Wireless ALL|OFF Energy Saving Study

Introduction

Wireless ALL|OFF is an energy saving occupancy sensor for hotel guest rooms that replaces conventional key-card switches. According to 'Architectural Association of America' traditional key-card switches are overridden by guests, usually with a business-card or spare key, up to 65% of the time. Wireless ALL|OFF intelligently senses when a room is occupied and automatically switches the light and HVAC off when it is empty. As it is impossible for the guest to override, the energy savings are assured.

The simple system uses a combination of a wireless door and occupancy (motion) sensors to determine when all guests have left the room. Typically, this involves two PIR motion sensors, one covering the main bedroom area and the other the bathroom. The Door sensor adds reliability and creates a welcome effect by triggering the lighting and HVAC when the guest enters.

How ALL|OFF works

Using PIR motion sensors alone is not a guest-friendly way to detect occupancy because regular movements are required to keep the lights on – as often seen in public lavatories. ALL|OFF solves this with the addition of a door sensor. When the door opens, the sensor is used to immediately switch on the lights, creating a pleasing welcome effect. If motion is detected *after* the door closes the room is 'latched on' with a status of 'occupied'. As it is latched on, further motion triggers are not required to keep the lights on.

When a guest leaves and the door closes a timer is started, typically running for 5-10 minutes. If there are no guests remaining in the room no motion will be detected. When the exit-delay expires the room lights and HVAC are switched off, and the room's status set to 'un-occupied.

The worst-case scenario is where two people are sharing a room and one leaves the other asleep in bed. There is a small possibility the sleeping guest will not trigger the motion sensor within the exit-delay period, resulting in the room switching off incorrectly. However, generally the departing guest will have manually switched the lights off for their sleeping partner before they left anyway, so this incorrect action goes un-noticed. Eventually, the sleeping guest will move and trigger the room back on but again this also goes unnoticed because the room's light-switch is still off. In summary, it rarely fails but when it does it recovers quickly and quietly, usually without the guest even being aware.

Energy Saving Strategy

The guest's comfort is obviously paramount, so it is important any energy saving schemes do not impact on their enjoyment or inconvenience them in any way. For this reason, ALL|OFF ensures that whilst a guest is in their room they remain completely in control of their environment. Therefore, ALL|OFF will only effect savings while a room is empty.

The possible energy savings very much depend on the guest's behaviour and the amount of time their room is unoccupied. An ideal, energy-conscious guest will switch the lights and HVAC off every time they leave, resulting in zero wasted energy. By contrast, our study revealed most guests make no effort to switch lights or HVAC off when they leave, resulting in significant waste. ALL|OFF significantly reduces this energy waste, saving 40-45% of the total energy used over a 24hr period.

Whitbread Hub by Premier Inn Case Study

Whitbread install occupancy sensing as standard in all their Hub branded hotels and kindly allowed us to use their newly-opened 108 room hotel in Soho to monitor the behaviour and energy usage of their guests over a 3 month period.

The occupancy sensing system in every room was connected to a central monitoring server to capture every guest action and log the power consumption of the HVAC and Lighting on a minute by minute bases. Data was also collected from the room's lighting and AC control panels to fully capture the guest's behaviour. This included which lights were switched on, off or dimmed and also when the AC/Heating was being used and at what temperature etc, also on a minute by minute bases.

The data was captured over a three month period from April to July 2021.

To create a comparison, the occupancy sensing system was disabled in a percentage of rooms, so lights and HVAC were not automatically switched off when the guest left. The data logging captured the power usage in all rooms over the whole 3-month period, during both occupied and un-occupied times.

The data logging coincided with Covid restrictions, which meant the hotel's occupancy levels were generally very low, particularly at the start. However, the hotel manager ensured the sub-group of specially modified rooms got regular use and plenty of meaningful data was collected. In total data from over 1,500 guest-nights was collected, enough to establish a reliable pattern of guest behaviour and energy consumption patterns.

Data was analysed in 24-hour periods, from 1pm to 1pm each day. This captured a guest's behaviour from check-in to check-out times and everything in-between.

Each room's data was collected, assembled and summarised together in the format shown in Fig 1.

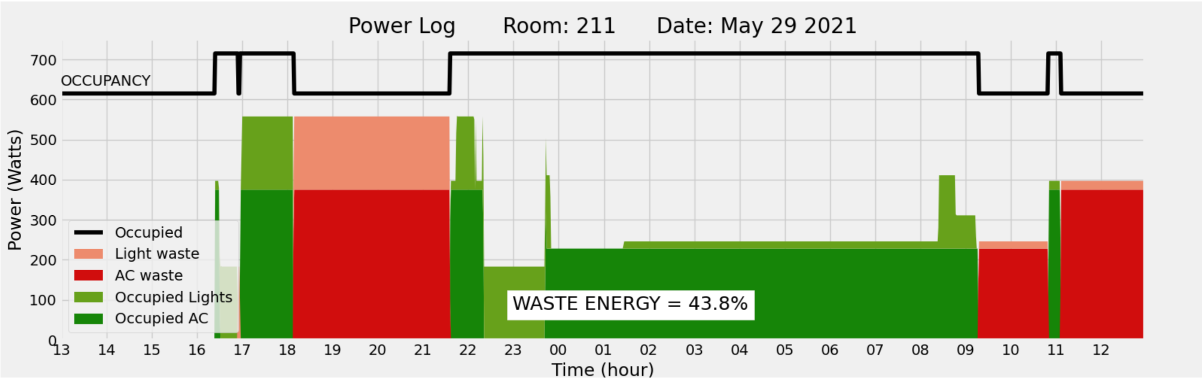


Fig 1

The black plot shows the room's occupancy status, where it is high the room is occupied and low it is empty. The Red and Green areas show the room's actual power consumption in Watts, with the darker colours representing the HVAC and the lighter aeras above indicating the lighting power. The red regions show the power consumption when the room is un-occupied (waste) and the green areas the occupied period.

