2019

Final Report for Bid No. 487

Cool Coating Kheis Marketing Intelligence Company

Low Exergy Consulting

FINAL REPORT

Bid No. 487: Cool Coating Kheis Marketing Intelligence Company

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EXECUTIVE SUMMARY

The aim of the work proposed was to determine the efficacy in cooling un-air-conditioned, low cost housing in the Northern Cape, !Kheis in order to encourage uptake of Cool Surfaces technology by the RSA market.

The assessment process included qualitative (survey-based) and quantitative components enabling an holistic review and analysis of the technology applied, its measurable and perceived effects and acceptance among occupants. The benefit of this approach is that an assessment of the technology was possible even without historic baseline data and that the beneficiaries of the project could directly describe the effects/benefits/disadvantages attained through the intervention while at the same time data measurements in sample buildings provide evidence of the effects.

The thermal comfort in summer is perceived to have increased through the application of cool coating and the main research questions allow the conclusion that the technology intervention is perceived to have increased people's standard of living through the perceived lower temperatures in summer and the fact that on average more time can be spent indoors than prior to the intervention. It should be noted that the perceived effect of the technology is that the interior of the coated buildings are colder in winter than the uncoated homes.

Households living in cool coated homes are very satisfied with the technology and the large majority would recommend it to others. The perception of cool coating in the entire community is very positive demonstrated in the fact that a large percentage of persons living in uncoated homes in the direct vicinity would also recommending the technology to others.

Regarding some of the other points investigated, such as whether there has been changes in health since the intervention, no such effect can be concluded from the survey.

An important finding of the survey is that over 20% of respondents living in cool coated homes noted that their roof is leaking after the application of the paint.

The data measurements in sample buildings and the following analysis provides quantitative evidence of the cool coating technology's efficacy in reducing indoor temperature both on average and regarding daily minimum and maximum temperatures and will thus increase the thermal comfort perceived by the occupants.

The sample application of thermal imaging in the work conducted shows that thermography could be a suitable quality control measure for future applications of Cool Surfaces technology.

SCOPE OF WORK

The aim of the work proposed was to determine the efficacy in cooling un-air-conditioned, low cost housing in the Northern Cape, !Kheis in order to encourage uptake of Cool Surfaces technology by the RSA market.

The following sections illustrate LowExCo's approach and activities in achieving this objective based on the agreed timeframes.

METHODOLOGY EMPLOYED

1.1 Approach and Overview of Methodology

The work conducted combines expertise in measurement instrumentation, thermal comfort in buildings, data analysis, market intelligence and stakeholder engagement to enable the assessment and efficacy benchmarking of the roof cool coating technology. The assessment process included qualitative and quantitative components enabling an holistic review and analysis of the technology applied, its measurable and perceived effects and acceptance among occupants. The benefit of this approach is that an assessment of the technology was possible even without historic baseline data and that the beneficiaries of the project could directly describe the effects/benefits/disadvantages attained through the intervention while at the same time data measurements in sample buildings provide evidence of the effects.

Our technical approach for the assessment of the cool coating technology consisted of the stages outlined in Figure-1. The timeframes shown enabled achieving the overall project timeframe set out by SANEDI. The approach taken allowed for the deliverables as set out in Figure 2 below and are described in more detail in sections 1.2 – 1.7.

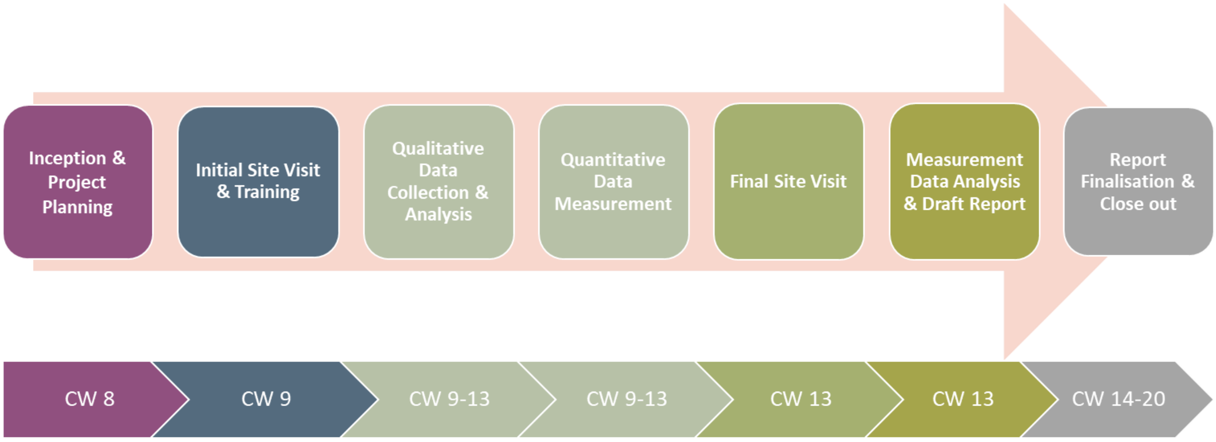

Figure-1. Overview of project steps and timeframe

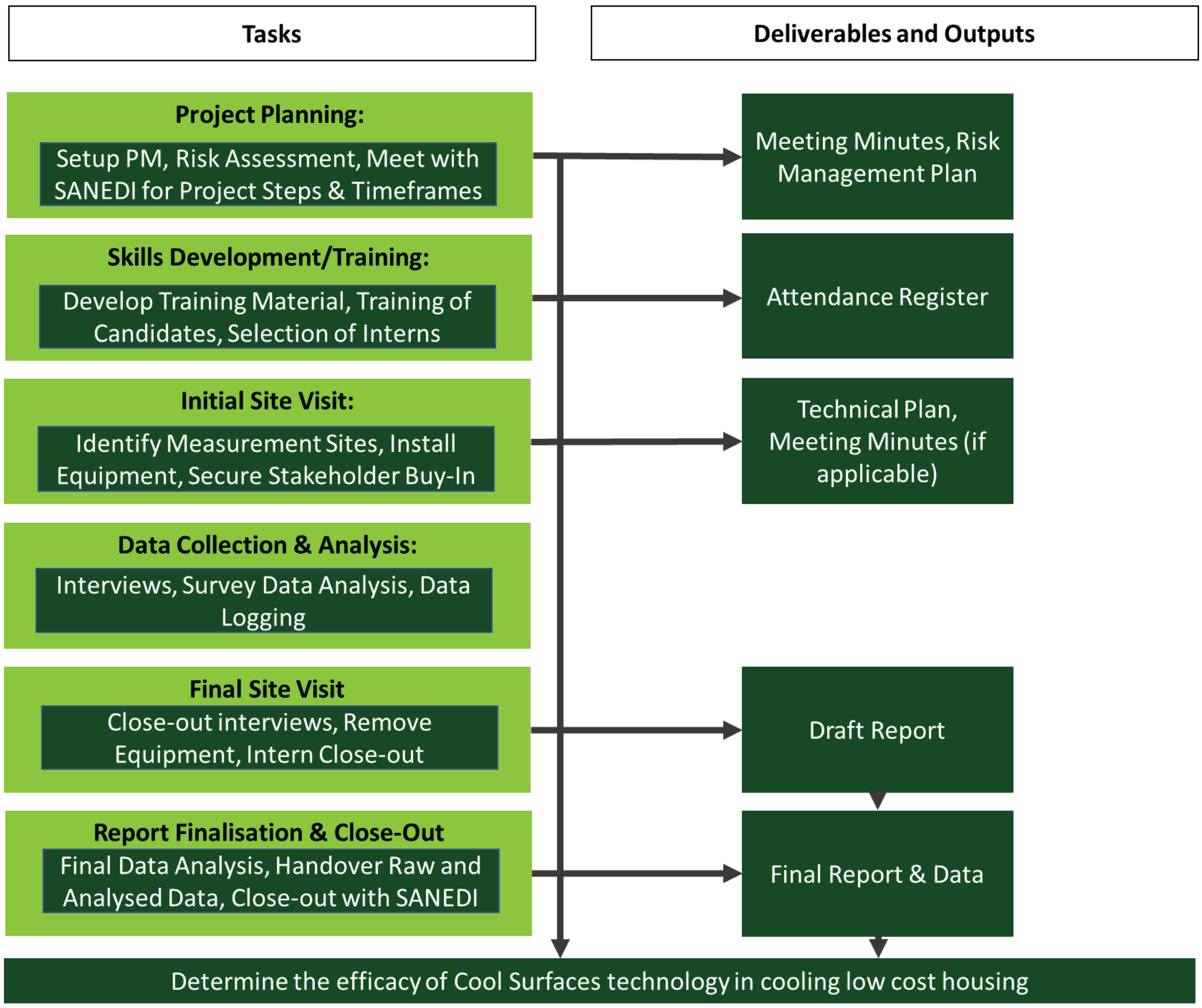

Figure 2. Overview of methodological steps, tasks and deliverables/outputs

1.2 Project Planning/Inception and Initial Site Visit

Project management was set up and the risk management conducted resulting in a risk management plan, which was discussed during the inception meeting and subsequently made available to SANEDI for approval.

A meeting was held with the SANEDI project manager to discuss in detail the project steps and confirm the timeframes for the assessment and the deliverables. The consultant compiled minutes of the meeting and made these available to SANEDI.

An initial site visit was conducted over 4 days to identify suitable sites for measurement instrumentation, install equipment and to secure buy-in and cooperation from relevant stakeholder in order to conduct this project successfully.

This site visit entailed:

- Candidate training and intern selection (See section 1.3).

