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MTN BTS – MANOCON SHELTER (KAGISO)

ENVIRONMENTAL STUDY REPORT

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AMENDMENT HISTORY			
Revision	**Date**	**Amendment Details**	**Authors**
00	25 January 2019	First Release	Johann Beyers

TABLE OF CONTENTS

TABLE OF FIGURES

1 INTRODUCTION

Energy Insight was tasked by Manocon Building Construction to conduct an environmental study at the MTN BTS Shelter in Kagiso.

This Shelter is in the proof of concept phase, and the data below is intended to provide information on the environmental and power consumption implications of the new Shelter Design.

Temporary measurement equipment was installed to measure the following variables:

- Temperature – External Temperature
- Temperature – Internal Shelter Temperature
- Temperature – Internal Tower Room Temperature
- Single Phase AC Power – Air Conditioner 1
- DC Power – DC Fans (Total)

The measurement and analysis data is presented in Section 3 of this document..

2 INVESTIGATION METHOD

The measurement timeline below shows the period over which the investigation took place.

Note from Figure 3-1 that there were periods where some cold days were experienced. In order to make reliable observations and comparisons only data sets with similar weather patterns were chosen for the analysis.

The periods chosen for the analysis are:

- **Raw Shelter:**
  - (9 – 16 January 2019)
- **Shelter Covered with 80% Shade Netting on the Western front:**
  - (17 – 21 January 2019)
- **Shelter painted with reflective paint:**
  - (22 – 25 January 2019)

It can be seen from Figure 3-2 that there is a period between 16:30 and 18:40 every day when the External Temperature shows a spike. This was due to the sun hitting the External Temperature probe directly under the roof overhang during that period of the afternoon. This caused an incorrect reading of higher than actual temperatures. Fortunately, during the period when the Shade Netting was deployed, this problem did not persist, therefore, this data was utilized to adjust the other two sets of data accordingly. After these “spikes” have been “filtered” out of the two affected data sets (Raw and Paint), the result that was left can be seen in Figure 3-6.

The average day temperatures also varied substantially between the three data sets, so all data was normalized to a single Average External Temperature as can be seen between Figure 3-5 and Figure 3-6.

Table 2-1 COMPLETE MEASUREMENT TIMELINE

	Shelter Configuration	Start	End
	Environmental Monitoring Timeline	12/1/18	1/25/19
1	Shelter Construction Complete	12/1/18	12/3/18
2	Environmental Measurement Period	12/4/18	1/25/19
3	Raw Shelter Configuration	12/4/18	1/16/19
4	Shade Netting covering Western Side of Shelter	1/17/19	1/21/19
5	Shelter Covered with Reflective Paint	1/22/19	1/25/19

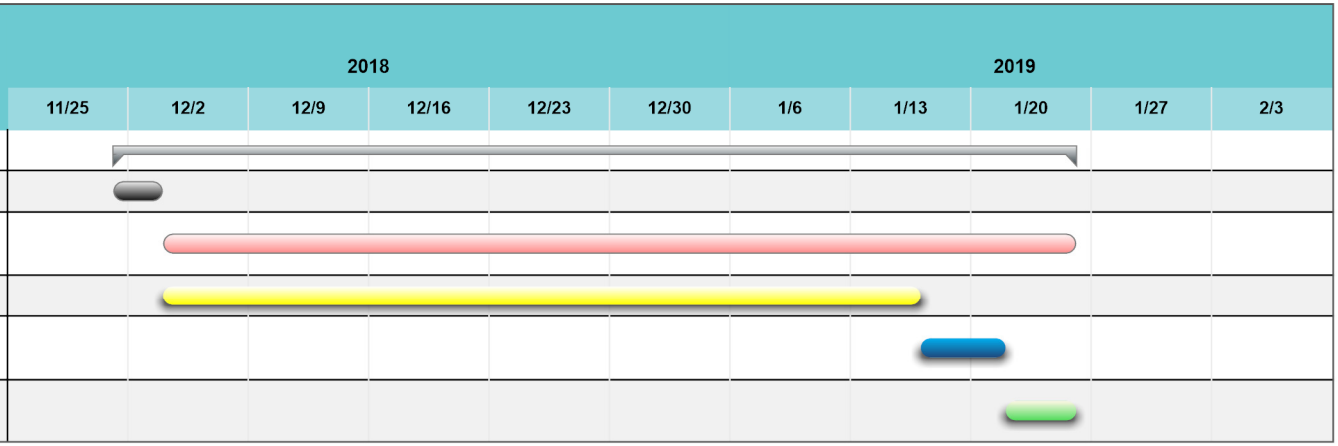


Table 2-2 RAW SHELTER CONFIGURATION MEASUREMENT TIMELINE

	Shelter Configuration	Start	End
	Environmental Monitoring Timeline	12/1/18	1/16/19
1	Shelter Construction Complete	12/1/18	12/3/18
2	Raw Shelter Configuration	12/4/18	1/16/19

