Case study of 34 Tavistock Square energy consumption

1 Introduction and context

34 Tavistock Square is one of the buildings used by Bartlett School, the total useful floor area of it is 543 square metres. In this research report, we will focus on its energy consumption analysis, from which we will give suggestions to improve its energy efficiency to help Bartlett's net zero target.

For the building usage, most of the building is devoted to office space with only two teaching rooms (capacity of 56 in total**)**. Most space is used by administration staff and academic staff. Most of them are in hybrid work mode, now many of them will work from home during the summer or winter vacation, but once the term starts, these offices will be fully utilized again. Therefore, this building may be different from those which are mostly used by students, the energy consumption may be less.

2 Existing building fabric

2.1 DEC Report

34 Tavistock Square does not have the EPC certificate but its DEC information can be found on the government website, which is shown in Figure 2.1.

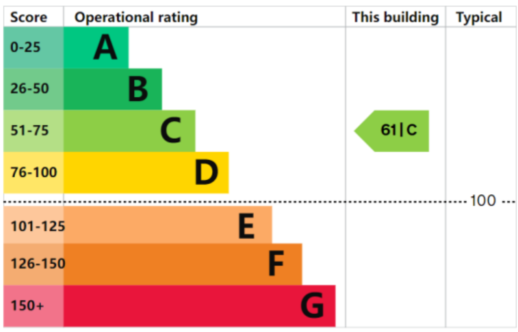

Figure 2.1 Display energy certificate (DEC) of 34 Tavistock Square (from find-energy-certificate.service.gov.uk)

The building’s energy performance operational rating is based on its carbon dioxide (CO_2) emissions for the last year. It is given a score and an operational rating on a scale from A (lowest emissions) to G (highest emissions). The typical score for a public building is 100. Therefore, 34 Tavistock Square has relatively high performance from the CO_2 emission perspective.

2.2 Recommendations from DEC Report

Display energy certificate (DEC) provides a recommendation report for each property, including 34 Tavistock Square. Those recommended improvements are grouped by the estimated time it would take for the change to pay for itself (GOV.UK). Each recommendation is marked as low, medium or high, which shows the potential impact of the change on reducing the property’s carbon emissions.

For recommended changes on this building that pay for themselves within 3 years, the report provides two low potential impact ways including improving building fabric’s air tightness and upgrading building equipment’s energy efficiency. It also recommends a change with a medium potential impact which is introducing or improving loft insulation.

For changes that pay for themselves within 3 to 7 years, several suggestions are proposed, including regular inspections of building fabric and applying a reflective coating to windows and/or fit shading devices to reduce unwanted solar gain. Most of them are also from the insulation and air tightness perspective.

For long-term recommendations which pay for themselves in more than 7 years, the DEC report gives three ways with high potential impact on improving building energy performance. The first one is replacing or improving glazing. The second one is to install meters and propose a regime of recording data for producing accurate operational rating for this building. Besides, from the supply side, it recommends installing building mounted solar water heating.

In conclusion, these recommendations are from three main parts, improving building and window fabric and material for heat insulation, installing smart meters for building performance observation and installing building-integrated equipment for renewable energy supply.

3 Energy data Analysis

There is an energy consumption management tool called Fabriq which provides detailed data about the energy used in the buildings in UCL, including 34 Tavistock Square. We mainly focus on two sectors, heating and electricity, which are the most important sectors for CO_2 emission. From Fabriq we can access different resolutions of time coverage, so we will analyse the energy performance data on different levels, from yearly analysis to weekly analysis.

We also have two benchmarks from CIBSE energy benchmarking tool. For space heating and natural gas, “Typical” (50th percentile) is 116 kWh / m2; “good practice” (25th percentile) is 83 kWh / m2. For electricity, the “Typical” (50th percentile) is 89 kWh / m2; “good practice” (25th percentile) is 57 kWh / m2.