This hotel has efficient modern LED lighting installed so the majority of power consumption is caused by the HVAC system, typically more than 70% on average.

Notice the lighting and HVAC power levels fluctuate as the guest switches on/off or dims different lighting circuits and selects different heating or cooling settings throughout their stay. In the un-occupied (red) regions the levels remain constant.

Energy Savings vs Guest Behaviour

As stated, the opportunity to save energy very much depends on the guest's behaviour, which Fig-1 clearly demonstrates. We can see they initially enter their room at 4:30pm, switch on the lights and appear to 'fiddle' with the heating momentarily, causing a brief spike in power before it settles down to a low level. About 25 minutes later the door opens again, perhaps their partner arrives, and the heating power ramps up to maximum. They leave at 6pm and do not switch anything off. This creates a constant wasted power consumption of circa 550W until about 9:30pm when they return. Around midnight the lights are switched off and the heating set low, which was very typical behaviour. At 8:30am the lights ramp back to full. They leave their room at around 9am, probably for breakfast, switching the lights off but leaving the heating on until 10:45am. They pop back for just 15 mins probably to grab their bags before leaving the lights on low and heating at full, where it remains until the cleaner arrives in the afternoon. This pattern of guest behaviour was very typical of the data we collected.

By comparing the total energy consumed in the green (occupied) region with the red (un-occupied) area the percentage savings achievable using the ALL|OFF occupancy sensing system can be demonstrated. In this case, 43.8% of the total energy was used (wasted) while the room was empty.

Extremes of Data Collected

As can be seen, the guest's behaviour plays an important role. If a guest diligently switches everything off each time they leave their room, then no savings are possible. However, in the hundreds of nights of data collected this perfect behaviour was only observed three times.

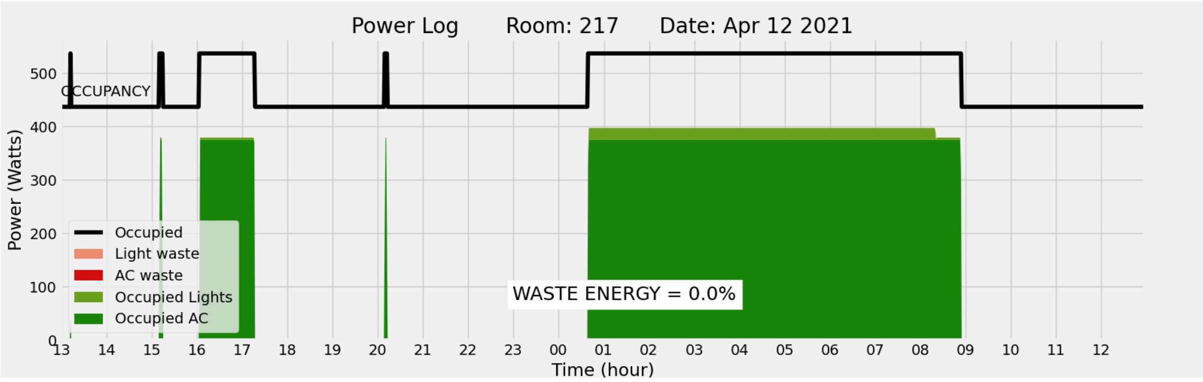


Fig 2

As can be seen in Fig-2, this guest appears to pop into their room briefly three times at 3pm, 4pm and 8pm, before returning for the night at 12:30am. In each case they switch on the lights and heating but also switch both off before leaving. This exceedingly rare example showed 0% wasted energy, which I'm sure they would be very proud to know about.

By contrast Fig-3 shows the complete opposite behaviour. Again, the guest pops in briefly at 2pm and switches everything on before leaving shortly afterwards. They return at 10:30pm and immediately switch the heating off, presumably because it is now uncomfortably hot from being on at 100% all afternoon. The lights go off at 3am. The only other power used during their stay is the lighting briefly at 9:10am. They leave their room around 11am having used almost no energy whilst in it. The event after 12:00pm is most likely the cleaning staff so was ignored. In summary, over 90% of the energy was used (wasted) when they were not in their room.

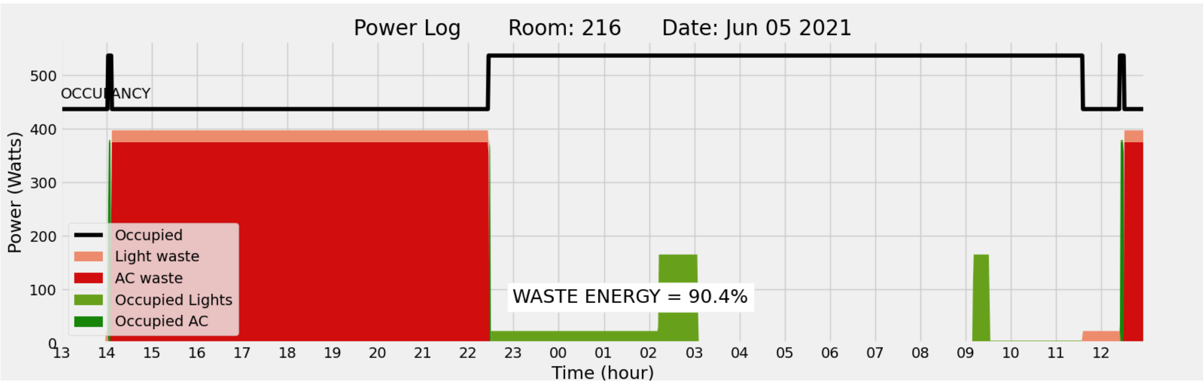


Fig 3

Key Times Where Energy Is Wasted

Although Fig-3 demonstrates the significant possible savings of using ALL|OFF, it also illustrates the guest's arrival and departure time can greatly impact on their energy waste.

