Multiple lighting arrangement which occupants can use different lights for different opportunities is thought to be a rich lighting style. But it is not clear whether it consumes more electric energy or not compared with single lighting. Kobayashi et al. (2013) carried out questionnaire survey for nearly five hundred family type apartments and classified lighting styles into multiple lighting and single lighting by number of lighting devices, use of local lighting for different behaviours, and lighting area in the family rooms. Evaluations of brightness, glare, lighting uniformity, performance and preference of lighting were better for multiple lighting than single lighting, but there was no statistically significant difference. This study analysed relation between lighting styles in the family rooms and electric bill more in detail. Lighting styles during night time were classified into lighting with single device, lighting with all multiple devices and local lighting. Difference of behaviours for local lighting was considered. Lighting styles during daytime were classified into almost lighting during stay, rarely lighting and variable lighting by weather. Duration of stay was considered in analyses of electric bill.

2. Survey Method

6,799 questionnaire sheets were delivered to family type sold apartments in Osaka City between June and November in 2012 and 2013. Family member who stayed the home longest were asked to respond. Basic attributes of the apartments, family rooms and respondents, lighting use in the family rooms in daytime and night time, and electric bill in May 2012 were asked. Natural ventilation season was chosen because the electric consumption included little heating or cooling electric consumption. Number of lighting devices, fixed positions and lamp types, total wattages of lamps in family rooms were asked besides lighting use for different behaviours such as eating, reading, watching TV and so on. 358 apartments responded.

3. Apartments and Respondents

3.1 Respondents

76.0 % of the respondents were female. Mean and standard deviation of age was 56.0±13.8. 42.7 % had occupations and 32.8 % was housewives. Mean family member was 2.51 and two was most dominant (35.5 %). Frequency distribution of home stay duration per day was shown in Fig.1. Mean duration was 15.9 ± 4.3 hours.

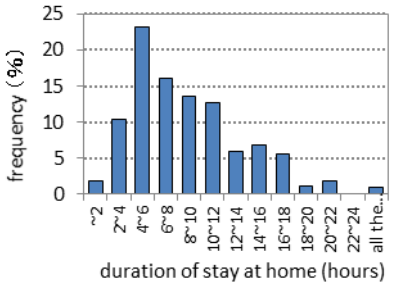

Fig.1 Frequency distribution of stay duration

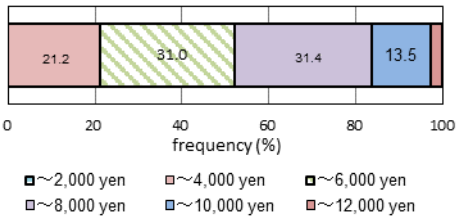

Fig.2 Frequency distribution of electric bill

3.2 Apartments

Mean ± standard deviation of apartments was 75.7 ± 20.2 m^2, mean living floor was 6.9, and mean built year was 1994. 64.9 %, 29.0 % and 22.7 % faced south, east and west respectively. 11.1 % and 29.7 % answered the apartment building was built ‘closely to the neighbour buildings’ and ‘rather closely to the neighbour buildings’ respectively. 50.2 % apartments were placed on the corner of the building. Mean family room area was 21.7 ± 7.5 m^2. Relative frequency of living-dining-kitchen and living-dining layout was 72.1 % and 14.6 % respectively. Mean of family room stay duration per day was 8.2 ± 4.6 hours. Fig.2 shows frequency distribution of electric bill. Mean bill was 6,033 ± 2,192 yen.

Fig.3 shows the evaluation of brightness in family rooms under different weathers. 54.2 % and 26.4 % evaluated ‘light’ and ‘slightly light’ respectively under sunny weather. But 43.0 % evaluated the brightness as ‘neutral’ under cloudy or rainy weather.

3.3 Lighting use in family rooms

Frequency distributions of number of lighting devices, lamp type and fixed positions were shown in Fig.4. 50.5 % possessed two lighting devices in family rooms. 58.0 % possessed only fluorescent lamps. More than 90 % lighting devices were fixed at the ceilings. Fig.5 shows total wattages of lamps and estimated total luminous flux in family rooms. Mean of total lamp wattages was 177 ± 93 W and mean of total luminous flux was 10,617 ± 5,585 lm.