- Selection of representative and comparable sites for monitoring equipment through inspection and interviews
- Explanation of data collection procedure
- Installation of equipment
- Testing of equipment
- Selection of occupants for survey interviews
- Securing buy-in from chosen homeowners and tenants
- Secure consent for telephonic contact

A community meeting was organised by !Kheis Municipal authorities where the project was explained and buy-in from the residents was secured. This also served as the basis for the site selection for the measurement equipment. Households willing to participate in the measurement campaign were asked to leave their contact details with the project team.

Figure 3. Photo of community members signing up for participation in measurement campaign

A technical plan detailing the placement of monitoring equipment as well as the number and structure of the survey interviews was drafted including assumptions made and criteria taken into account based on initial interviews and motivations/justifications.

1.3 Skills Development/Local Participation/Training

A key factor of the methodology was local participation and skills development. A total of 8 survey interviewers were trained on thermal comfort basics, general interview techniques and conducting the survey developed for this project in a one-day training intervention. The candidates were recruited from the pool of graduates from a previous training intervention on the application of cool coating conducted on behalf of SANEDI with the aim of giving these candidates the opportunity of working with LowExCo on this project as interns, thereby gaining valuable insights and experience for their future professional development. The training was conducted in the course of the initial site visit to minimise additional time and cost overheads. Training material was developed, and the training conducted by LowExCo to ensure the candidates attained the skills required for project participation.

The training of the candidates and project participation of the interns has formed a contribution to skills development and upliftment of historically disadvantaged youths in the region and enhanced the perception of the project through local participation.

Figure 4. Photo of training intervention held at Kheis Municipal buildings

1.4 Qualitative Data Collection

In order to assess the perceived effects, acceptance and market potential of the cool coating technology interview-based surveys were conducted with a representative number of occupants living in houses with roofs coated with the cool surface technology and a control group living in homes with uncoated roofs. The methodology is outlined in Figure 5. A total of 282 interview surveys were conducted (178 cool coated homes and 104 uncoated homes) from 28.02.2019 to 22.03.2019 which constitutes a representative sample size.

The interviews were conducted primarily by the trained interns and followed a predefined questionnaire. The draft questionnaire was developed in the initial phase of the project and was finalised based on the information and outcomes of the initial site visit. The draft survey questions were evaluated using a combination of the methodologies of expert review and cognitive interviewing during the initial site visit. The aim was to identify potential problems in the response process in order to obtain valid and accurate data from the surveys.

The questionnaire assessed the following points:

- Occupancy data (number of people, ages…)
- Perceived thermal comfort in the course of the day and night
- Satisfaction with cool coating technology
- Perceived effects of technology
- Occupant usage pattern
- Potential heat loads
- Heating behaviour incl. cost changes
- Cooling behaviour incl. cost changes
- Changes in health situation

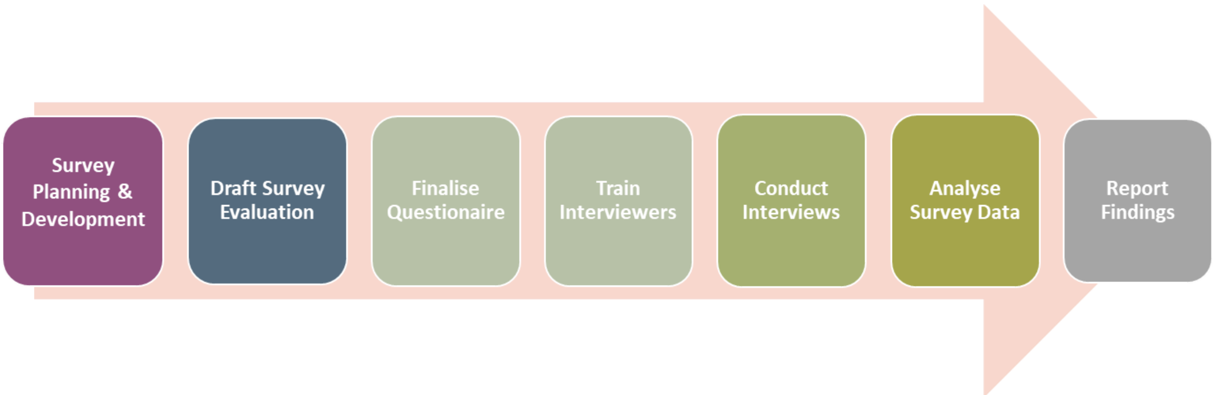

Figure 5. Methodology and steps of qualitative data collection and analysis

The candidates were split into three groups (2 x 3 interviewer team. 1 x 2 interviewer team), where the surveys were conducted in those groups together with each team member rotationally conducting the specific interview.

The survey area has been grouped into three sections based on the block numbering shown in the map (see Figure 6). Team 3 was allocated a somewhat smaller area, because it consists of only two persons. The aim was for each interviewer to have conducted roughly the same number of interviews at the end of the survey. The following sections were allocated to the three groups:

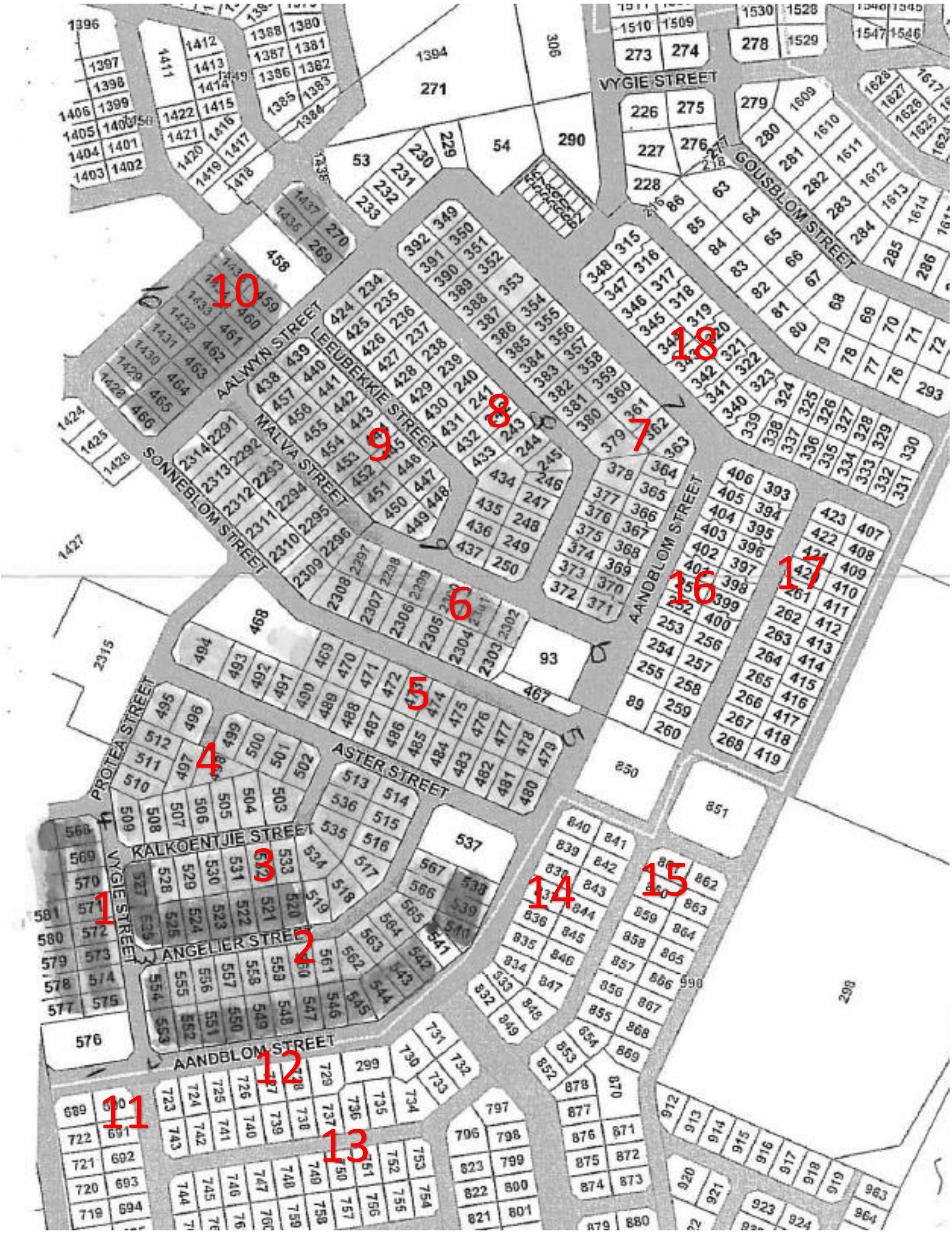

Figure 6: Split of survey area into blocks. Block 1-10 cool coated homes, Block 11-18 uncoated homes.

Cool Coating Homes:

Area 1: Block 1, 2, 3 and 4

Area 2: Block 5, 6 and 7

Area 3: Block 8, 9 and 10

Uncoated Homes:

Area 1: Block 11, 12, 13 and 14

Area 2: Block 15 and 18

Area 3: Block 16 and 17

Figure 7. Photo of interview conducted by trained intern

Figure 8. Photo of interview conducted by trained intern

The first set of interviews was conducted following the initial site visit by the interns with the support of the project team. The subsequent survey interviews were conducted by the interns independently using mobile phones with the filled-out questionnaire being made available for data analysis electronically. Figure 7 and Figure 8 show photos of interviews in progress.