3.1 Yearly Analysis

First, we focus on how the energy performance varies during recent years to have a broad view. For the space heating and natural gas sector, Figure 3.1 shows that from 2016 to 2021, every year’s heating energy performance is much worse than the “typical” benchmark. The energy consumption decreased from 2017 to 2020 but increased again in 2021.

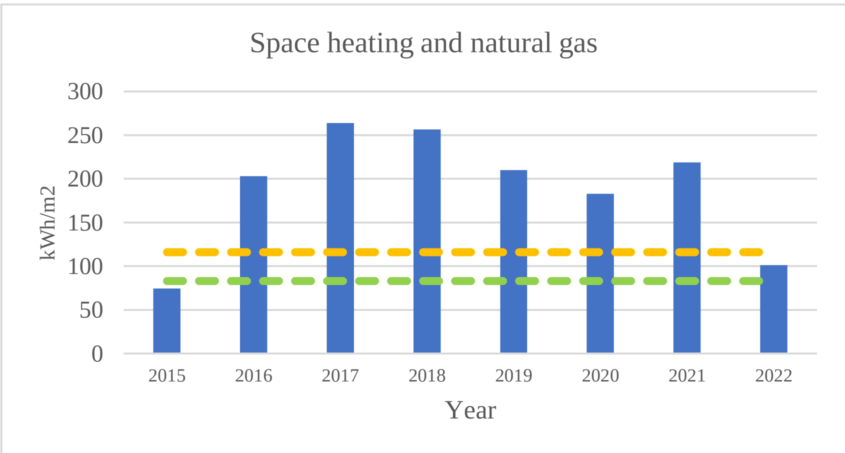

Figure 3.1 Yearly energy consumption for heating

Figure 3.2 shows how the electricity consumption changes, for all the years from 2016 to 2021, the electricity consumption performance is around the "good practice" benchmark.

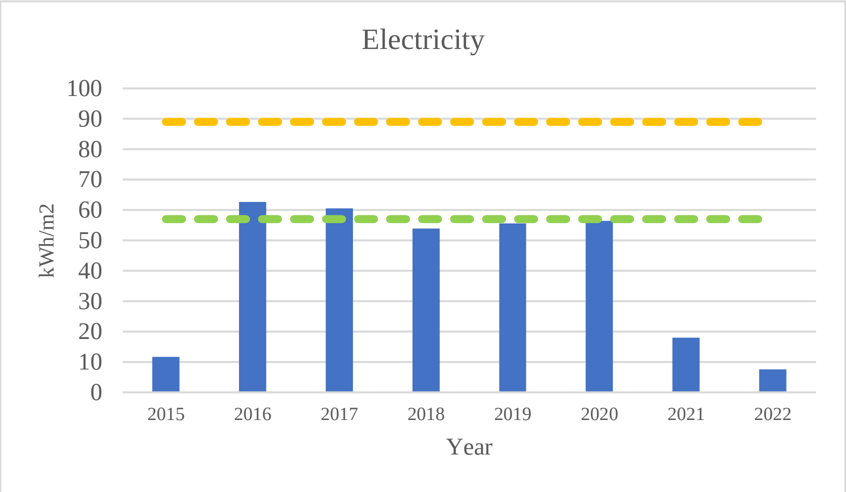

Figure 3.2 Yearly energy consumption for electricity

From the energy consumption's difference between heating and electricity we can find that electricity consumption is much more efficient than heating, which can partly explain why 34 Tavistock Square has a C level of DEC rating when its heating energy efficiency is relatively bad.

3.2 Monthly Analysis

Next, we explore deeper at the month level, we can see from Figure 3.3 that the energy consumption for heating shows an obvious time pattern. The energy consumption decreases significantly from June to October, and the peak appears in the period from December to March. This result is reasonable because it indicates the energy from heating depends highly on the demand, during summer there is almost no need for heating so the energy demand for that sector is much less than the peaks in winter. In comparison, the fluctuation of power consumption is significantly smaller.

