# Thermal insulation tests: Preliminary Lab Experiment results

**Disclaimer**: This preliminary analysis has been conducted under laboratory conditions. It's important to note that in real-world settings, factors such as ambient temperature, the position of the sun, and building insulation will influence the room's heat retention. Also, reduction in temperature fluctuations at the window with blinds closed and higher attainment of maximum temperatures does not equate to the degree at which heating can be reduced by – this will be impacted by several other factors such as building insulation and window, window type, external conditions, and size of room.

An inuslated box was built mimicing a real room 81.5cm by 50.5 by 41.95cm (173L). The box is fitted with a double glazed window and a BS01 blind from BlindScreen at the top as shown in the Figure 1 below.

K-Type temperature sensors were installed at different points, inside the box (T1), at the window inside (T2), and outside the box (T3) to provide an intial analysis of the effect of the particular blind fitted. Inside the room is a 250W infrared bulb, fitted in to heat up the box and to simulate the effect of heating.

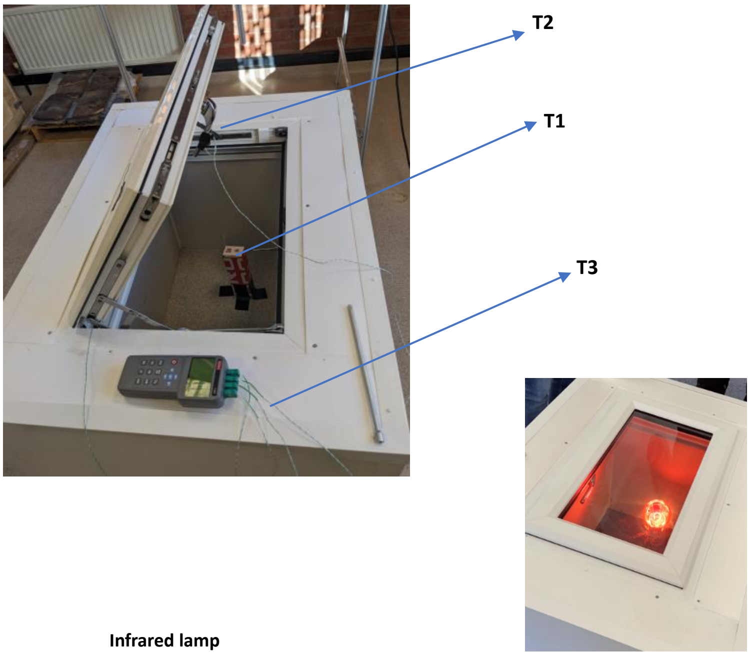

*Figure 1: Lab Experiment Setup*

The initial analysis was made for winter conditions where the heat/temperature retention in a room was simulated under lab conditions. Two experiments were conducted separately:

- Window closed and **Blinds Open**.
- Window closed and **Blinds Closed**.

The objective of these two different experiments was to identify and highlight the potential effect that the blind could have on a simulated heating inside the box. The heating was switched off after 19 minutes from the start of both experiments (1140 seconds). All positions of sensors were left unchanged.

As the experiment progresses and especially after the IR lamp is turned off at the 19-minute mark, leading to the cooling down of the inside of the box, the temperature dynamics would be influenced by the loss of the heat source and the gradual equalization of temperature within the box as the heat disperses and eventually dissipates through the window and the box's walls.

To standardize the two experiments, the relative change in temperature within each experiment rather than absolute temperatures is used in the analysis (*cf.* Figure 2). This approach allows for a more direct comparison of thermal performance by focusing on how quickly or slowly temperatures change in response to external factors (like the IR lamp being turned off) relative to the starting condition.