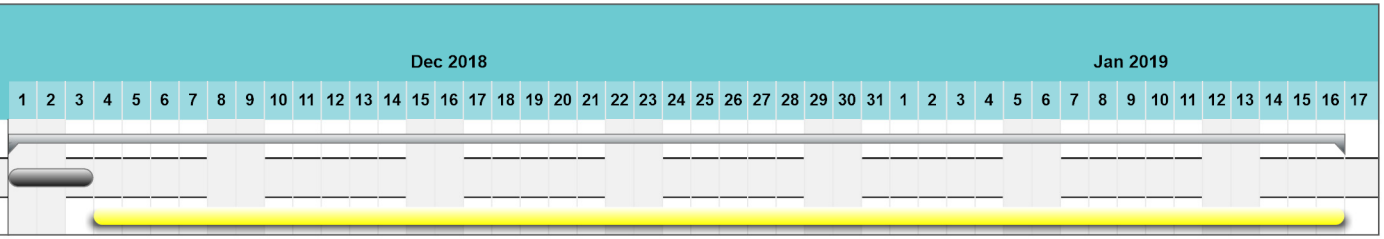
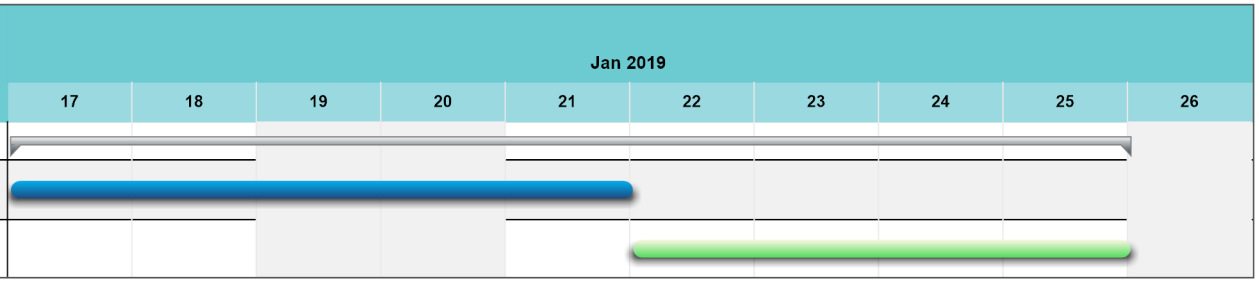


Table 2-3 ADJUSTED SHELTER CONFIGURATION MEASUREMENT TIMELINE (Shade Netting & Reflective Paint)

	Shelter Configuration	Start	End
	Environmental Monitoring Timeline	1/17/19	1/25/19
1	Shade Netting covering Western Side of Shelter	1/17/19	1/21/19
2	Shelter Covered with Reflective Paint	1/22/19	1/25/19



