

## What is the Effect of Ramadan on Domestic Occupancy Patterns and Energy-Use in Muslim Households in London Compared to Pre-Ramadan

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**Abstract:** Ramadan, the ninth month of the Islamic Hijri calendar, involves fasting and other forms of worship. While behaviour changes during Ramadan are well-documented, there's limited research linking these changes to domestic energy use. This study aims to explore the reasons for changes in domestic behaviours and their impact on energy use during Ramadan. Seven participants were studied using a mixed-methods approach, including interviews, occupancy sensors, and energy data, to examine changes during Ramadan (March-April 2023-2024). Interviews revealed significant shifts in routines, such as increased nighttime activity, altered sleep patterns, and more intense cooking and socialising. Occupancy sensors showed peaks in kitchen activity around mealtimes, and energy data indicated more peaks in electricity use. These findings highlight the need for culturally sensitive energy management strategies to reduce peak loads and promote energy-saving behaviours, especially given the current energy and climate crises and fuel poverty affecting many Muslims in the UK.

**Keywords:** Ramadan, Occupancy, Behaviour Pattern, Energy-use, Demand-side management.

### 1. Introduction

This study poses the question: What is the effect of Ramadan on occupancy patterns and behaviours on energy-use amongst Muslims residents in London compared to pre-Ramadan use. Due to the climate emergency, a growing body of literature recognises the importance of managing energy-use to balance supply and demand as well as reduce carbon emissions. Ramadan is a key event for Muslims where behaviours are known to change, however there is no precedent on the impact on energy-use. There is a significant Muslim population in the UK, thus understanding the impact of Ramadan can improve energy forecasting.

The study hypothesises significant shifts in peaks of energy-use due to more night-time activities (Terrence et al., 2018) as well as two daily peaks around Ramadan mealtimes. This study whilst small in scale and non-representative sampling, aims to gain initial understanding of the impact of Ramadan behaviours, occupancy and energy-use. Overall aims include:

- To understand changes (and reasons) in domestic behaviours in Ramadan.
- To track changes in occupancy and energy-use in Ramadan.
- To understand the effect of Ramadan on energy-use: schedules, peaks, load forecasting, demand-side management.

### 2. Literature

In the context of renewable energy targets and decarbonising the grid, there is mismatch between peak renewable generation and demand. It is estimated that renewable

generation will account for 45% of the UK electricity market by 2035(BEIS, 2016), however, renewable sources run with diurnal and seasonal variability(Mulder, 2014, Burnett et al., 2014) with limited flexibility compared to fossil fuels(Parra et al., 2015). Understanding peak-generating behaviours and aiming for more predictable base loads are important goals, especially as residential occupants are “one of the most unpredictable consumer groups”(Imran, 2021) and a “peakier network [poses] a threat to network security”(2019).

To understand unique domestic behaviours during Ramadan, studies on Muslim households in the UK are reviewed as they highlight different demographics(Hussain, 2010) from majority groups(Hussain, 2010). Largely due to immigration, Muslims live in larger families with the highest number of children, and intergenerational living. In England and Wales, Muslims made up the highest percentage (26.6%) of social tenants, compared with 16.6% of the overall population. Sovacool et al.(Sovacool et al., 2017) noted that social housing residents had compounded vulnerabilities when using smart meters. This overall picture of deprivation and lack of agency suggests Muslims may have less control and ownership over the running of their homes, such as energy and maintenance decisions.

Depending on when Ramadan falls in the year (Gregorian calendar), the daily length of fast varies significantly(Faris et al., 2020). There are a variety of worship observed during this time, with the most investigated in literature being fasting (abstinence of food and drink from dawn to dusk)(Faris et al., 2020). The effect of fasting on behaviour and activity is outlined in literature with a strong health focus, including disruption of sleep cycles(Faris et al., 2020). Other related changes include changes in caloric and nutrient intake(Khatib, 2022), increased night-time activities such as prayer and social gatherings(Faris et al., 2020). These changing behaviours are predicted to impact both time and amount of domestic energy use. Although current literature has not explored this, this study aims to address this gap.

An important study linking religious events and energy-use is the work of Elgazzar and Hemayed(Elgazzar and Hemayed, 2016) who found that considering Hijri calendar-based events helped improve electric load forecasting North Cairo(Elgazzar and Hemayed, 2016). They found that changes in behaviours (working hours, fasting, and higher use of air conditioning) were key causal factors to increased electricity use in Ramadan.