Typically, the behaviour data showed most energy was wasted in two key time periods. Generally, a guest would visit their room briefly after checking-in, typically around 3pm - 5pm. They would often then leave the room un-occupied until anytime between 9pm and 12pm, which creates a period of wasted energy of between two and nine hours.

The second significant period begins after check-out, typically around 8:30am, after which the room usually remains fully on until the cleaner arrives between 10:30 and 1pm. This creates another two to four hours of waste. These random timing events sometimes combine to create the huge waste figures of >90%, as shown in Fig-3, although 30-60% was much more typical.

Conclusion

Including extremes of behaviour, the aggregated results revealed 40-45% waste was typical overall. The small ambiguity in this figure comes from the uncertainty of who is visiting the room (guest or staff) because the key-card information was not available. As stated above, the waste at 12:30pm in Fig 3 was ignored as it was probably the cleaner, but it was not always this obvious. It is very possible for a cleaner to visit a room soon after a guest left which left pockets of energy that could not be categorically allocated to either the guest or waste. These typical 30-minute periods left 3-5% margin of ambiguity in the overall results, which were nevertheless conclusive and compelling***: on average, 40% to 45% of energy saving is reliably realised by the ALL|OFF occupancy sensing system.***

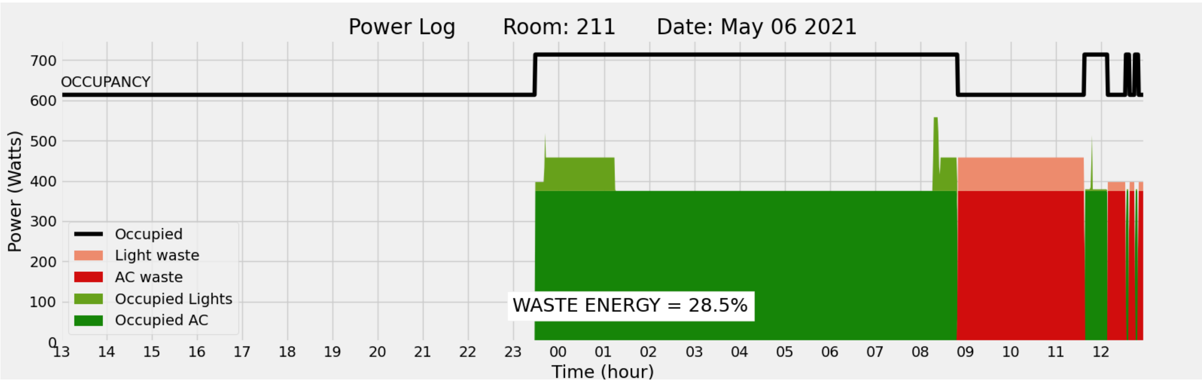
Case Study Data

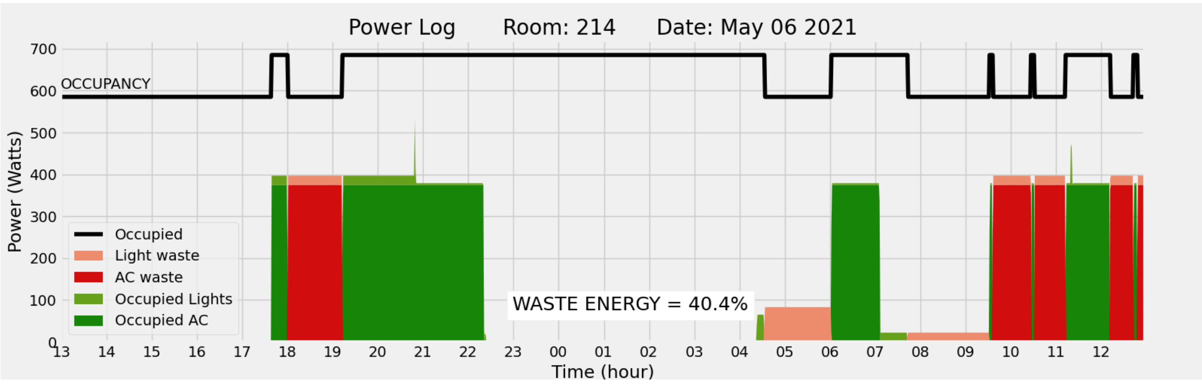
Client	:	Whitbread PLC
Site	:	Hub by Premier Inn Hotel Berwick Street Soho London
Study Period	:	April 4th to June 30th 2021
Rooms	:	108
Rooms Logged	:	108
Modified Rooms	:	Automatic occupancy energy saving disabled in 10 rooms (10%) for purpose of study
Data Resolution	:	1-minute, extrapolated from timestamped recorded events
Interval Period	:	24hrs, 13:00 – 12:59
Data Captured	:	Total Lighting Power, Total HVAC Power, Occupancy Status, Lighting mode, AC mode
Data Collection	:	Centralised Windows PC running bespoke app logging to local SQL database
Data Preparation	:	Bespoke Windows app translated SQL to Excel format
Data Presentation	:	Bespoke Python app collated and plotted data
Result	**:**	**Average Saving 40% - 45%** (small ambiguity due to uncertainty of some events being guest or house-keeping)