3 MEASUREMENT DATA

3.1 ENTIRE MEASUREMENT PERIOD (4 DEC '18 – 25 JAN '19)

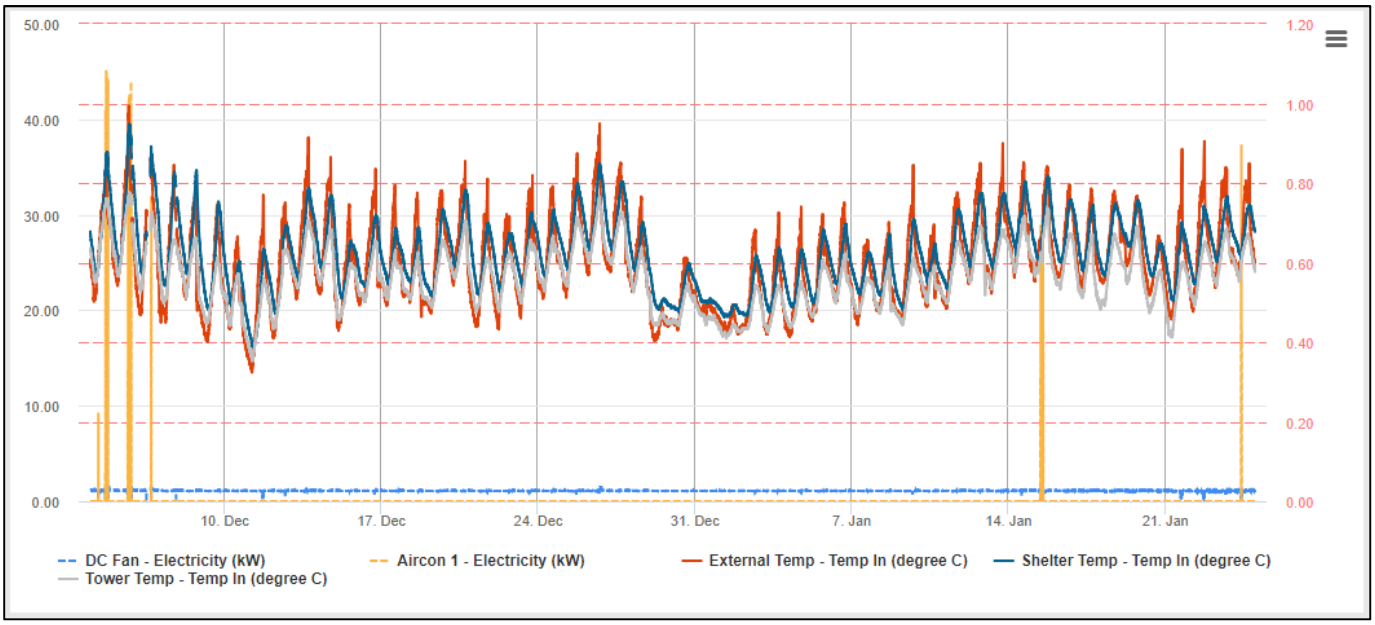


Figure 3-1 Raw Environmental Data – (5-Minute Interval)

- Note DC Fan running continuously at approximately 270W for the whole period.
- The AC air conditioner only started a few times, but this was not during normal operation, but when the shelter door was opened for contractors to carry out work inside.
- Some cold days were experienced over the measurement period, and these data sets were left out of the analysis of the data.

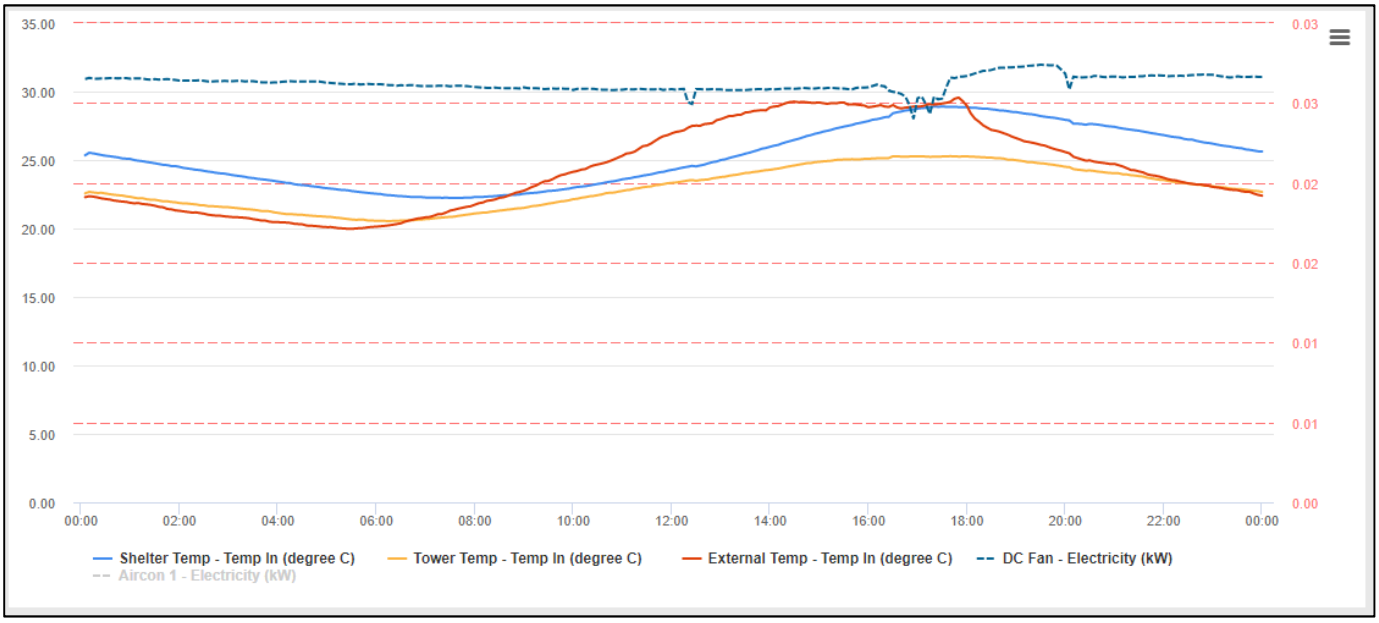


Figure 3-2 Average Day Environmental Data – (4 DEC '18 – 25 JAN '19)

- Note the External temperature spike between 16:30 and 18:40 in the afternoon. This data was filtered to provide more accurate information as in Figure 3-5.