Domestic occupancy schedules refer to common patterns of behaviour and use of residential spaces, with research showing a strong impact on operational energy-use(Ozarisoy and Altan, 2022). Occupancy research has often been restricted to averages and ‘standard’ groups; however, this is unrepresentative of diversity in in modern UK society and especially in London. Furthermore, current literature often depicts occupant behaviour as an isolated activity proxied or modelled by CO2 levels for example(Tahmasebi et al., 2022). This fails to note cultural factors and motives for behaviour in a broader perspective.

The research to date has tended to focus on health and cognitive performance during Ramadan(Ahmad et al., 2012, Qasrawi et al., 2017, Faris et al., 2020) rather than a holistic view of changing habits and domestic behaviours. There is potential for this study to highlight less understood areas:

- Ramadan is known to cause significant changes, however the impact on energy-use is not known.
- Demand shifting and off-peak behaviour: night-time worship and socialising.
- Communal and group activities in Ramadan and impact on energy.
- The significance of a shift in load for the Muslim population for 30 days.
- Understanding decision-making and adaptive behaviours in Ramadan.
- Understanding vulnerabilities and obstacles faced by Muslims residents in the UK.

### 3. Methodology

#### 3.1 Outline

This research aims to identify and understand behavioural changes during Ramadan and resulting energy-use. To both quantitatively measure this change, and qualitatively understand behaviours, a mixed method approach has been taken, as seen in Table 1.

Table 1: Aims, Method and Data

Research Question	Method	Data Purpose	Details
Reasons for changing behaviours in Ramadan	Semi-structured interview	Qualitative for understanding	Understand how culture/ attitudes/ beliefs shape use of space and create unique occupancy patterns
Domestic occupancy pattern before and during Ramadan	Occupancy sensor installation and collection	Quantitative for confirmation/ triangulation of interviews and data	Understand time of use, intensity and duration of occupation of domestic spaces- before and during Ramadan
Domestic energy-use impact of Ramadan	Existing smart meter data/ energy data	on occupancy and energy	Compare energy-use to baseline

#### 3.2 Interviews

Fifteen-minute interviews were carried out with seven participants covering their living arrangements general domestic routines and activities and changes of behaviours during Ramadan (and the reasons for these changes). The aim of these were to:

- Understand how attitudes/ beliefs shape the use of space and create unique occupancy profiles for Muslim domestic occupants.
- Understand specific architectural and energy needs of residents during Ramadan, (e.g. home layout, time of use, thermal conditions, worship.)

#### 3.3 Occupancy Sensors

Tracking domestic occupancy helped confirm interview findings about self-reported behaviours. Occupancy sensors were placed in the homes for three to six weeks before and during Ramadan (February-March 2024).

#### 3.4 Smart Meter Energy Data

To understand daily energy-use patterns and changes during Ramadan, smart meter data was required as it reports electricity and gas usage at half-hourly time stamps. Two participants provided their daily energy-use data before and during Ramadan (March-April 2023 and February-March 2024) in spreadsheet format.

### 4. Results

#### 4.1 Overview of Homes

Table 2 provides an overview of participants' households and data gathered from them.

Table 2: Participant Household Information

Participant	1	2	3	4	5	6	7
Household	House		Flat				
Interview	Yes	yes	yes	yes	yes	yes	yes
Energy data	yes	no	no	no	no	yes	no

Occupancy sensor	yes	yes	yes	yes	no	yes	yes
No. People	4	5	5	4/5	3-5	2	6
No. Bedrooms	4	4	3	3	3	2	1
Ramadan abroad	Egypt	no	Pakistan	Finland, Bangladesh	Oxford, home	Qatar	Egypt
Changes to Home in Ramadan	yes	no	no	no	no	yes	no

## 4.2 Summary of Interviews

Interviews revealed participants' domestic behaviours and how these change in Ramadan. Variety in participant's living arrangements was a key determinant of how they observed Ramadan, with those in family homes and strong social networks reporting the most changes. Prayer times impacted daily routines, especially sleep. During Ramadan the additional meal before fajr prayer and the night prayers (tarawih) meant their sleep schedules shifted to waking up earlier and sleeping later with daytime napping. Cooking intensity around mealtimes increased significantly and reduced throughout the day. Community was important during Ramadan, and those who did not have a strong community either tried to socialise more or pass the time through increased use of electronic devices and gaming.