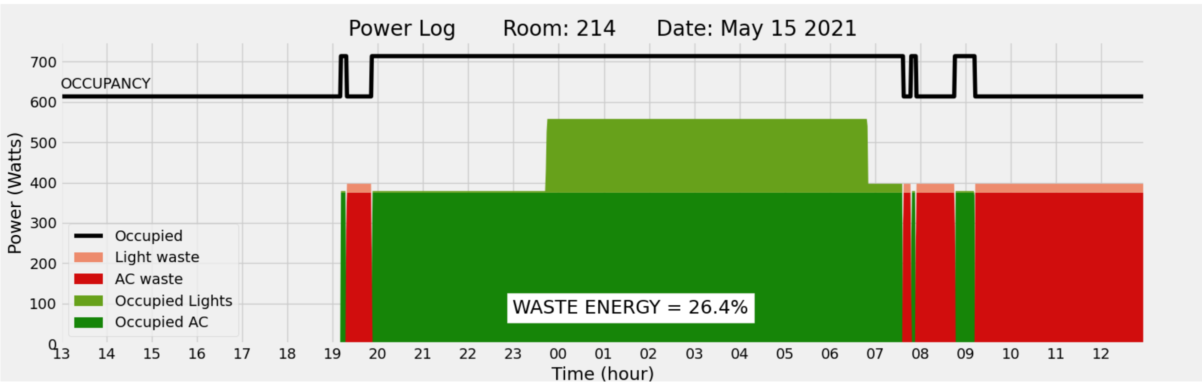
APPENDIX

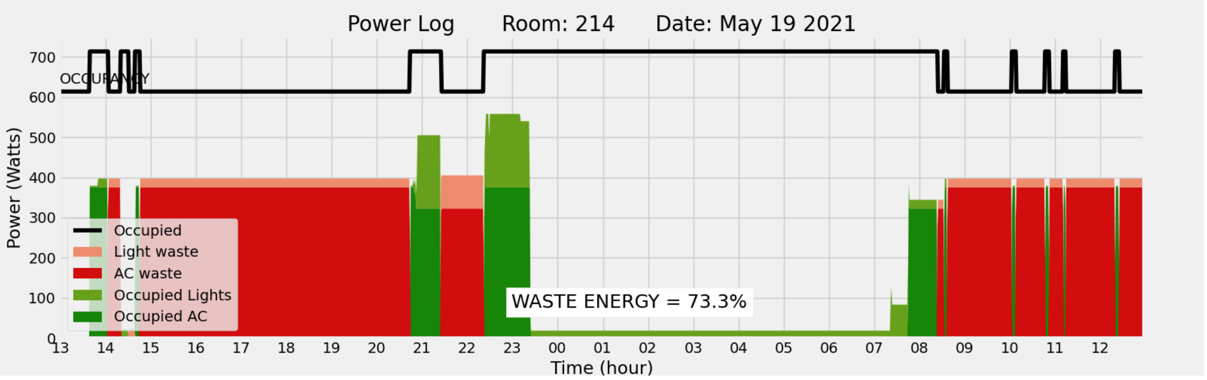
Random data sample of 20 rooms

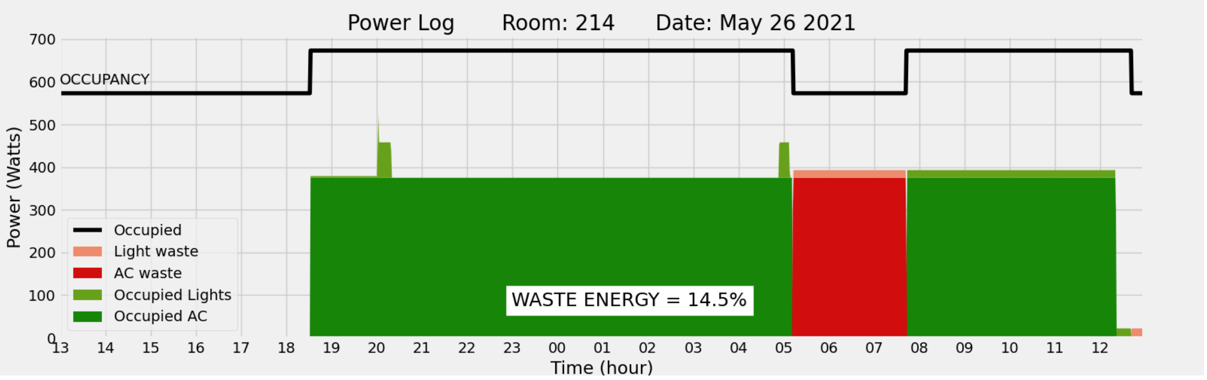
AVERAGE SAVING: 41.8%

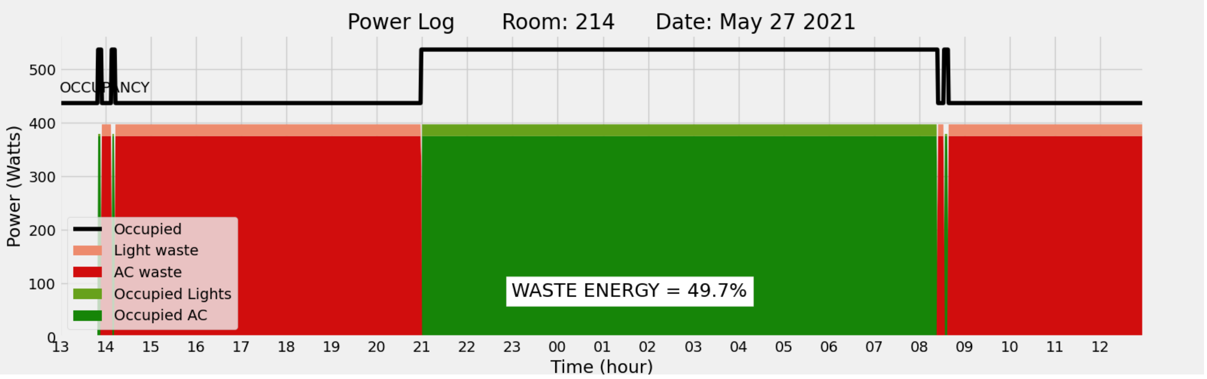


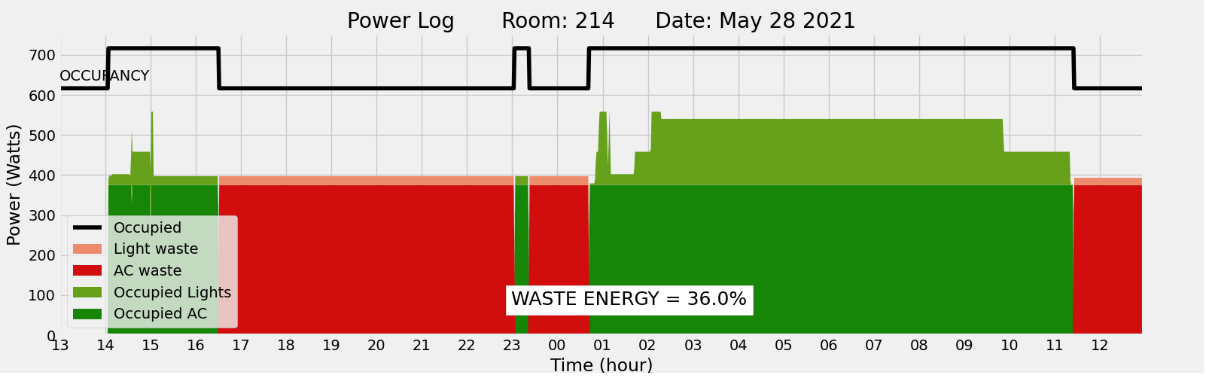


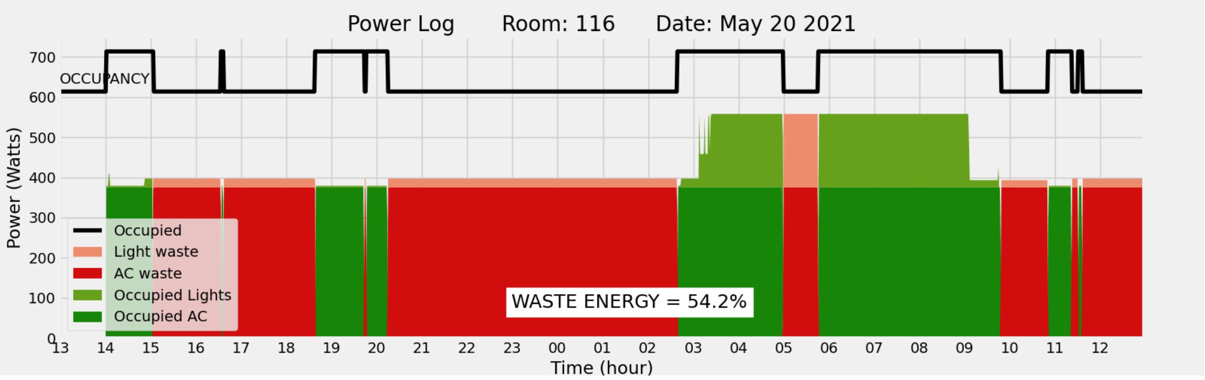