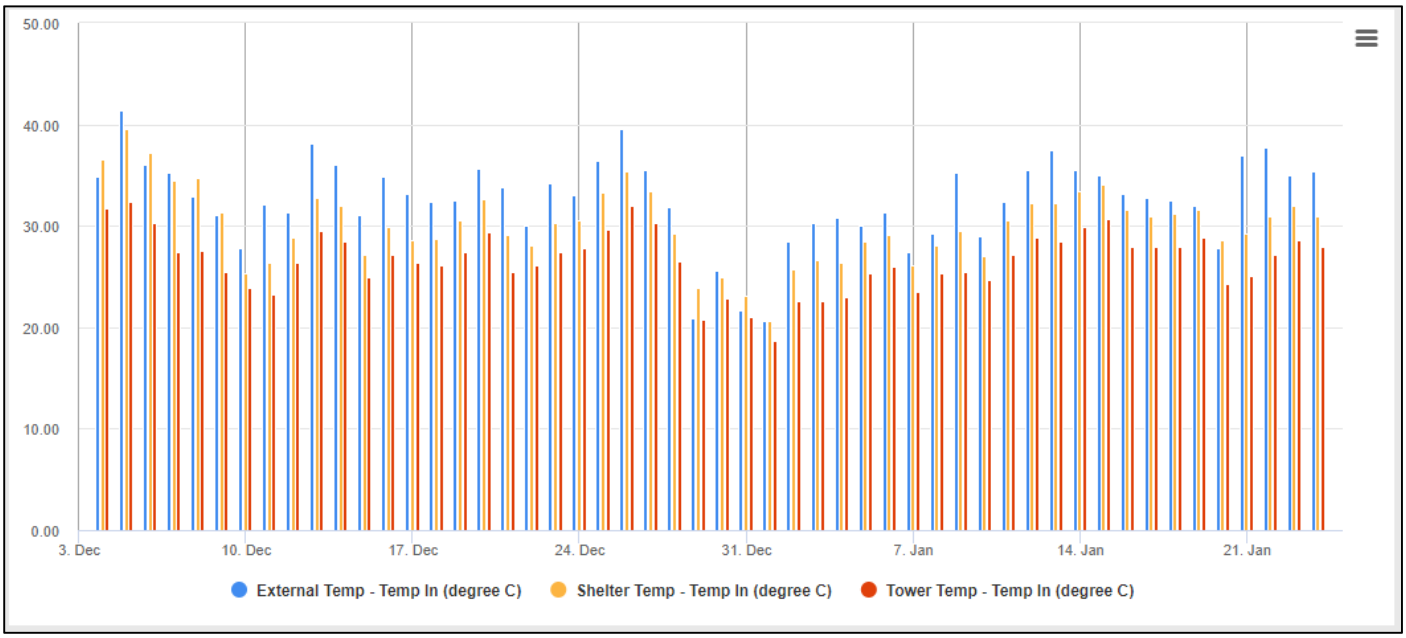


Figure 3-3 Daily Maximum Temperatures – (4 DEC '18 – 25 JAN '19)