To ensure quality management and continued buy-in from the homeowners and tenants, both the interviewer and a random sample of interviewees were contacted telephonically by the project team to assess, if the interview processes was running smoothly and to attain feedback.

1.5 Quantitative Data Collection

The second component of the efficacy assessment of the cool coating technology intervention involved data measurements in sample buildings to provide quantitative evidence of the effects. The methodology is outlined in Figure 9. In total 10 homes were equipped with measurement instrumentation allowing the measurement of indoor temperature and relative humidity. The sites were selected based on the willingness of homeowners/tenants that took part in the community meeting to participate in this measurement campaign. Due to low participation in the community meeting, the selection options for representative and comparable homes were limited.

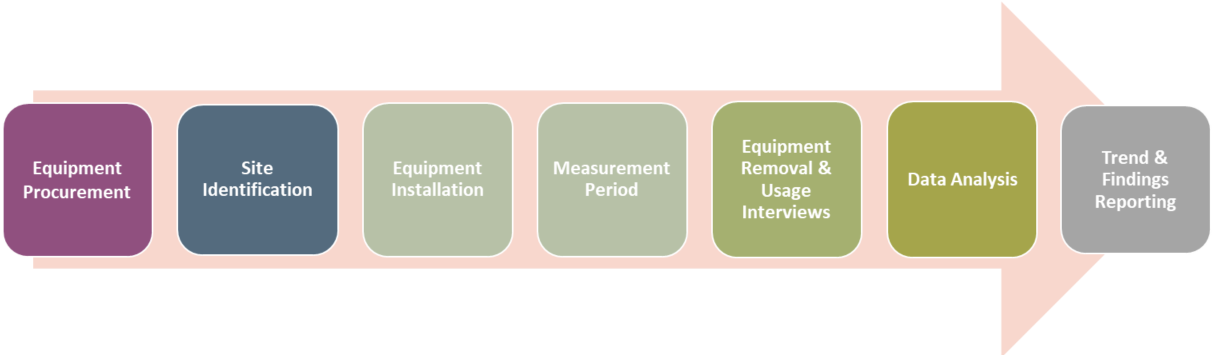

Figure 9. Methodology and steps of quantative data collection and analysis

In total 6 loggers were placed in cool coated homes and 4 loggers were placed in uncoated homes. All loggers were placed in 2 meters height (out of reach of children) in the living room. Placing was done in such a manner to avoid exposure to direct sunlight and other heat sources in the direct vicinity and to minimise exposure to draughts. Figure 10 shows a photo of a data logger being positioned.

The site and occupancy information for the selected sites is shown in Table 1. This information was taken from usage/occupancy interviews conducted in combination with survey interviews at the addresses specified.

The loggers were collected, and the data extracted during the final site visit. The measurement period incorporating full days was thus from the 01.03.2019 -26.03.2019.

					Occupancy Schedule					
Logger ID	Address	Cool Coating	Structure	Total Occupancy	Mornings 8 am - 1 pm	Afternoon 1 pm - 6 pm	Night time 6 pm - 8 am	How many meals are prepared / cooked in the house per day	Is ironing done inside the house	Is there a fan used in the house
10	61 Safaristr.	No	Original building + extension	8	4	4	8	1	Yes	Yes
9	90 Skoolstr.	No	Original building + extension	9	4	4	9	1	Yes	No
8	577 Rossouwstr.	Yes	Original building + extension	6	3	4	4	1	Yes	Yes
7	551 Aanblomstr.	Yes	Original building only	2	2	2	2	2	Yes	Yes
6	17 Duifdoringstr.	Yes	Original building + extension	10	3	10	10	2	Yes	Yes
5	72 Malvastr.	Yes	Original building only, inside tiled	12	4	12	12	1	Yes	No
4	566 Angelierstr.	Yes	Original building + extension	5	1	3	5	2	Yes	Yes
3	497 Asterstr.	Yes	Original building + extension	4	3	4	4	3	Yes	No
2	70 Sonneblomstr.	No	Original building + extension	4	1	3	4	2	Yes	No
1	83 Madeliefiestr.	No	Original building only	2	1	1	2	1	Yes	No

Table 1: Building and occupancy data for selected measurement sites

The required temperature and humidity data loggers were made available by LowExCo for the measurement period.

Figure 10. Photo of placement of data logger by member of project team

Figure 11 and Figure 12 show thermal images of two cool coated roofs and two uncoated roofs respectively. It can clearly be seen that the surface temperatures of the coated roofs are lower than those of the uncoated roofs. In Figure 11 the right thermal image shows a section where the surface temperatures are higher than the surrounding area which is attributed to flawed application or subsequent damage to the cool coating. This example shows that thermography could be a suitable quality control measure for future applications of Cool Surfaces technology.

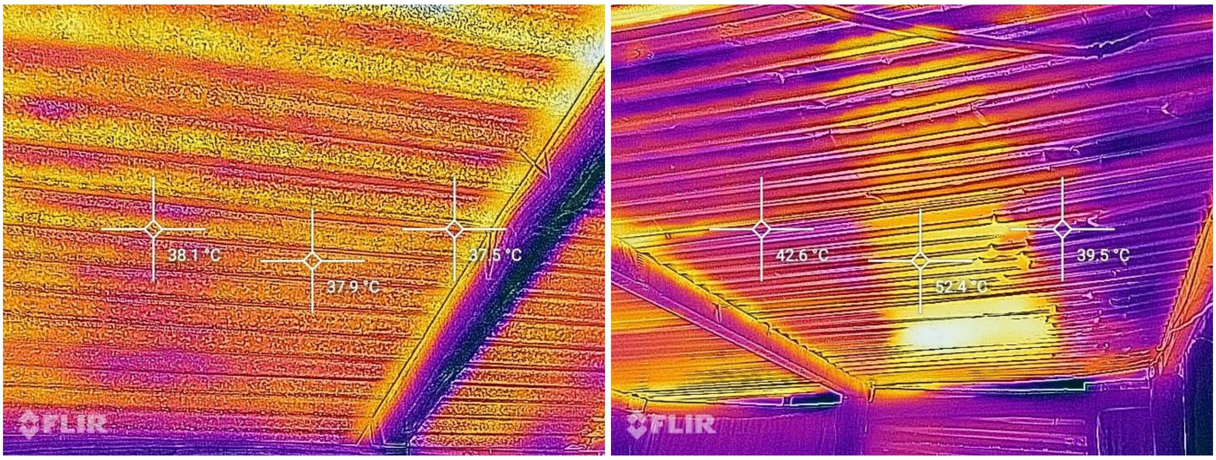

Figure 11. Thermal images of cool coated roofs – the right image shows a section where application is flawed

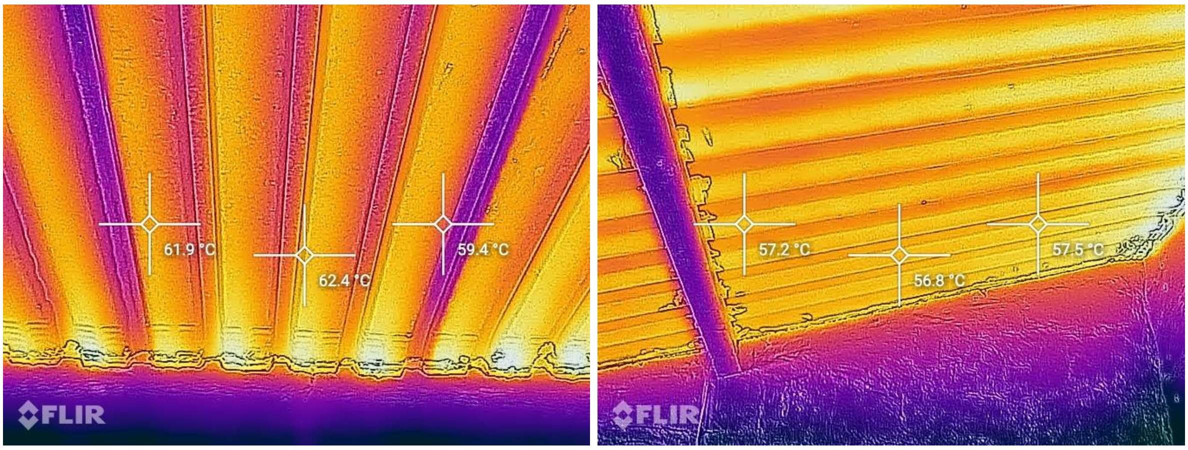

Figure 12. Thermal images of non cool coated roofs

1.6 Qualitative Data Analysis

In this section we will discuss the survey results focusing on the main research questions which are to assess the perceived comfort, any changes in quality of life and the satisfaction with the cool coating technology. We have purposefully not shown the comprehensive evaluation of each question in the survey as this is in our opinion not conducive to concise and results orientated reporting but rather focused on the main intention of the survey and additional points of interest.

In the following Figure 13 and Figure 14 the perceived thermal comfort in summer and winter is evaluated for cool coated homes and compared to the responses of the households with uncoated roofs in order to establish differing trends for these two groups.

In Figure 13 the perceived summer thermal comfort during the day and night is shown. It becomes clear that in the coated homes the heat is not perceived as equally extreme as is the case with the uncoated homes as can be seen by the lower percentage of answers perceiving the temperature as "Hot throughout" and some respondents with cool coated roofs perceiving the temperature as "Slightly cool" or "Cool" compared to nobody with that perception out of the uncoated roof group.

This allows the clear conclusion that the temperature in summer both during the daytime and nighttime is on average perceived as more comfortable than in homes without cool coating.