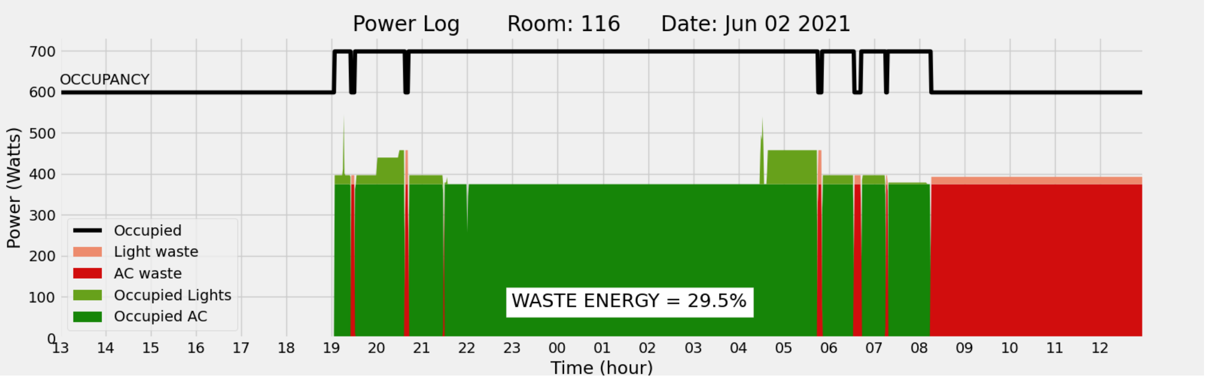

Power Log Room: 214 Date: May 19 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 73.3%
Time (hour)

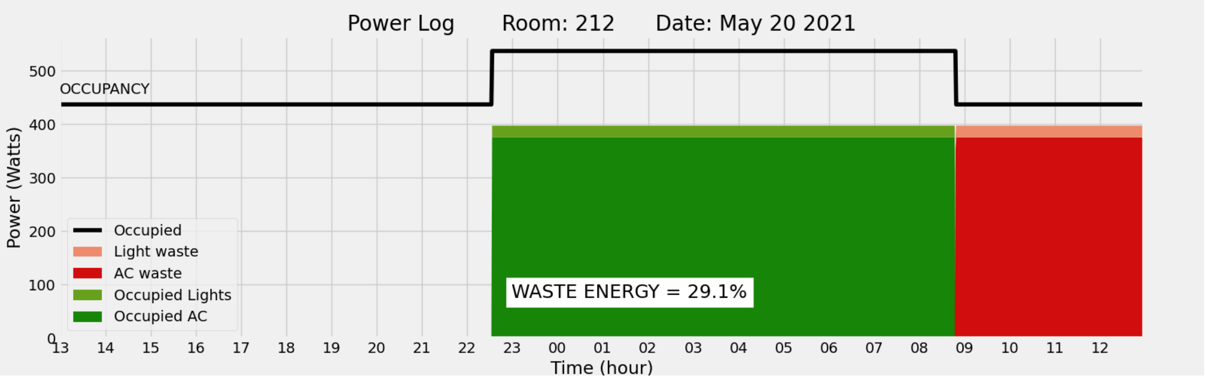

Power Log Room: 214 Date: May 26 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 14.5%
Time (hour)