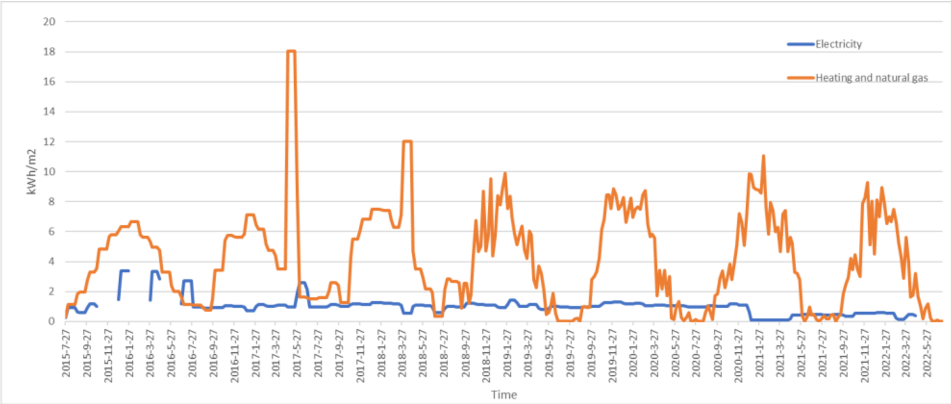

Figure 3.3 Monthly energy consumption

This is more obvious when we zoom in at a one-year time coverage, as shown in Figure 3.4.

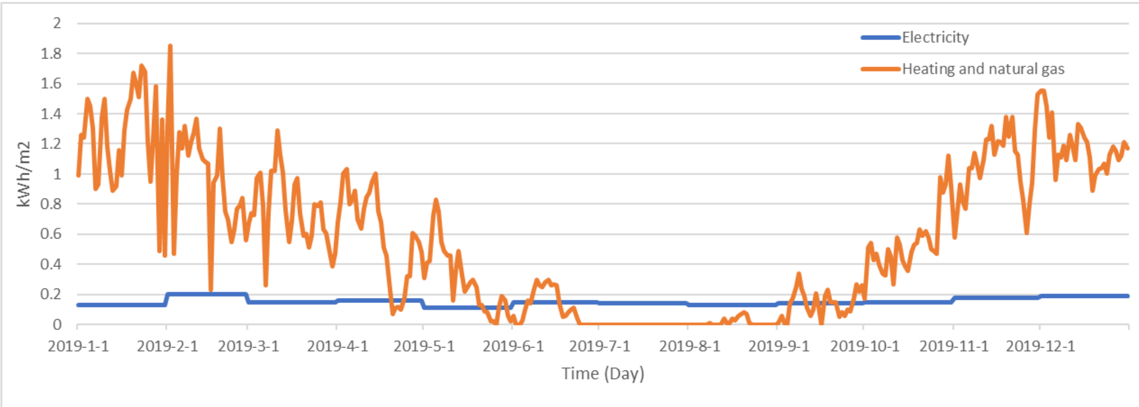

Figure 3.4 Monthly energy consumption in 2019

To explore more about the energy demand from heating, we studied the relationship between energy consumption for heating and the monthly temperature, which is from the Met Office's Historic station data(Met Office, no date), we chose Heathrow which is the nearest station to this building. We used the average temperature of the maximum and minimum temperature of each month from 2015 to 2022. From Figure 3.5 we can see that the energy used for heating holds an obvious opposite pattern compared with the average temperature, which means that the energy consumption for heating is highly related to the temperature.

We also notice that there are two peaks of energy consumption around May 2017 and around May 2018, which did not happen in the other years. There are no such peaks at those two time periods in the temperature line, so this can be explored more if it is not the issue about the Fbriq data itself.