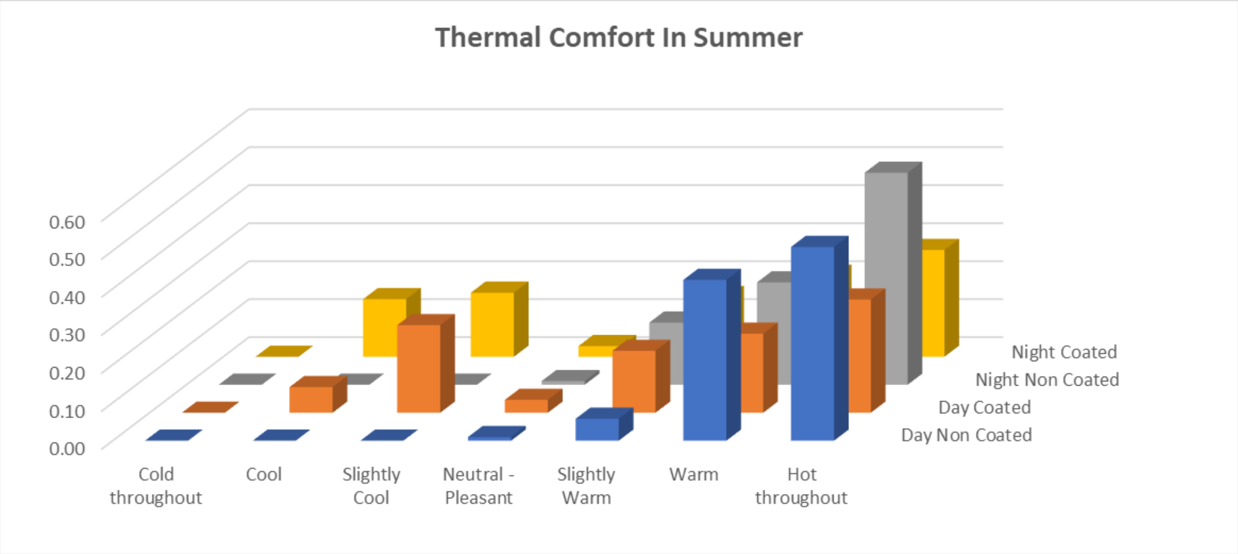

Figure 13: Thermal Comfort perceived between non coated and coated households in Summer

Looking at Figure 14 a slightly different perception becomes apparent for the cold winter periods. Here it can clearly be seen that comparing day and night temperature perception the households with cool coated roofs perceive the temperature as being colder than the group with uncoated roofs. This perception however further underlines the efficacy of cool coating as the technology principal is based on solar radiation being reflected and not absorbed and this will by necessity lead to a reduction of heat uptake of the homes in winter. This will however clearly impact negatively on the perceived thermal comfort during cold periods.

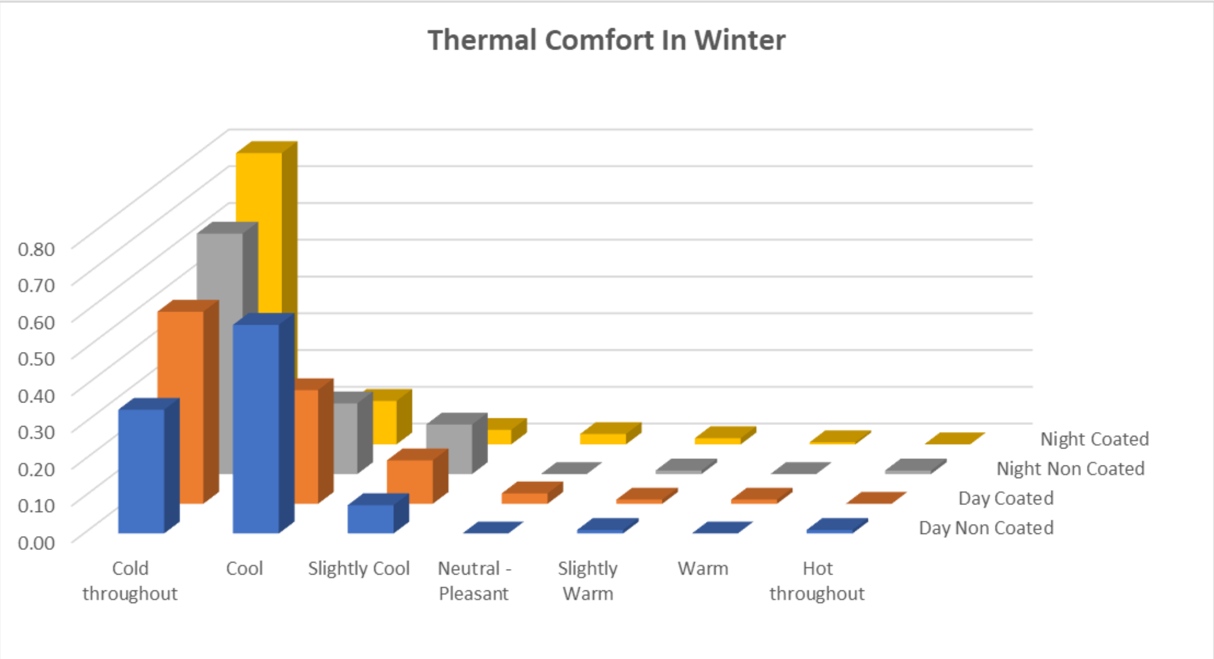

Figure 14: Thermal Comfort perceived between non coated and coated households in Winter

To better be able to better interpret the above results, the possible sources of cooling and heating have been included in the survey questions. Figure 15 shows the overall percentage of households that have and make use of a fan during summer. It becomes clear that only about one third of households utilise a fan. This share is quite similar for both the cool coated and uncoated homes although the cool coated homes have a slightly higher share of fan usage. Nonetheless it is not seen that this has a significant effect on the interpretation of the thermal comfort perception.

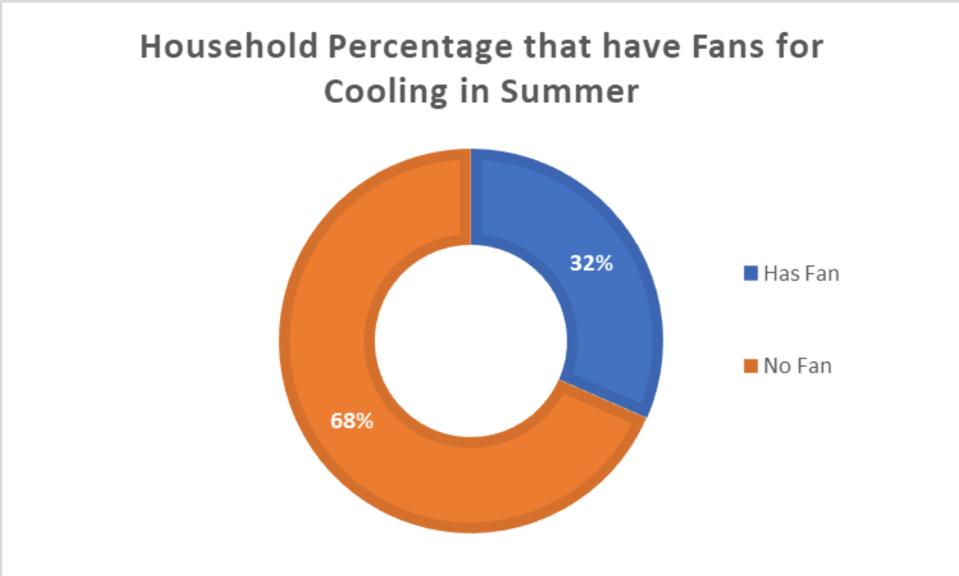

Figure 15: Summary of fan ownership per household

Figure 16 shows the overall percentage of households that heat in winter together with the utilised heat sources. The Other category is synonymous with no heating except in two cases. As it is not anticipated that the type of heating will have a significant effect on the perceived thermal comfort and the distribution of heating sources is similar for both groups, this will not have an effect on the interpretation of the thermal comfort above.

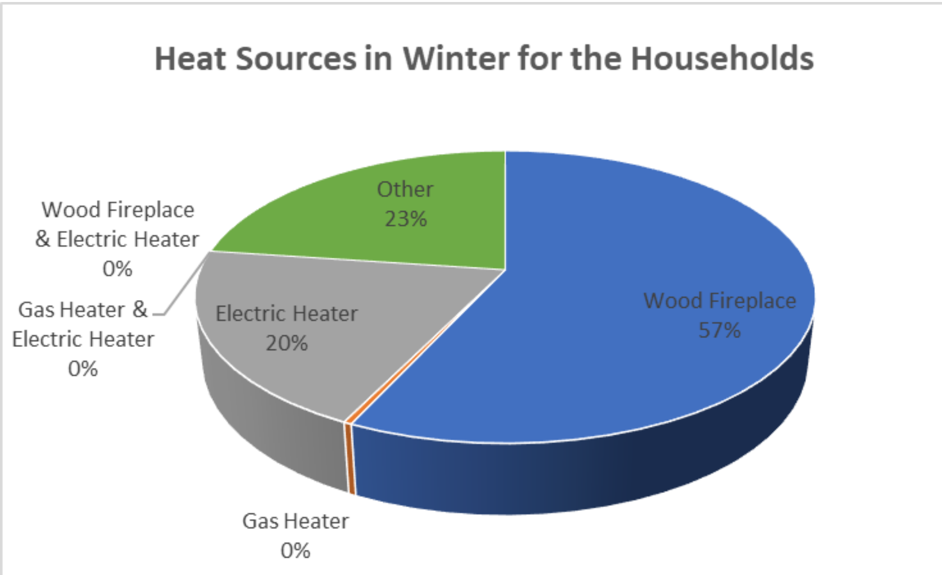

Figure 16: Mix of heat sources in the winter for the households surveyed

It should also be noted that cool coating does not correlate clearly with any decrease in electricity for cooling (fans) or an increase in heating bill and as such does not financially negatively impact the cool coated households. The perceived impact on the heating requirement can be seen in Figure 17.