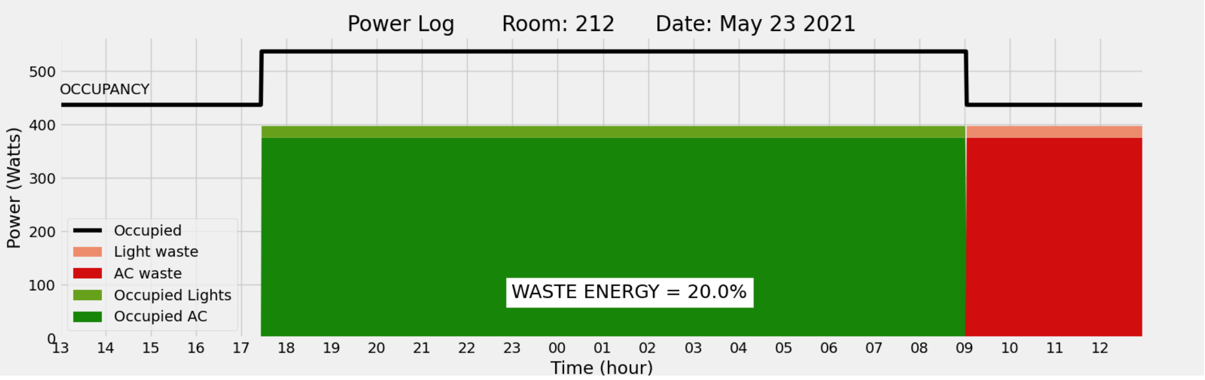

Power Log Room: 214 Date: May 27 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 49.7%
Time (hour)

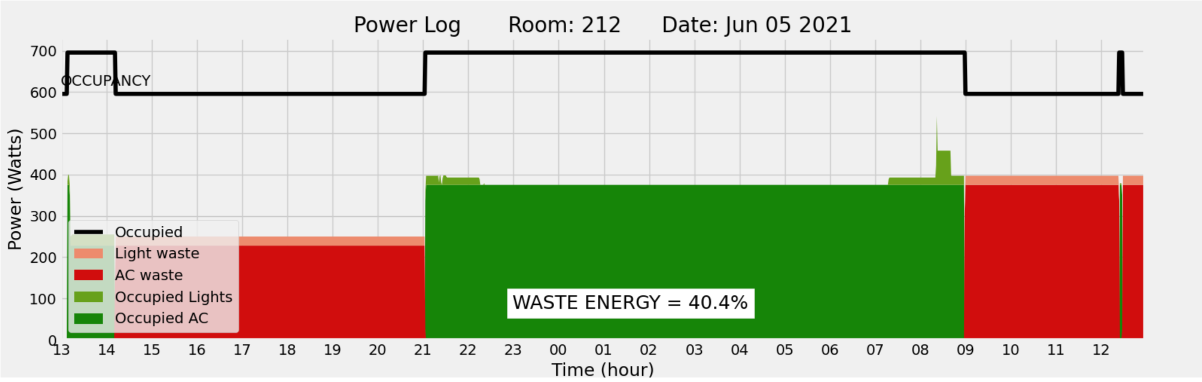

Power Log Room: 214 Date: May 28 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 36.0%
Time (hour)

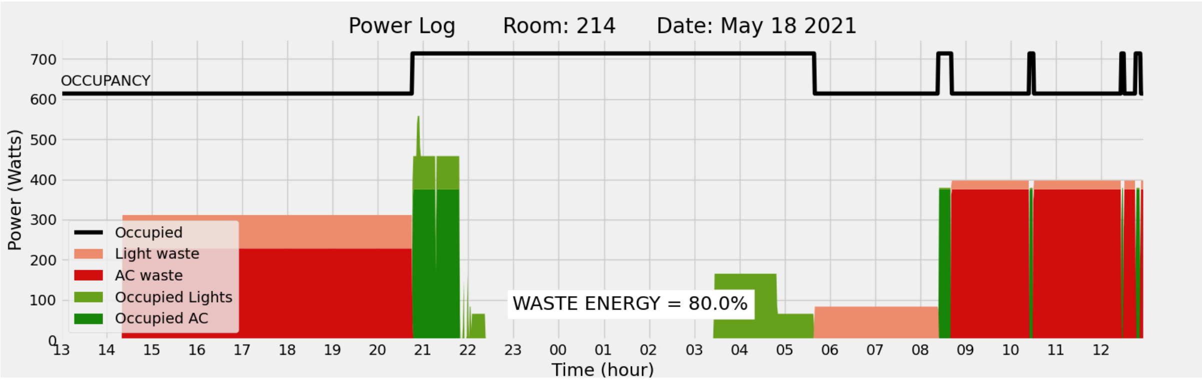

Power Log Room: 116 Date: May 20 2021
OCCUPANCY
Power (Watts)
Time (hour)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 54.2%