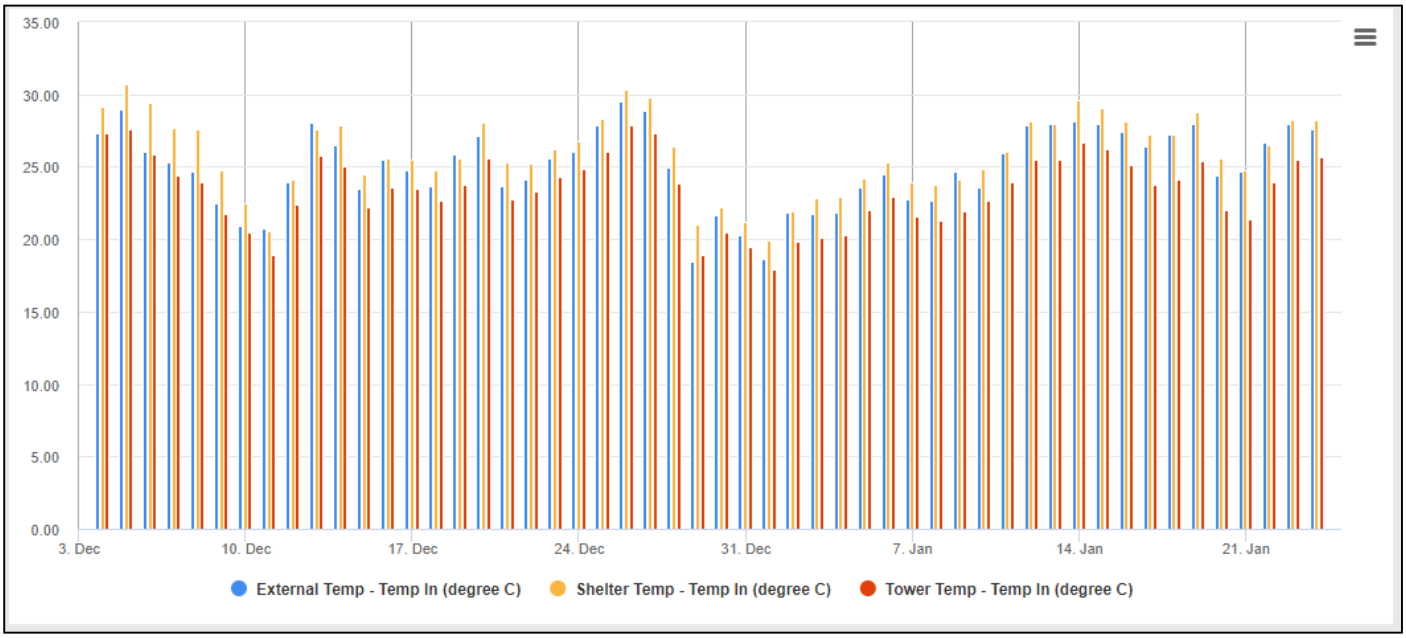


Figure 3-4 Daily Average Temperatures – (4 DEC '18 – 25 JAN '19)

- Comparing Figure 3-3 and Figure 3-4 shows that daily **maximum** External temperatures were higher than the Internal Shelter temperatures. However, daily **average** Internal Shelter temperature were higher than the External temperatures.