Interestingly the perception is such that cool coating is seen to reduce the need for heating. This would to an extent indicate a contradiction to the perceived thermal comfort in winter as seen in Figure 14.

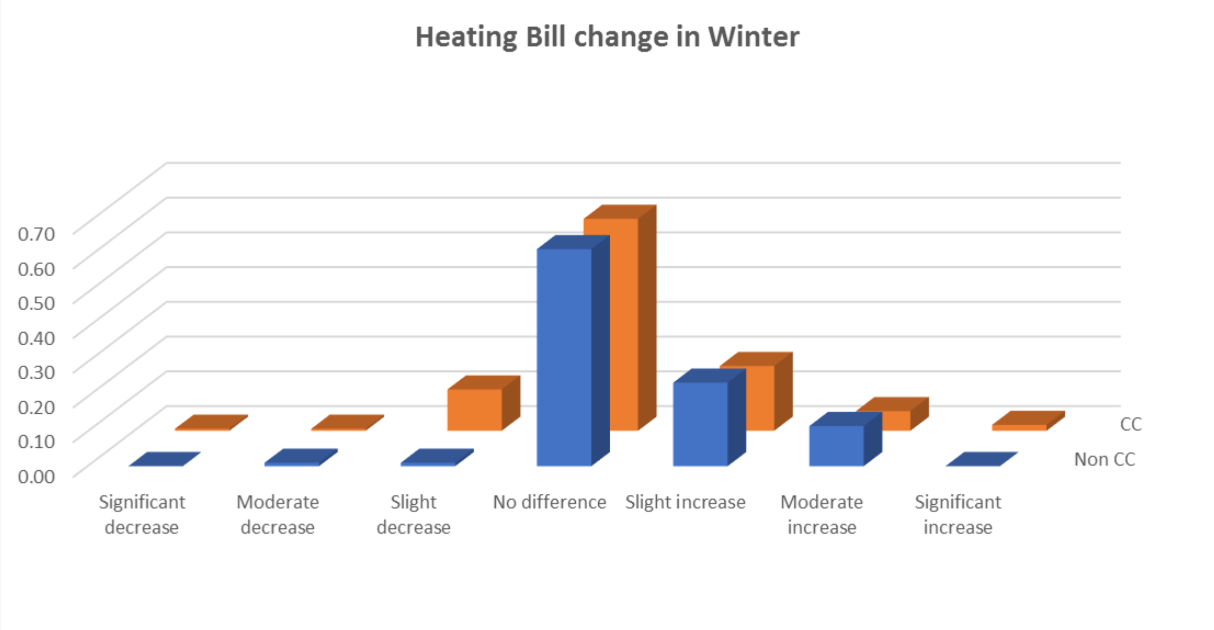

Figure 17: Changes in heating bill over the past 2 years (note perceived change not actual verified change)

In the next section we will focus on the survey questions aiming to assess the perception of the cool coating technology, the quality of life and the satisfaction with the technology.

Figure 18 shows the perception of the two groups whether they are spending more time indoors in the last two years. It becomes clear through the histogramic depiction and the distribution of answers that there is a clear trend that the respondents living in cool coated homes have increased the time spent indoors since the technology intervention more than the respondents living in uncoated homes. It should however be noted that this is a relative quantification as the absolute time spent indoors depends greatly on a number of factors like lifestyle and work situation and as such would be very subjective based on the individual respondent. Regardless this does not allow the conclusion that the people living in cool coated homes spend more hours indoor than those in uncoated homes.

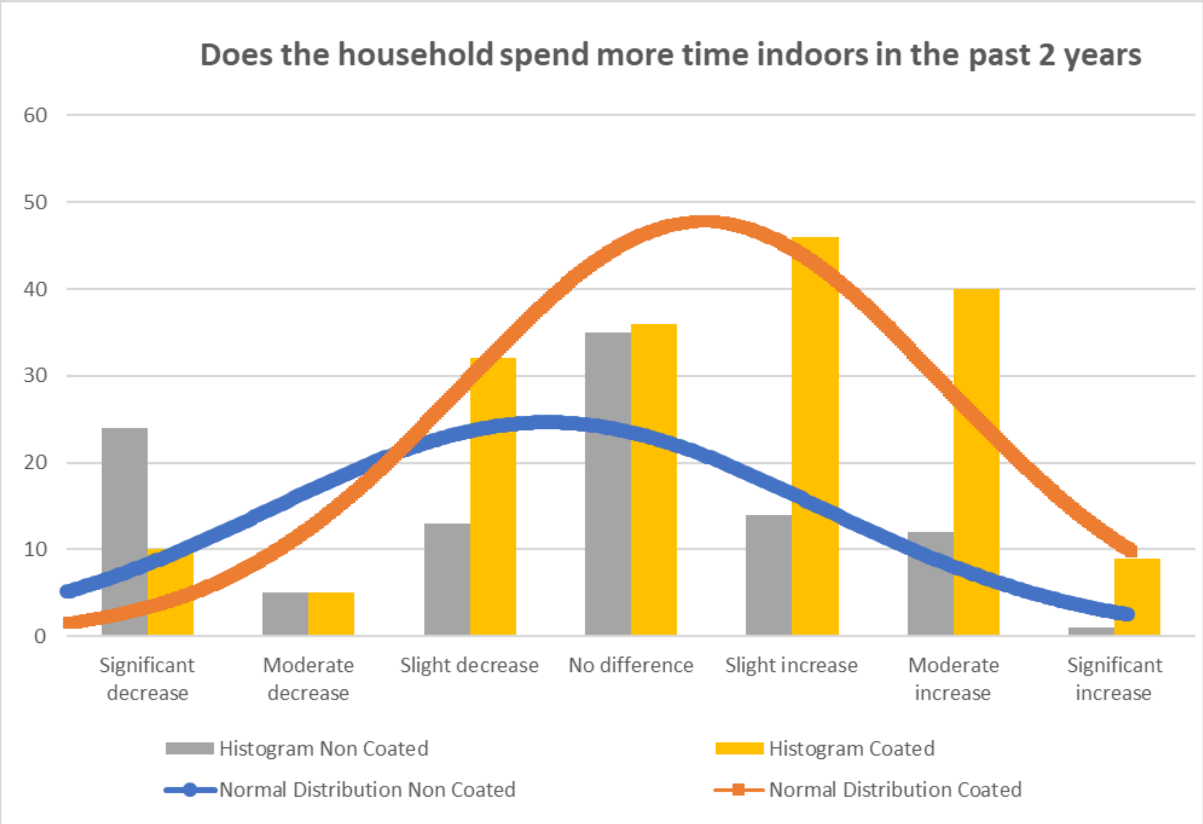

Figure 18: Summary of the respondents perceived usage of their homes over the past 2 years

In the following figure the cool coated groups perception is shown, whether the cool coating technology intervention has changed their standard of living. Again, it becomes clear looking specifically at the distribution curve that there is a clear perceived trend that cool coating has increased the standard of living.

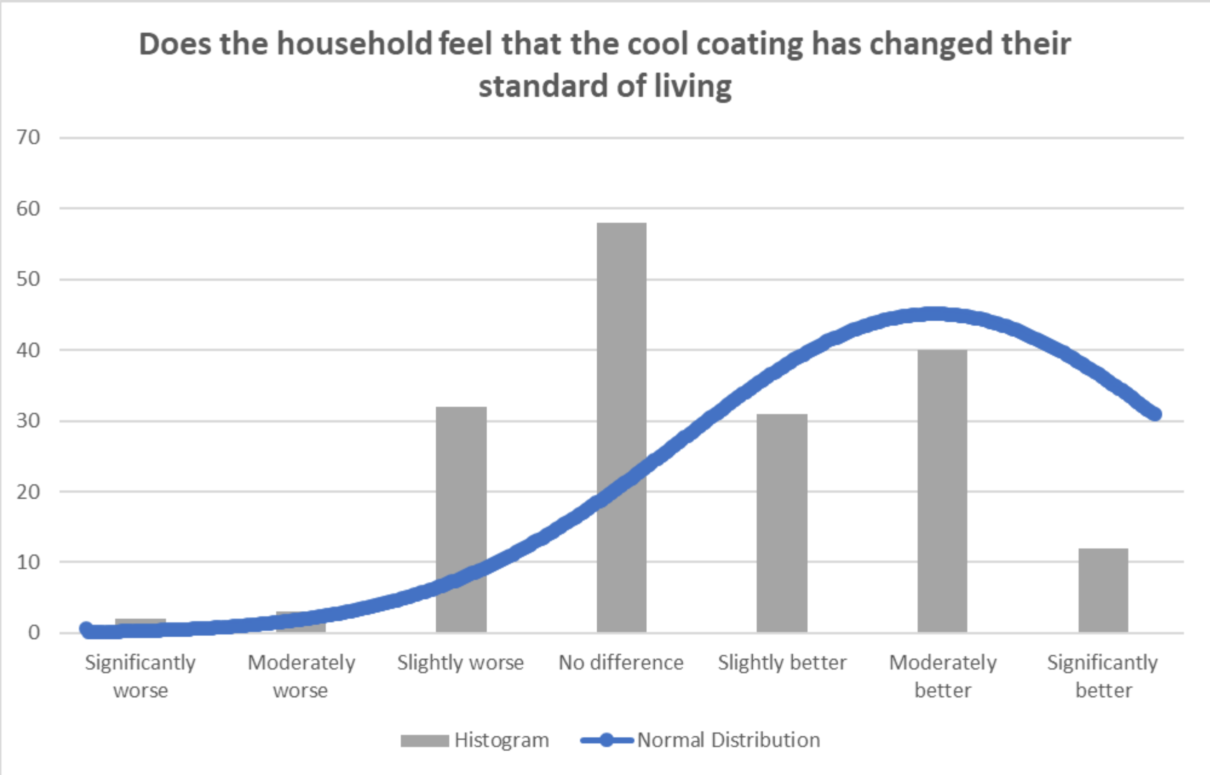

Figure 19: Respondents perceived impact of cool coating on their general quality of life.