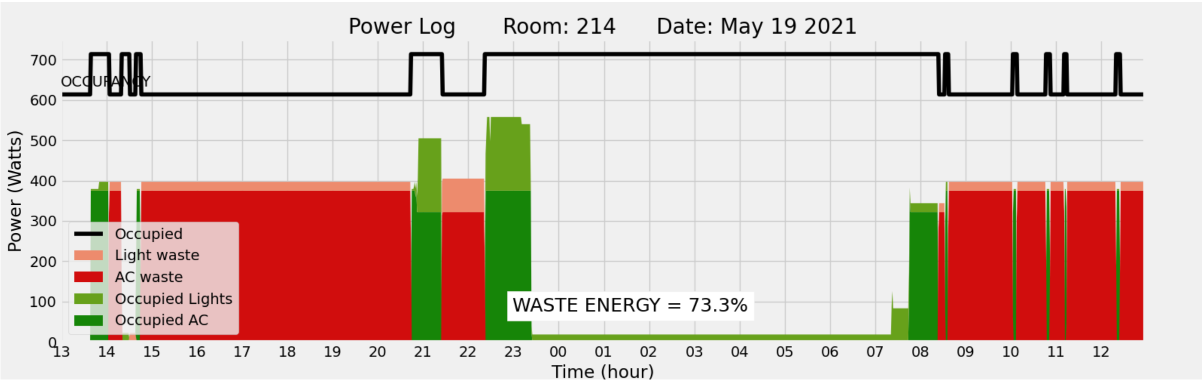

Power Log Room: 116 Date: Jun 02 2021
OCCUPANCY
Power (Watts)
Time (hour)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 29.5%

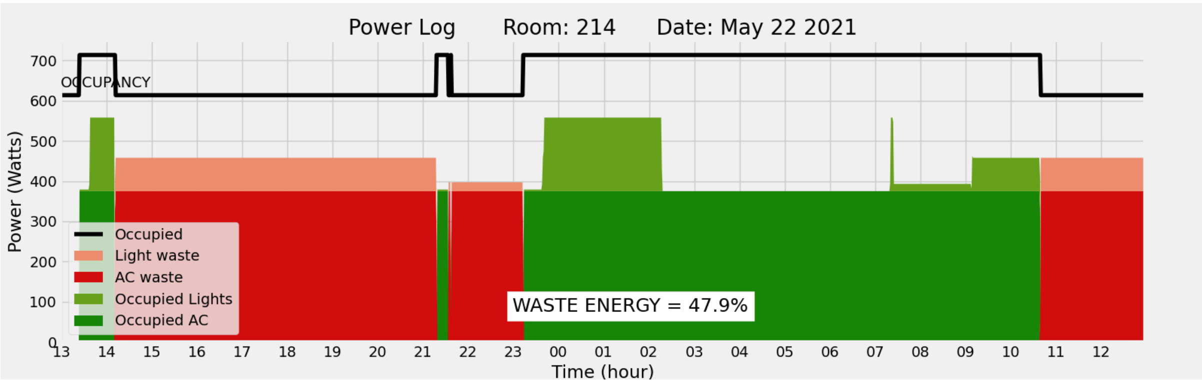

Power Log Room: 212 Date: May 20 2021
OCCUPANCY
Power (Watts)
Time (hour)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 29.1%

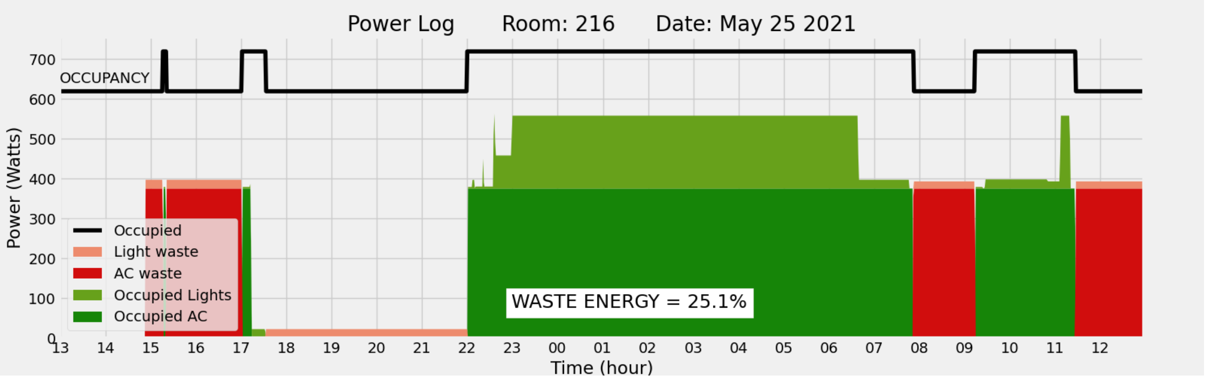

Power Log Room: 212 Date: May 23 2021
OCCUPANCY
Power (Watts)
Time (hour)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 20.0%

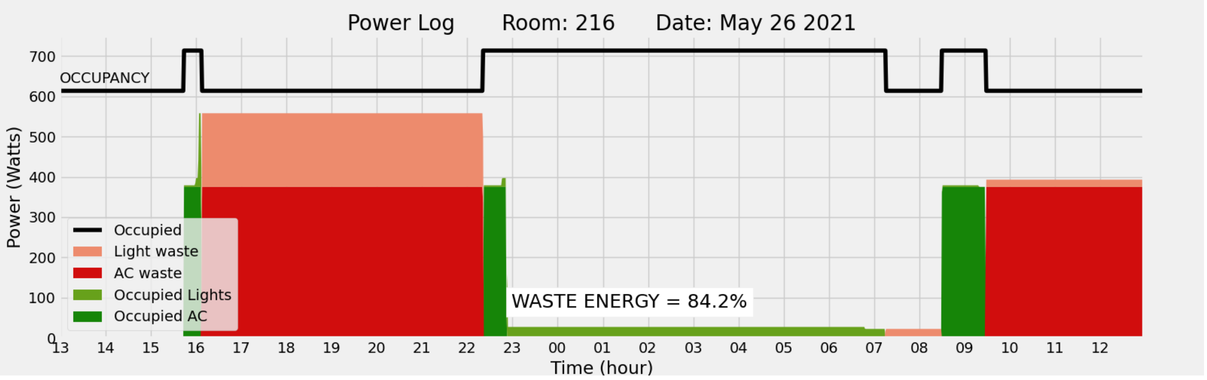

Power Log Room: 212 Date: Jun 05 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 40.4%
Time (hour)