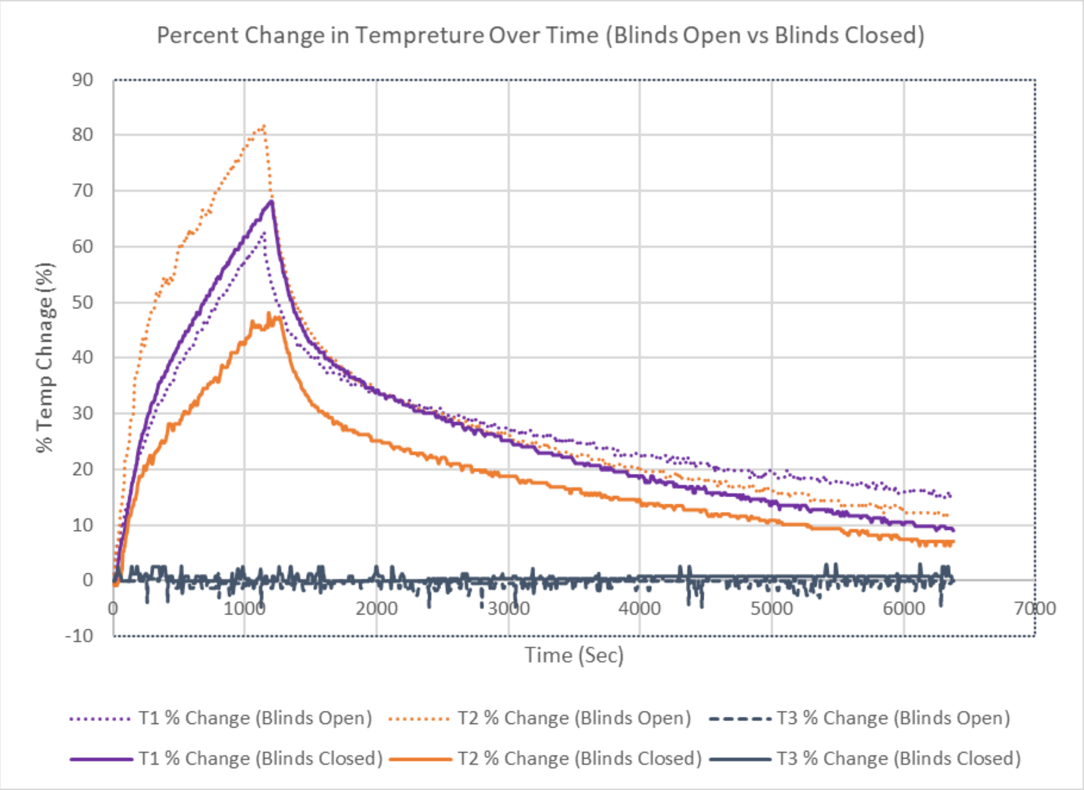

*Figure 2: Setup 2 - Windows Closed, Blinds Closed*

To provide a more quantified analysis, the following metric have been considered:

- Maximum Percentage Change in Temperature for T1 (Inside Box) and T2 (Window Inside) under both scenarios to gauge the peak thermal impact.
- Average Rate of Temperature: Change before and after the IR lamp was turned off – to provide insight into how quickly temperatures rise or fall.

**Maximum Percentage Change in Temperature:**

T1 (Inside Box) had a maximum percentage change of 62.61% (**Blinds Open**) and 68.05% (**Blinds Closed**), indicating a slightly higher peak temperature change with the blinds closed.

T2 (Window Inside) had a significant difference, with 81.74% (**Blinds Open**) compared to 48.68% (Blinds Closed), showing that closing the blinds significantly reduced the temperature fluctuation at the window. For the **Blinds Open** experiment, a higher concentration of warmer air near the window at the top is seen before it has a chance to evenly distribute throughout the box. Consequently, T2 records higher temperatures initially compared to T1. This effect is consistent with the principle of convection, which is the transfer of heat (through fluids – air inclusive) from warmer to cooler areas.

T3 (Outside Box) changes were minimal, 1.27% (**Blinds Open**) and 3.04% (**Blinds Closed**), highlighting the relatively stable external conditions.

**Average Rate of Temperature Change (Before and After IR Lamp Turned Off):**

***Before Turn Off:*** The average rate of temperature increases for T1 and T2 (**Blinds Open**) was 0.0122 °C/sec and 0.0164 °C/sec. For **Blinds Closed**, T1 changed at an average rate of 0.0155 °C/sec thus indicating a slightly faster temperature increase. T2 changed at the lower rate of 0.0107 °C/sec indicating a reduced heat transfer through the window and greater heat retention.

***After Turn Off:*** For **Blinds Open**, T1's average rate was -0.0017 °C/sec, and T2's rate was -0.0025 °C/second. Through the experiment, T1 experienced a decrease of approximately -29.09% and T2 experienced a decrease of approximately -38.52%. The higher rate of temperature decreases for T2 compared to T1 after turning off the IR lamp suggests that the window area (T2) was losing heat more quickly than the interior (T1). This is consistent with the window being a primary site of heat transfer to the external environment allowing for more direct heat escape.

For **Blinds Closed**, T1's rate was -0.0029 °C/sec, and T2's rate was -0.0019 °C/sec. In general, T1 showed a decrease of approximately -34.54% and T2 had a decrease of approximately -26.17%. The slower rate of temperature decreases for T2 compared to T1 indicates that closing the blinds effectively reduced heat loss through the window with the blinds acting as a barrier, reducing the thermal gradient and the rate of heat transfer from the window to the external environment.

T1 however has a faster temperature rate decrease with the blinds closed after the heat source was removed contrary to what may seem like the expectation. The primary reason for this could be the insulation effect and heat retention and distribution effects. As seen previously, the blinds closed leads to higher initial temperature. Once the heat source is removed, the trapped heat within the insulated environment may initially cause a faster rate of temperature decrease as the system seeks to reach thermal equilibrium with its surroundings more rapidly due to the higher thermal gradient. Similarly, the heat retained within the box could be more uniformly distributed, leading to a more homogenous temperature decrease. In contrast, with the blinds open, heat dissipation mechanisms might vary across different parts of the box, leading to a slower and more uneven cooling process. This thesis is to be further verified by the incorporation of thermal imaging into the analysis which can provide more insights on the thermal dynamics.

**Conclusion -** The experimental analysis demonstrates that the presence of blinds (specifically Blind Screens BS01) significantly affects thermal behaviour within the simulated room environment. Closing the blinds leads to enhanced heat retention inside the box and reduces heat transfer through the window, as evidenced by the higher maximum temperature increase in T1 by 5.44% and a substantial reduction in heat transfer through the window (T2) by a 33.06% decrease (in maximum temperature increase), highlighting how the blinds can contribute to modifying the thermal environment.

Similarly, with the IR lamp turned off, the average rate of temperature decrease for T2 was 0.0006 °C/sec or 24% slower with the blinds closed compared to when the blinds were open. This thus shows the effectiveness of the blinds in reducing heat transfer through the window.

This analysis underscores the importance of blinds in regulating indoor temperatures, offering valuable insights for optimizing energy efficiency and thermal comfort in building design and management. Comparing other blinds will thus offer a more valuable insight on the efficacy of different blind types. Incorporating thermal imaging could further substantiate these findings by providing a direct visualization of heat fluxes.