## 4.3 Kitchen Occupancy

Fig.1 shows the daily average kitchen occupancies before and during Ramadan for participants 1 and 2. There is a clear trend of two occupancy peaks around mealtimes in Ramadan (around 4am and 6pm). There is also a gradual increase in occupancy between 4pm-6pm for, showing food preparation in the lead up to meals and lower daytime occupancy compared the pre-Ramadan. Participants 1 and 2 live in family homes and therefore had more group meals (as discussed in interviews).

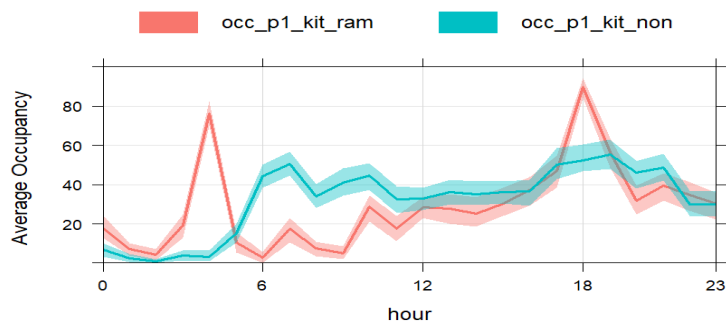


Figure 2: Kitchen, Pre and During Ramadan for Participant 1, Daily Average

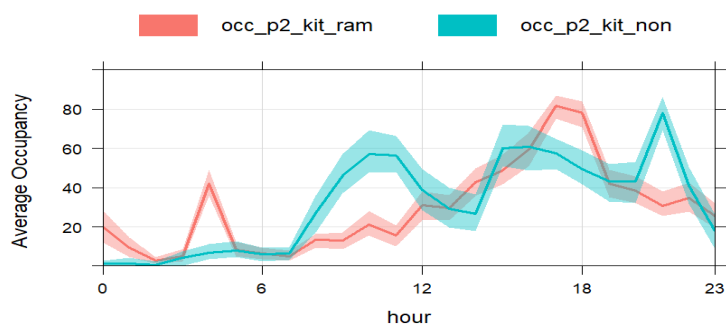


Figure 1: Kitchen, Pre and During Ramadan for Participant 2, Daily Average

## 4.4 Energy

### 4.4.1 Energy-Use: Ramadan 2024

Overall, difficulties with meters meant only two participants had suitable data for analysis. Electricity and gas consumption slightly decreased during Ramadan 2024 for both participants and dropped off towards the middle of the month which coincided with a holiday period when both participants left the UK to visit family abroad.

Table 3 shows weekly and daily average electricity and gas usage for participant 1 (living in a family home of four people) before and during Ramadan 2024.

Table 3: Domestic electricity and gas usage Participant 1 before and during Ramadan 2024

Electricity Usage 2024	Before Ramadan	During Ramadan	Gas Usage 2024	Before Ramadan	During Ramadan
Weekly average (kWh/m <sup>2</sup> )	0.76	0.66	Weekly average (kWh/m <sup>2</sup> )	2.85	2.07
Weekly average (kWh)	83.21	71.59	Weekly average (kWh)	311.07	225.48
Daily average (kWh)	11.89	10.23	Daily average (kWh)	44.44	32.21
Min daily (kWh)	7.16	2.81	Min daily (kWh)	22.62	0.00
Max daily (kWh)	18.95	17.58	Max daily (kWh)	85.68	54.85
Max. Daily Range (Max-Min) (kWh)	11.79	14.78		63.06	54.85

## 5. Conclusion

This research aimed to understand the reasons for changing behaviours and the impact on domestic energy-use in Ramadan in UK homes. A mixed-methods approach produced data supporting the hypothesis of behavioural and energy changes in Ramadan. Occupancy data and interviews suggest significant changes in sleeping, cooking and social behaviours in Ramadan which are known to impact energy-use (Ozarisoy and Altan, 2022). Energy data showed some peaks during Ramadan and overall decreased electricity use.

### 5.1 Recommendations for Future Work

The findings address an under-explored area of domestic behaviours and energy during Ramadan with under-represented minority populations. Considering lowering carbon emissions to tackle climate change, recommendations for research include:

- Studying patterns and causes of changes in Ramadan occupancy and energy-use.
- More accurate Ramadan peak load forecasting thus planning energy provision.
- Better energy modelling and creation of Ramadan-specific occupancy profiles.
- Identify energy-lowering behavioural patterns and provide targeted advice for energy-saving measures for Muslims during Ramadan.
- Promoting and incentivising energy-use in off-peak hours (such as the pre-dawn meal) and increasing energy-literacy.
- Understanding energy-sharing and district-level energy in mosques etc.

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