3.2 DATA ANALYSIS

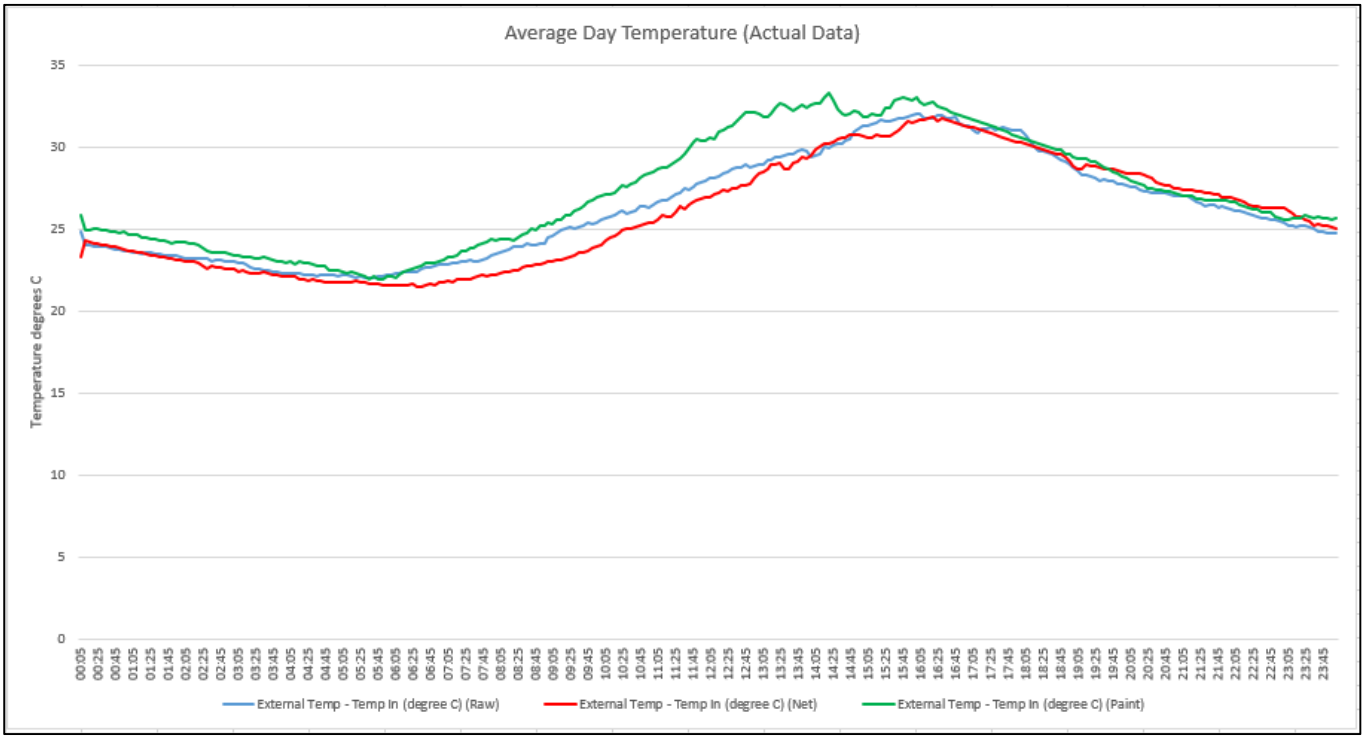


Figure 3-5 Average Day Temperatures Actual (9-16 Jan: Raw, 17-21 Jan: Net, 22-25 Jan: Paint)

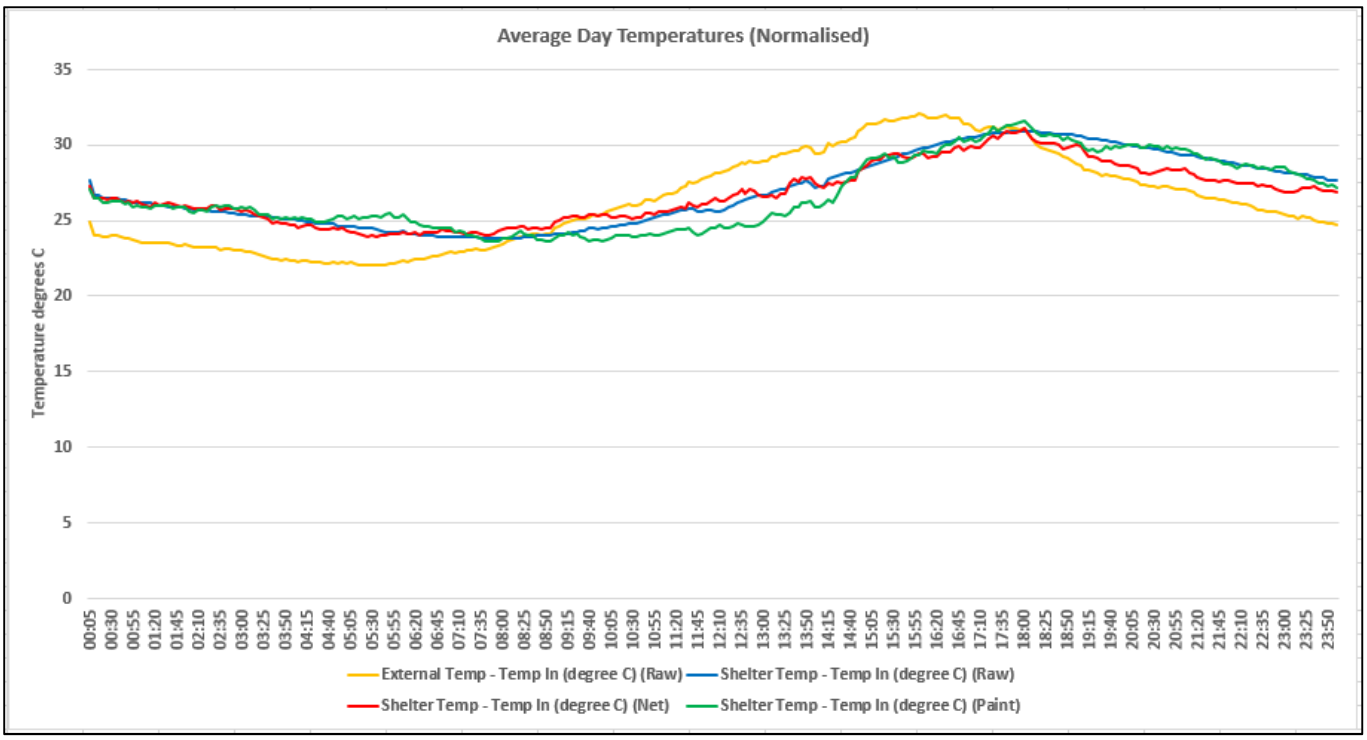


Figure 3-6 Average Day Temperatures Normalized (9-16 Jan: Raw, 17-21 Jan: Net, 22-25 Jan: Paint)

- Comparing Figure 3-5 and Figure 3-6, the difference between the actual measured data and the normalised data for the External temperature can be seen. Note that the Internal Shelter temperatures for the three measurement periods were also adjusted with the same normalisation ratios.