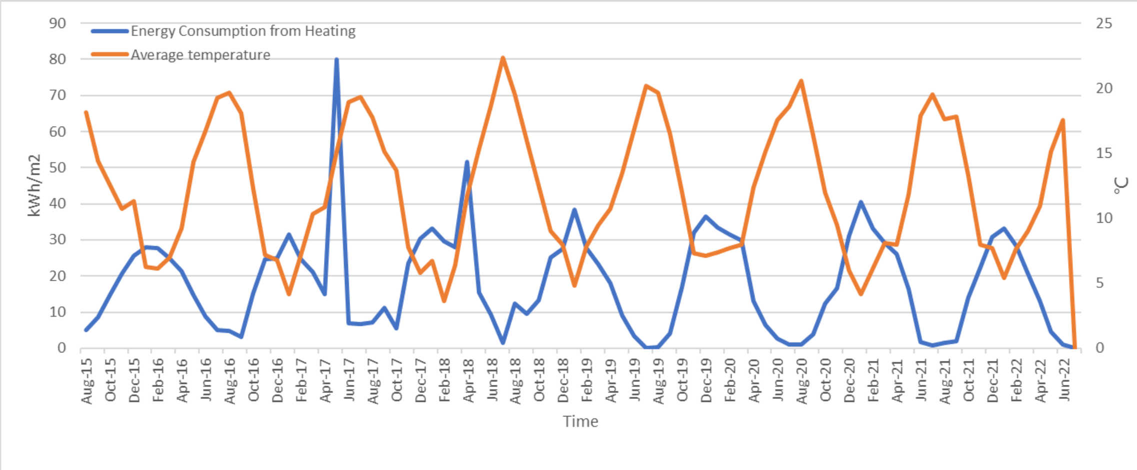

Figure 3.5 Relationship between energy consumption for heating and the monthly temperature

3.3 Weekly Analysis

In this part we study how energy consumption changes on different days, for example, it is reasonable that the energy may be consumed less on weekends due to less use. we select several months and investigate the daily energy performance from heating and electricity. Because we found that the daily energy consumption pattern is not that obvious compared to monthly change. In some time periods, it has some pattern but in some periods, it shows no pattern. So here we put all 4 buildings together to have a comparison.

3.3.1 Heating and fuel

The two figures below show the daily energy consumption change of the four buildings in November and January in 2019. The energy consumption pattern is different in different months and different buildings, which is more complicated than the monthly change pattern.

However, the four buildings have some similar trends in the heating energy consumption in both months, for example, the energy consumption will decrease slightly from Friday to Sunday and then increase from Monday, although each building rises and falls by a different amount between weekdays and weekends. This result is consistent with our hypothesis, which is the heating demand is related to how people are using the building.

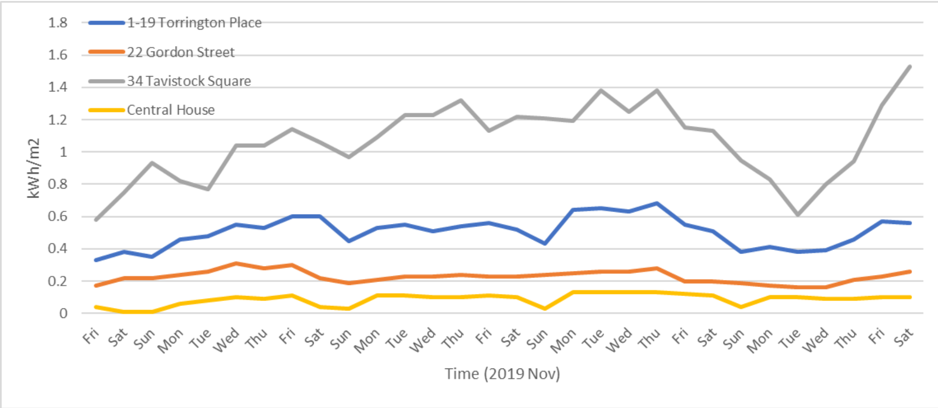

Figure 3.6 Daily energy consumption change for heating of the four buildings in November 2019