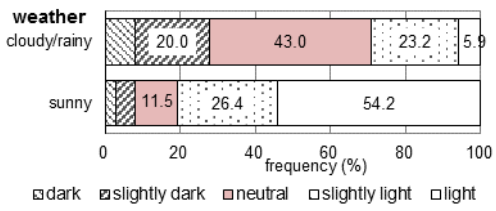

Fig.3 Subjective brightness in family rooms

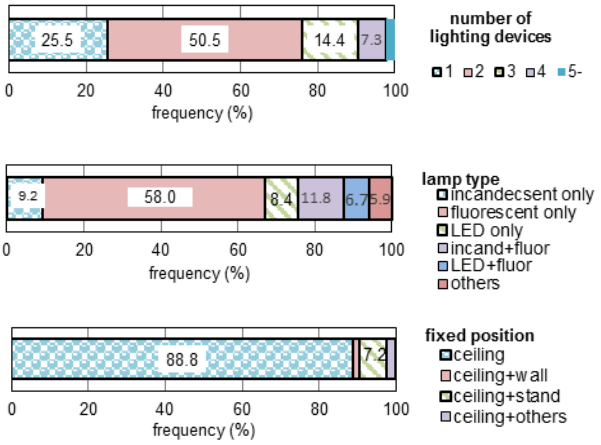

Fig.4 Lighting devices in family rooms

Fig.6 shows daytime lighting use in family rooms. 49.7 % answered ‘rarely lighting’ in daytime, whether only 14.6 % use lighting during family rooms stay. Fig.7 shows night lighting use by different behaviours. Frequency of local lighting use was lower for eating, reading and working.

4. Lighting use and electric bill

Fig.8 shows mean electric bill for different daytime lighting use. Here electric bill were adjusted by area ratio of family room to the apartment. Electric bill of ‘rarely daytime lighting’ were 12.0 % lower than that of ‘almost lighting during stay’. But they were almost the same when home stay duration was under 12 hours.