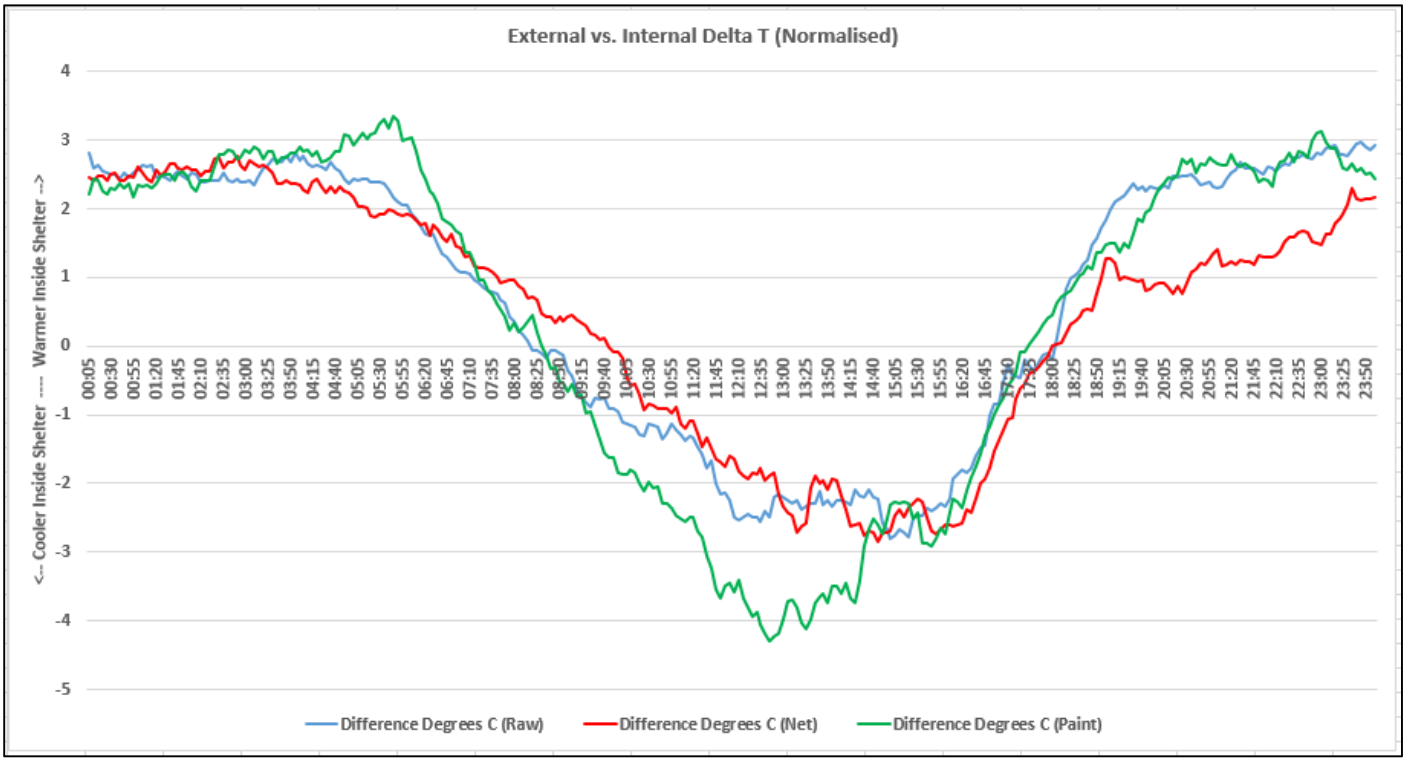


Figure 3-7 Average External vs. Internal Temperature Difference Normalized (9-16 Jan: Raw, 17-21 Jan: Net, 22-25 Jan: Paint)

- The graph above (Figure 3-7) provides a good indication of the effect of the various configurations of the Shelter.
- The Shade Net configuration provided a result where it was cooler inside the Shelter during the evening hours than the other configurations, but for the rest of the time, temperatures were similar to that of the Raw Shelter configuration.
- The Reflective Paint configuration yielded a result where it was cooler during the late morning and mid-day period than the other configurations, but for the rest of the time, temperatures were similar to that of the Raw Shelter configuration.
- All the above data provides valuable information, but it is important to attain an indication of the amount of daily cooling Energy required for each of the configurations. The data analysis in Figure 3-8 below provides this information.
    - The scatter plot shows the hysteresis of the temperature lag between the External and Internal temperatures.
        - Smallest hysteresis: Shade Net Configuration
        - Medium hysteresis: Raw Shelter Configuration
        - Largest hysteresis: Reflective Paint Configuration
    - Note that the Trend Line Gradients of each scatter plot also provides quite a bit of insight on the effects of the different configurations.
        - Flatter gradient = more beneficial
        - Lower y-axis intersection = more beneficial
    - Possibly the best indicator of the effectiveness of each configuration lies in the Cooling DegreeDays calculation for each of the configurations. Calculations were done on the basis of maintaining an Internal temperature of 25 degrees C or lower. The results are summarized below:
        - **Raw Shelter Configuration: 1.96 Cooling DegreeDays**
        - **Shade Net Configuration: 1.75 Cooling DegreeDays**
        - **Reflective Paint Configuration: 1.75 Cooling DegreeDays**