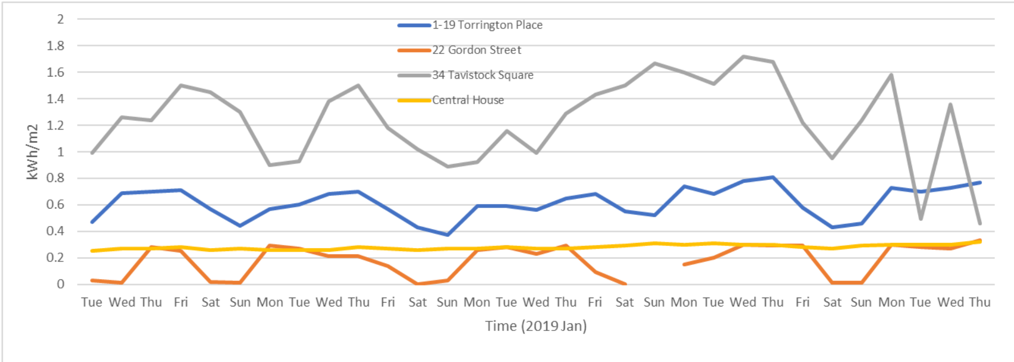

Figure 3.7 Daily energy consumption change for heating of the four buildings in January 2019

3.3.2 Electricity

Similarly, we chose June and December in 2019 to see how energy consumption from electricity changes on different days. It is clear that 1-19 Torrington Place, 22 Gordon Street, and Central House show a similar change pattern, which is decreasing from Friday to Sunday and generally keeping unchanged during weekdays. This pattern is similar but more obvious than that shown in the heating energy consumption.

However, the 34 Tavistock Square has a flat and much lower line. We think the reason may be that the electricity consumption data for 34 Tavistock Square has some error or data missed, or this building has a very different use purpose compared to the other three buildings.

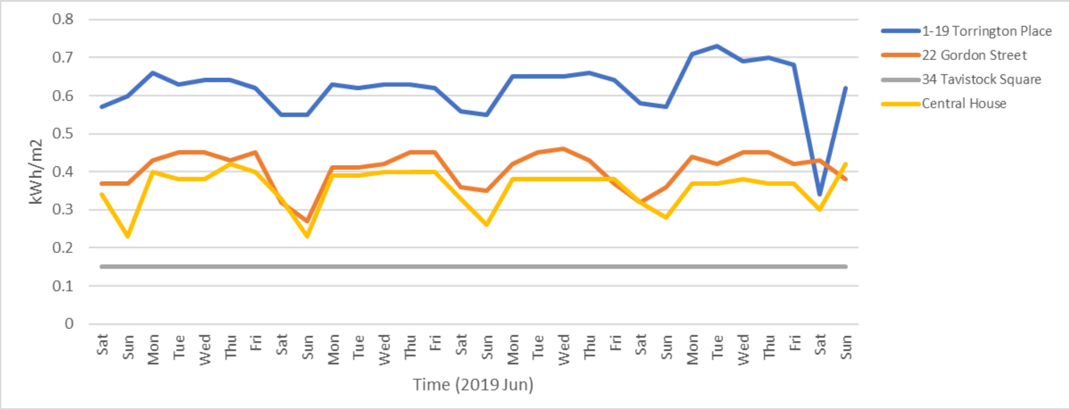

Figure 3.8 Daily energy consumption change for electricity of the four buildings in January 2019