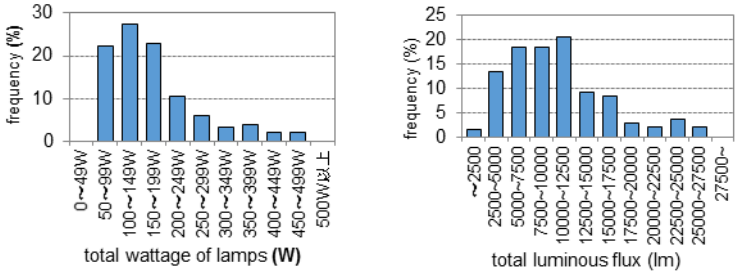

Fig.5 Total wattages of lamps and total luminance flux in family rooms

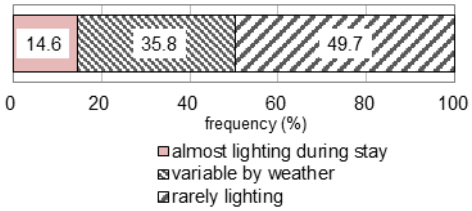

Fig.6 Daytime lighting use

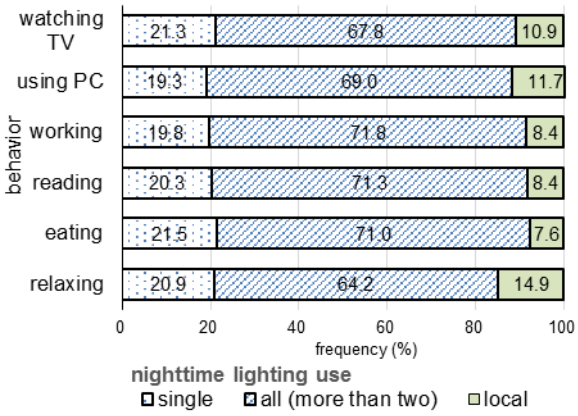

Fig.7 Night time Lighting use

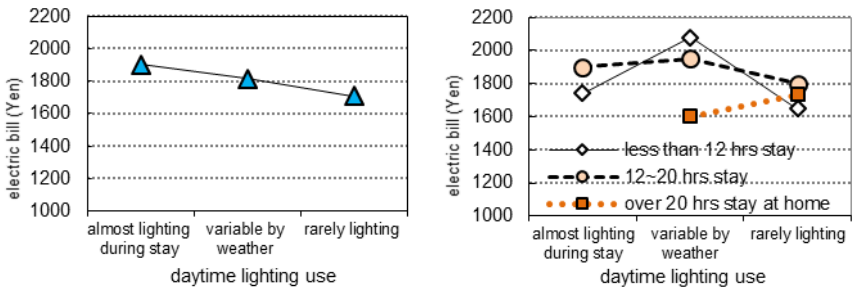

Fig.8 Daytime lighting use and electric bill

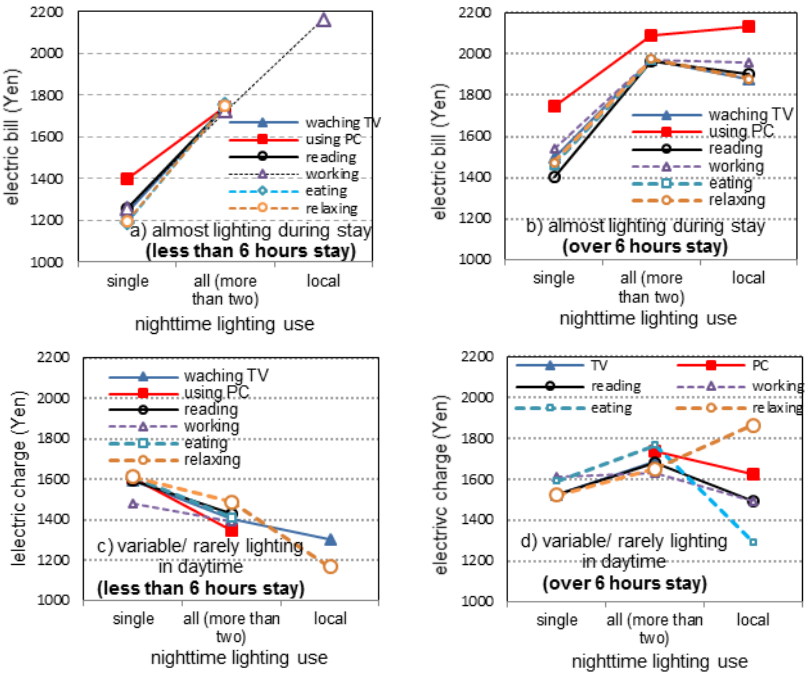

Fig.9 Night time lighting use and electric bill

Fig.9 shows mean electric bill for different night time lighting use. Figure a) and b) show that electric bill of night time 'single lighting' and daytime 'almost lighting during stay' were the lowest regardless of the stay duration. Figure c) shows that electric bill of night time 'single lighting' were the highest if family room stay duration was shorter. On the other hand, Figure b) and d) show that electric bill of night time 'all (more than two) lighting' were the highest for longer stay duration regardless of daytime lighting use. Figure d) also shows that electric bill depended on the behaviours when local lighting was used. Electric bill were the highest when local lighting was used when relaxing, though it were the lowest when 'local lighting' was used when eating.

5. CONCLUSIONS

Actual condition of relations between lighting styles and electric consumption were surveyed and analysed for more than three hundred family type apartments in Osaka. Results show that: 1) 74.5 % had more than two lighting devices in family rooms but few use them for night time local lighting. 2) In daytime, 49.7 % rarely used artificial lighting and 14.6 % used lighting during stay. 3) Electric bill differed 12 % by daytime lighting use. 4) Electric bill was the lowest for night time 'single lighting' and daytime 'almost lighting during stay' regardless of the stay duration. 5) Electric bill of differed among behaviours, if daytime lighting was rarely used and stay duration was longer.

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