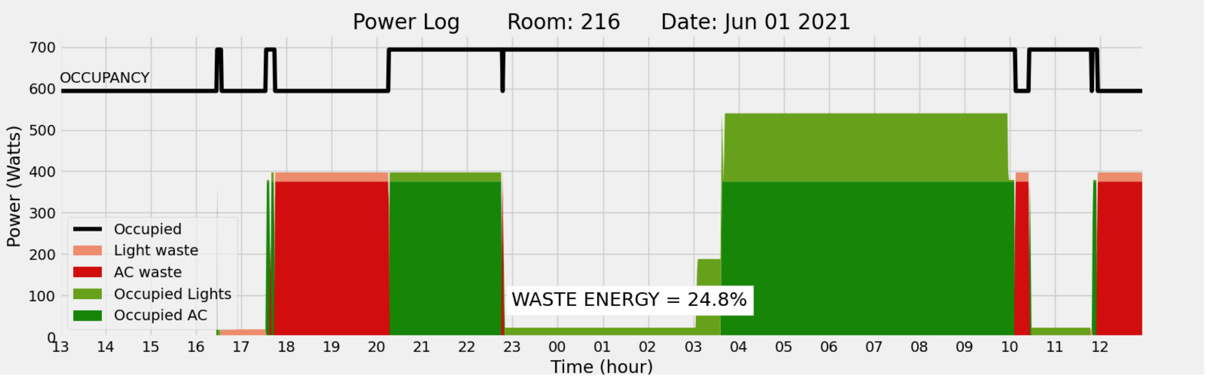

Power Log Room: 214 Date: May 18 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 80.0%
Time (hour)

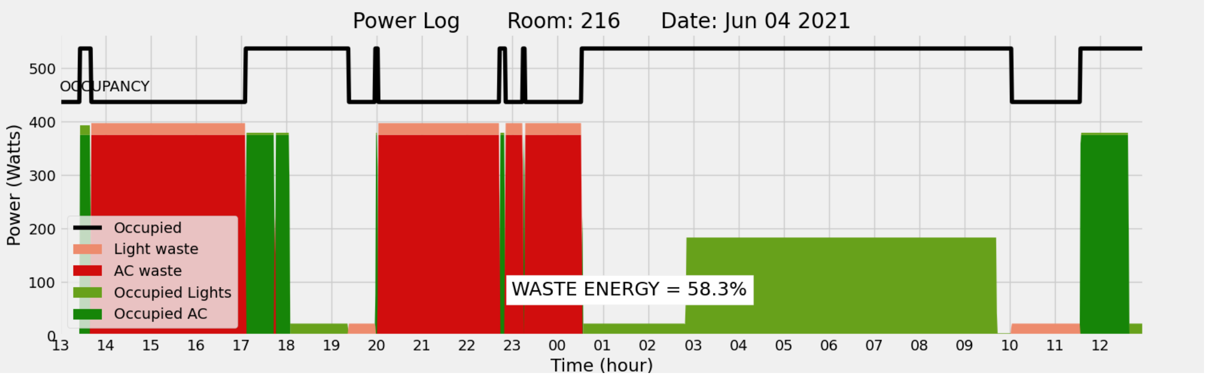

Power Log Room: 214 Date: May 19 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 73.3%
Time (hour)

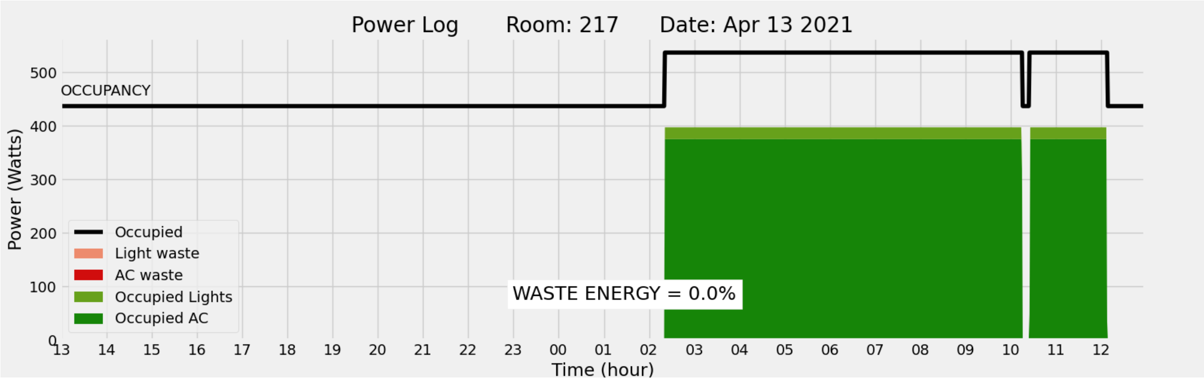

Power Log Room: 214 Date: May 22 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 47.9%
Time (hour)


Power Log Room: 216 Date: May 25 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 25.1%
Time (hour)


Power Log Room: 216 Date: May 26 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 84.2%
Time (hour)


Power Log Room: 216 Date: Jun 01 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 24.8%
Time (hour)


Power Log Room: 216 Date: Jun 04 2021
OCCUPANCY
Power (Watts)
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 58.3%
Time (hour)


Power Log Room: 217 Date: Apr 13 2021
OCCUPANCY
Power (Watts)
500
400
300
200
100
0
Occupied
Light waste
AC waste
Occupied Lights
Occupied AC
WASTE ENERGY = 0.0%
13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12
Time (hour)