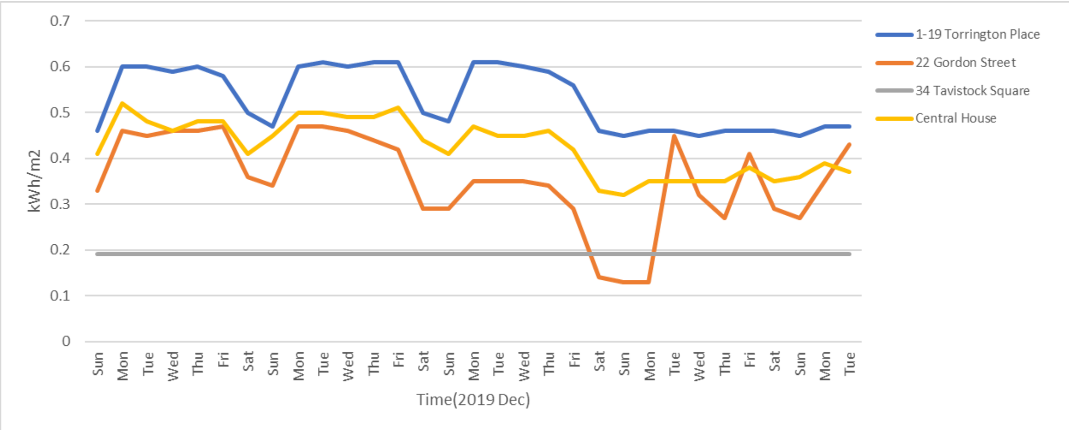

Figure 3.9 Daily energy consumption change for electricity of the four buildings in December 2019

Conclusions

From the energy consumption analysis of different time resolutions for 34 Tavistock Square and some comparisons with the other three buildings. We find that the energy consumption for electricity and heating show some patterns in different time scales.

Generally, energy consumption is related to the weather and human usage/behaviour. Specifically, the energy used for heating is highly related to the temperature, so it will increase in winter and get to the peak between December and February while keeping a low level in the summer. Also, the heating energy consumption will decrease slightly during weekends due to the less use of people.

For electricity use, at the year level, the energy consumption does not have a similar pattern across seasons as heating does, it shows a flat line in most cases. However, at a smaller time scale, not like the other three buildings' decreasing in weekends, the consumption for electricity in 34 Tavistock Square shows almost no change across one week, which may be due to the error of the data itself.

Based on those results, we know that this building's energy consumption is related to the weather (temperature) and how it is used. Temperature affects the heating demand greatly, therefore, how to keep the building less influenced by the external weather is important, which is the reason why the suggestions from DEC report are mostly about improving the heat insulation of the building, including upgrading building fabric and materials. Those methods can help buildings to be less influenced by external weather so that it can keep a relatively consistent and proper temperature inside and use less energy for heating and cooling.

Human behavior also affects energy performance, especially electricity. Those physical improvements may not help as much as they do in reducing heating demand. Therefore, we need to actively care about people's behavior and flexible use of space in the building to reduce electricity waste. For example, during weekends or at night, the building can close some rooms to avoid the case that only several students use a large room with all lights on. To make it more accurate and active, smart meters can be installed to monitor the energy use in each part of the building, which can then help building manager actively control the energy usage. Beyond this, raising energy-saving awareness among building users is also important.

Besides, from the energy supply side, we can use building-integrated equipment for renewable energy supply, for example, integrating solar PV into buildings.

This research focuses on the energy performance of 34 Tavistock Square and gives recommendations for improving energy efficiency. Further analysis could focus on: (1) The detailed usage of 34 Tavistock Square building including hours of building usage every day and some other building information for explaining the energy consumption pattern. (2) To what extent the building energy consumption is related to users' behaviour (e.g. occupancy), this can be studied by combining the footfall data of the building.

Reference

GOV.UK, *Recommendation report – Find an energy certificate – GOV.UK*. Available at: https://find-energy-certificate.service.gov.uk/energy-certificate/0260-9983-0235-4610-2004 (Accessed: 11 August 2022).

Met Office, *Historic station data*, *Met Office*. Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/historic-station-data (Accessed: 11 August 2022).