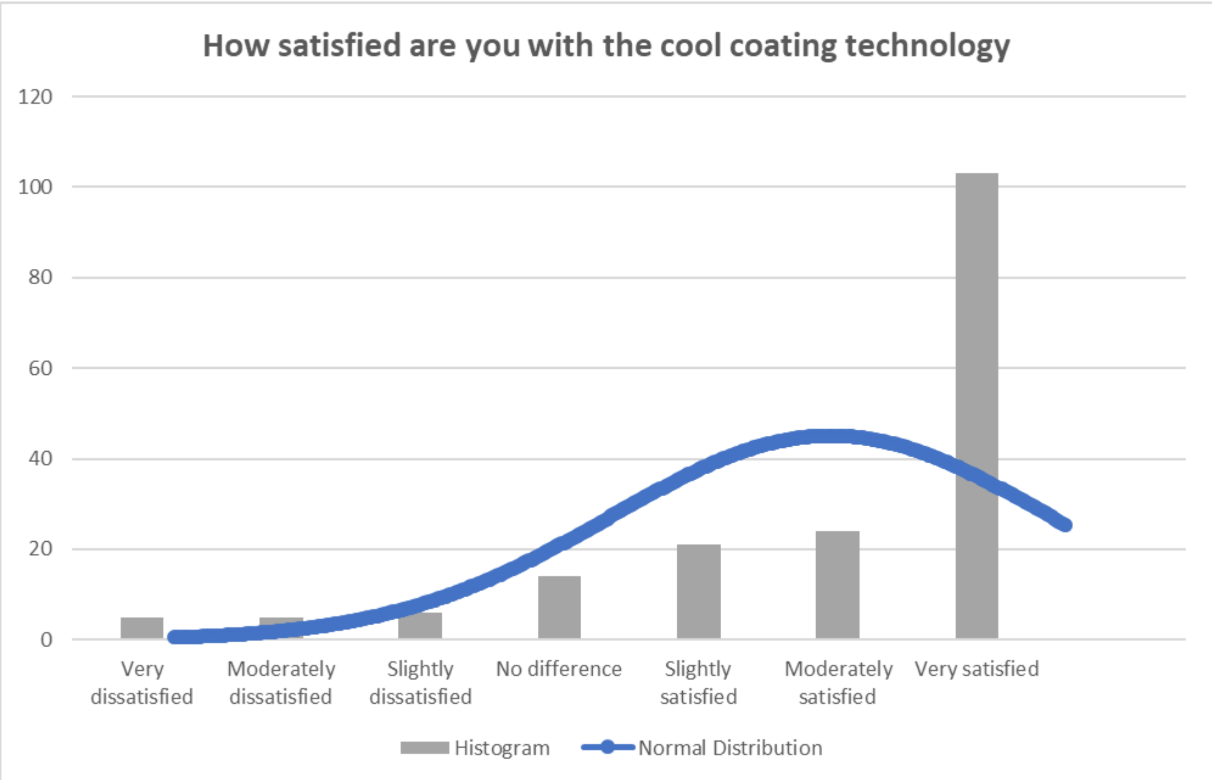

Figure 20: Summary of satisfaction with the cool coating technology.

Figure 20 illustrates the respondents living in cool coated homes answers to how satisfied they are with the technology. This allows a very clear conclusion that the great majority of these households are very satisfied with cool coating.

The last of the main research questions was to ask all respondents whether they would recommend cool coating to others regardless of whether they live in coated or uncoated homes. The results can be seen in Figure 21. It becomes clear that almost 80% of respondents who live in cool coated homes would recommend the technology to others. This again allows a clear conclusion as to the perceived impact and benefit of the technology by this group. Interestingly however from the group living in uncoated homes an even greater share (87%) would recommend cool coating. This shows that the perception in the community and the homes neighbouring the cool coated section is very positive towards the technology. The answers of this group to this question are however very likely to be biased based on the desire and hope to become a future beneficiary of this technology intervention.

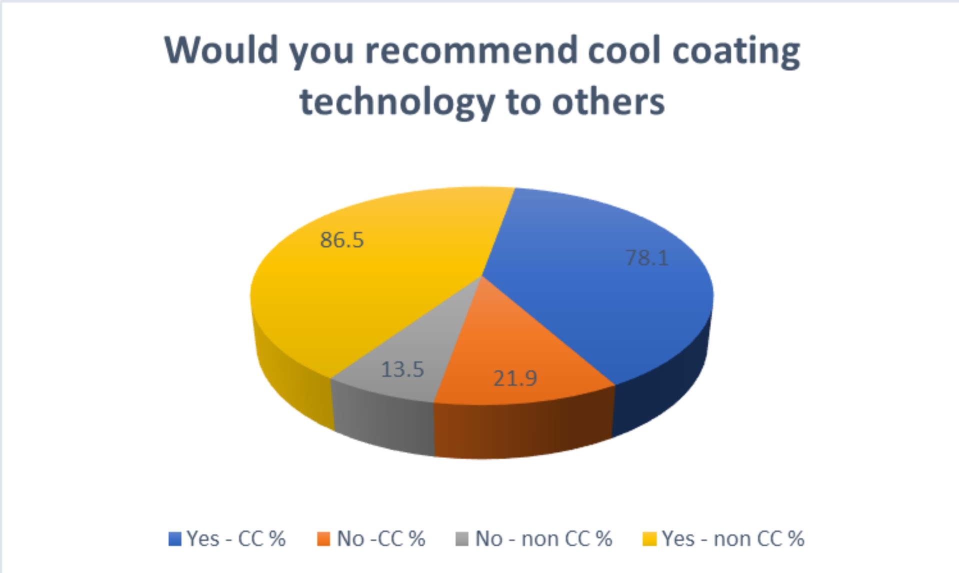

Figure 21: All respondents response to the question "Would you recommend cool coating technology to others"

1.7 Quantitative Data Analysis

The measured indoor data was compared to meteorological data for the measurement period. Meteorological data from Upington weather station as the closest SAWS station was utilised. Historical weather data for Upington was not available for the 01.-02.03.2019 and thus evaluations and graphs shown below which contain weather datasets are shown for the period of 03.03.2019-26.03.2019.

The measurement data was aggregated to hourly and daily averages as required. These datasets include minimum and maximum values for the averaged intervals. An analysis of the full dataset and possible external influence factors is shown in APPENDIX C – Measurement Data Analysis.

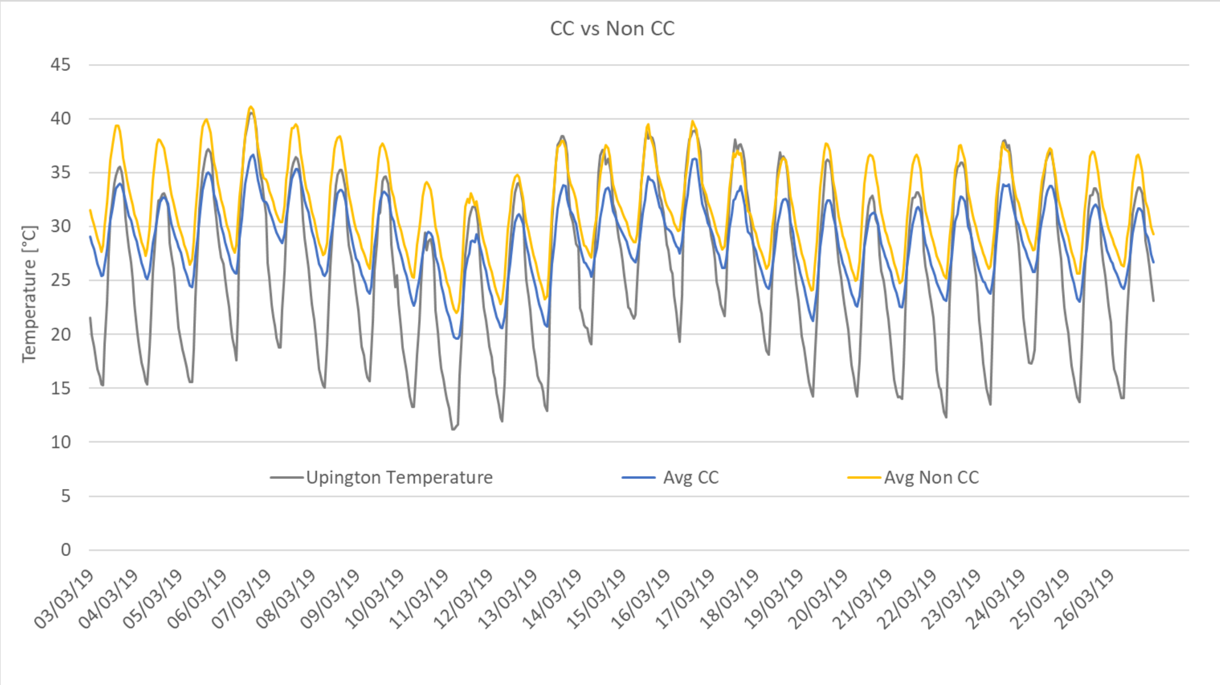

Figure 22: Average hourly temperature profiles of cool coated and uncoated homes and Upington temperature

Figure 22 shows the hourly temperature profiles averaged over cool coated and uncoated homes respectively and the Upington temperature dataset for reference. It can clearly be seen that the average maximum temperatures in non-cool coated homes is significantly higher than in cool coated homes. On the other hand the minimum temperature at night are lower on average in the cool coated homes than in the uncoated ones. These results underline the efficacy of cool coating as the technology principal is based on solar radiation being reflected and not absorbed and this will by necessity lead to a reduction of heat uptake of the homes during the day resulting in colder temperatures at night. It should also be noted that the daily temperature differences between maximum and minimum temperatures are smaller for the cool coated homes resulting in an increased thermal comfort as large temperature fluctuations are perceived as uncomfortable.