- These results show that both the **Shade Net and Reflective Paint configurations yielded lower and equal cooling demand** than the Raw Shelter Configuration.
- It is interesting to note that the Shade Net and Reflective Paint had different effects during different parts of the day.

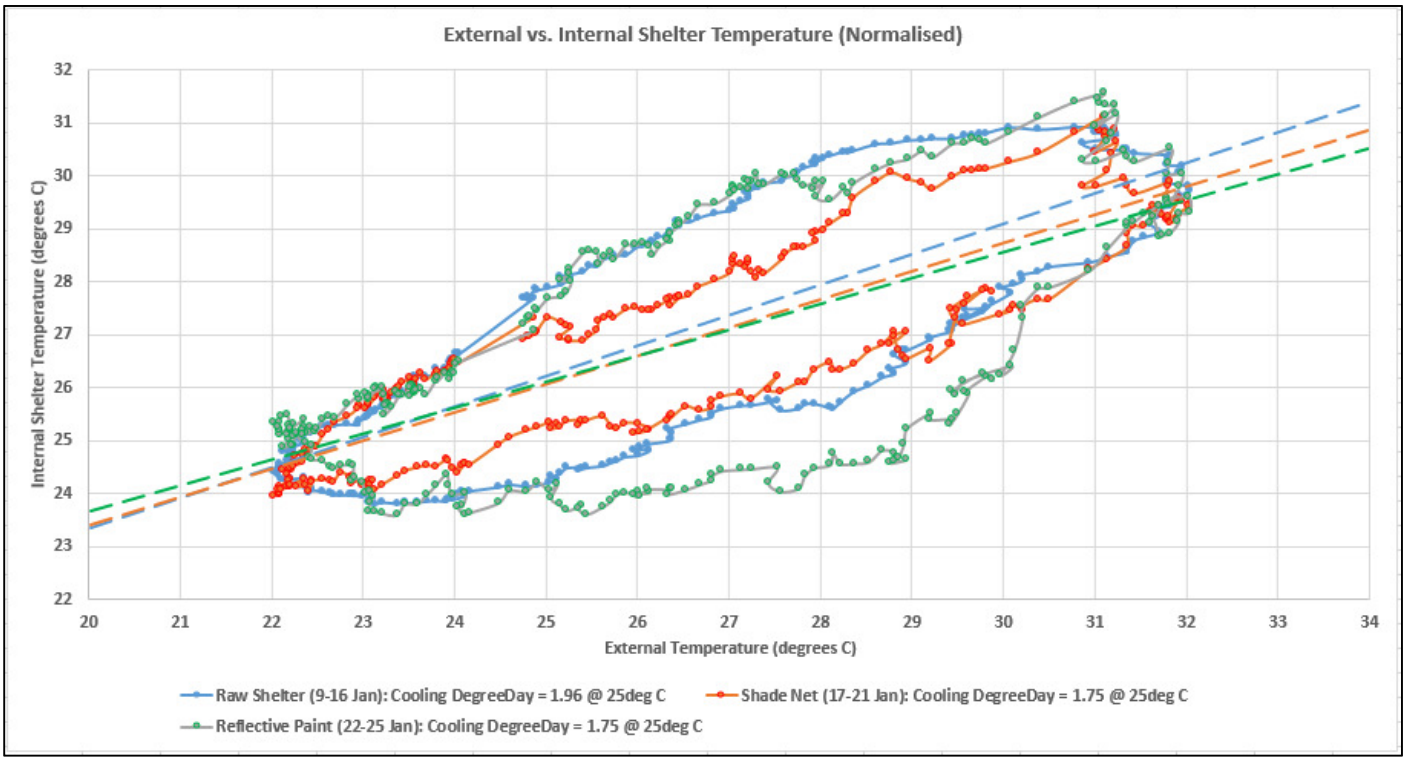


Figure 3-8 Average External vs. Internal Temperatures Normalized (9-16 Jan: Raw, 17-21 Jan: Net, 22-25 Jan: Paint)