Figure 23 shows the daily average temperatures of cool coated and uncoated homes during the measurement period and further demonstrate the efficacy of the technology. It can clearly be seen that the average temperatures of the cool coated homes are consistently 3-4 °C lower than the uncoated homes. It can also be seen that through the heating effect of the sun on the roofs, indoor temperatures are in general higher than ambient temperatures regardless of coating but on some days the daily average temperatures in the cool coated homes and the ambient temperatures are very similar. The differences in maximum and minimum temperatures discussed above can also be clearly seen. The minimum and maximum values shown respectively are the recorded minimum or maximum values of the individual loggers and not averages.

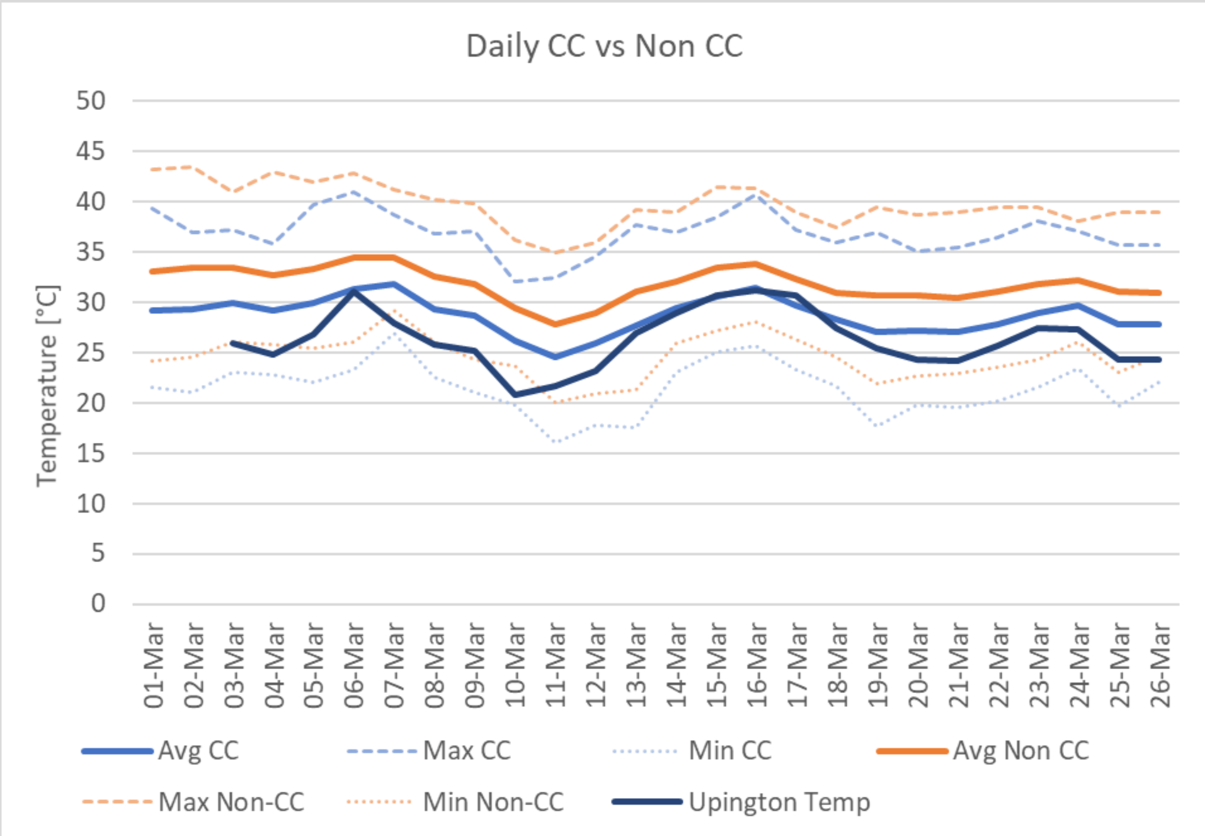

Figure 23: Daily temperature averages of cool coated and uncoated homes with minimum and maximum temperatures recorded and Upington temperature as reference

Figure 24 shows the daily average relative humidity of cool coated and uncoated homes during the measurement period and the averaged Upington humidity for reference. It should be noted that the relative humidities measured do not correspond well with the data from Upington weather station. This is to be expected as the relative humidity is influenced more than temperature by local weather conditions (e.g. rain showers).

The fluctuations in relative humidity are mainly attributed to the corresponding fluctuations in temperature ranges shown above as the temperatures directly influence the relative humidity. Moist air at a higher temperature will have a lower relative humidity given the same amount of absolute humidity in the air.

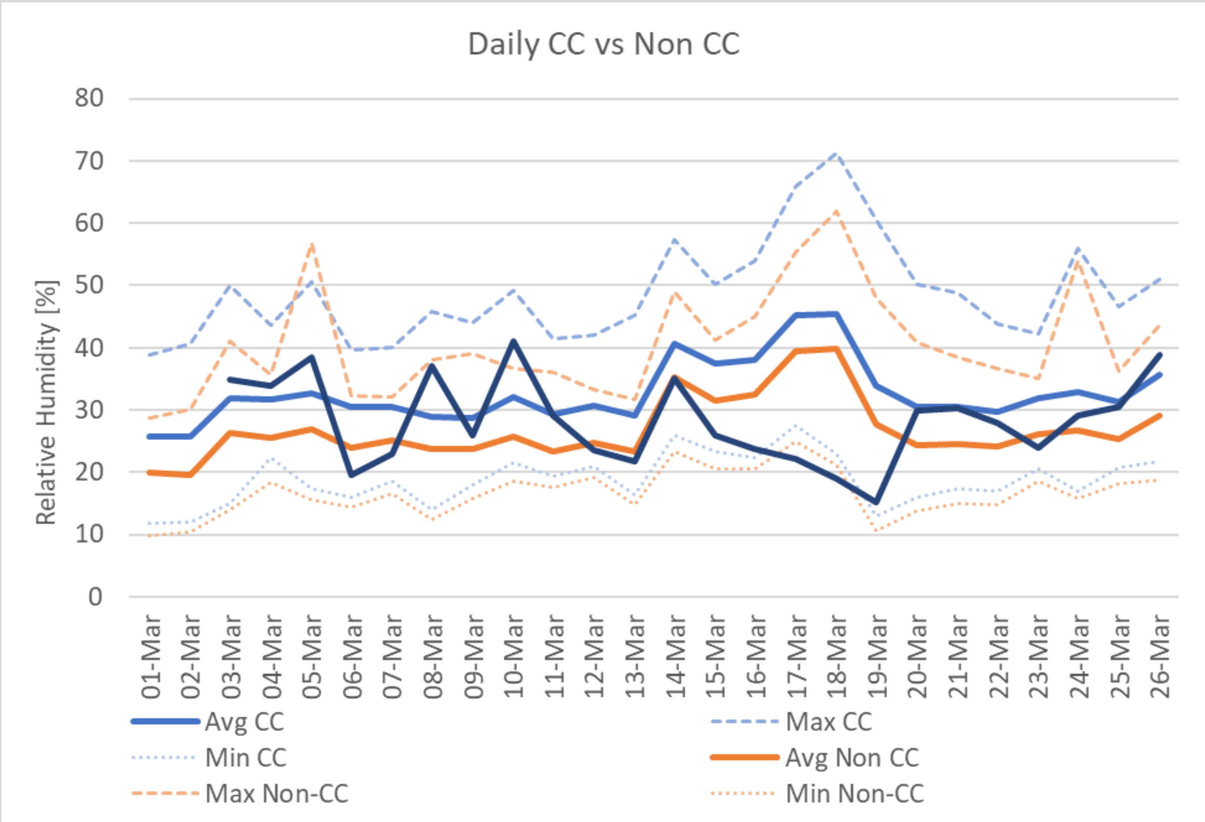

Figure 24: Daily humidity averages of cool coated and uncoated homes with minimum and maximum relative humidities recorded and Upington humidity as reference

In summary it can be clearly concluded that the second component of the efficacy assessment of the cool coating technology intervention which involved data measurements in sample buildings provides quantitative evidence of the effects of the technology in reducing indoor temperature both on average and regarding daily minimum and maximum temperatures and will thus increase the thermal comfort perceived by the occupants.

1.8 Findings

Besides the conclusions discussed in the previous sections there is one other finding that is worth noting. Over 20% of respondents living in cool coated homes noted that their roof is leaking after the application of the paint. This may be because the majority of structures painted are old. Despite leakages there is no clear correlation among these respondents that shows they are dissatisfied with the intervention.

Regarding some of the other points investigated, such as whether there have been changes in the health situation since the intervention, no clear correlation is seen and thus no such effect can be concluded.

The sample application of thermal imaging in the work conducted shows that thermography could be a suitable quality control measure for future applications of Cool Surfaces technology.

1.9 Conclusion

The thermal comfort in summer is perceived to have increased through the application of cool coating and the main research questions allow the conclusion that the technology intervention is perceived to have increased people's standard of living through the perceived lower temperatures in summer and the fact that on average more time can be spent indoors than prior to the intervention. It should be noted that the perceived effect of the technology is that the interiors of the coated buildings are colder in winter than the uncoated homes.

Households living in cool coated homes are very satisfied with the technology and the large majority would recommend it to others. The perception of cool coating in the entire community is very positive demonstrated in the fact that a large percentage of persons living in uncoated homes in the direct vicinity would also recommend the technology to others.

Regarding some of the other points investigated, such as whether there have been changes in health since the intervention, no such effect can be concluded from the survey.

An important finding of the survey is that over 20% of respondents living in cool coated homes noted that their roof is leaking after the application of the paint.

The data measurements in sample buildings and the following analysis provides quantitative evidence of the cool coating technology's efficacy in reducing indoor temperature both on average and regarding daily minimum and maximum temperatures and will thus increase the thermal comfort perceived by the occupants.

The sample application of thermal imaging in the work conducted shows that thermography could be a suitable quality control measure for future applications of Cool Surfaces technology.

APPENDIX A – The Survey Application

The Survey application screenshots in this section serve to show the survey application as well as the questions used in sequence during the fieldwork.

The Survey Data Section is shown below in Figure 25: In this section we captured the detail of who is taking the survey and where the survey is taken.

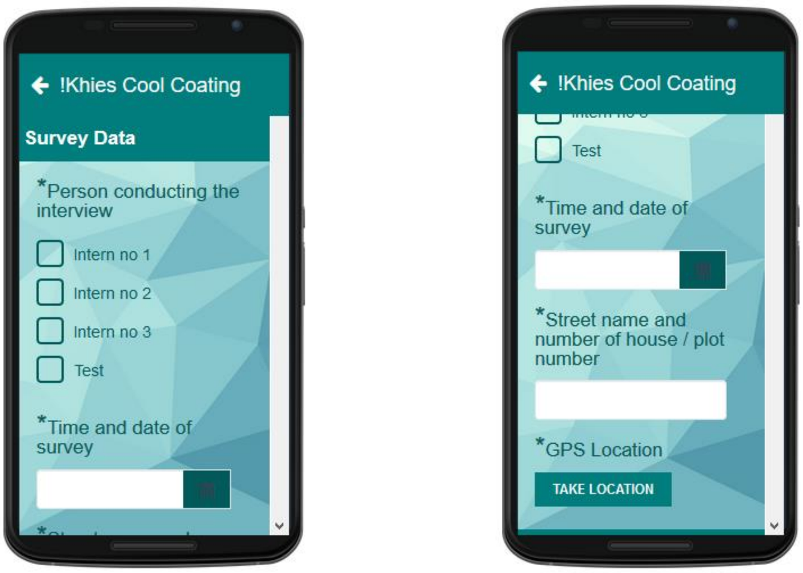

Figure 25: In this section we captured the detail of who is taking the survey and where the survey is taken.

The Interviewee Data Section is shown below in Figure 26.

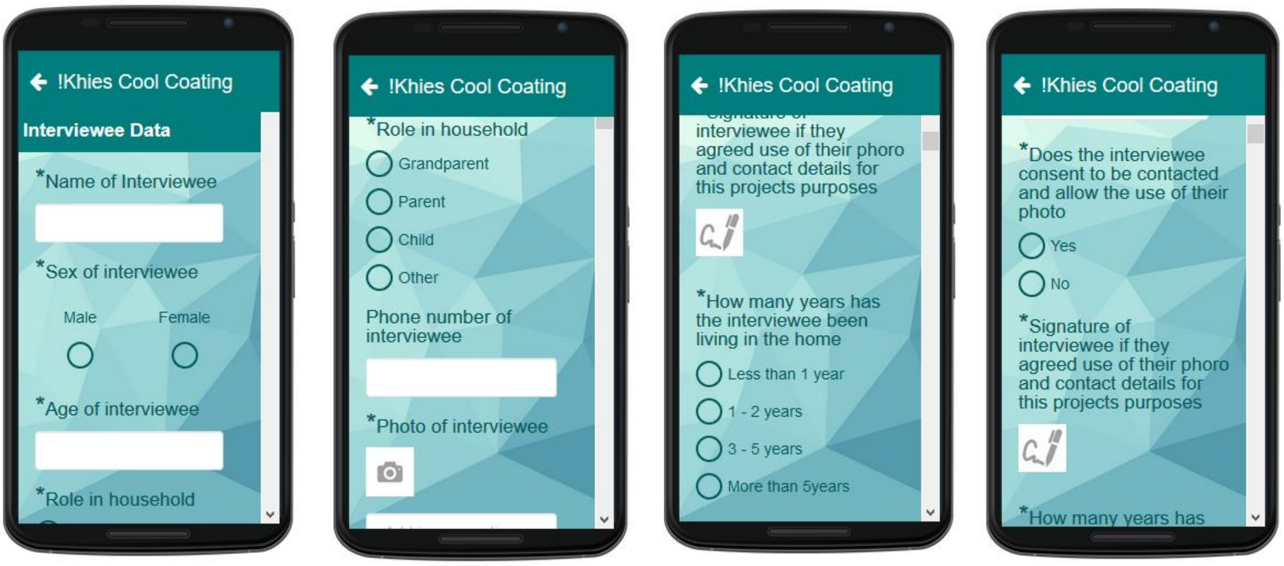

Figure 26: In this section we captured the detail of the person being interviewed and any forms of consent required from the person to use their photo or contact personal details.

The Property and Occupancy Data Section is shown below in Figure 27.

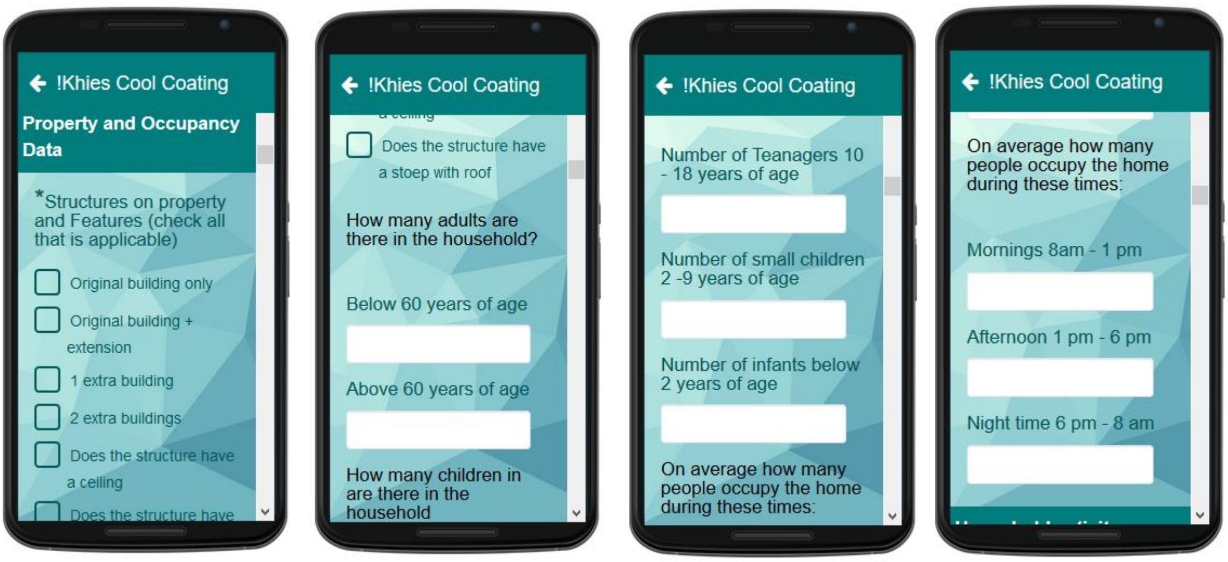

Figure 27: In this section the information of the property at which the interviewee resides, and the properties occupancy data was captured.

The Household Activity Section is shown below in Figure 28.

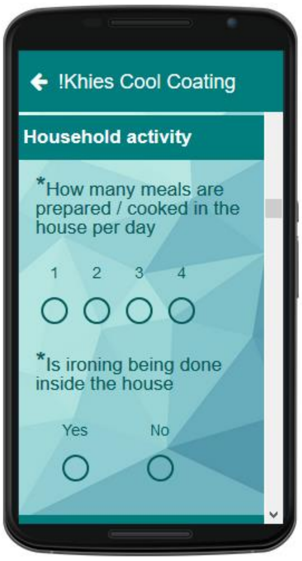

Figure 28: In this section we record the household activity that is relevant to the project

The Thermal Comfort Data Section is shown below in Figure 29 and Figure 30:

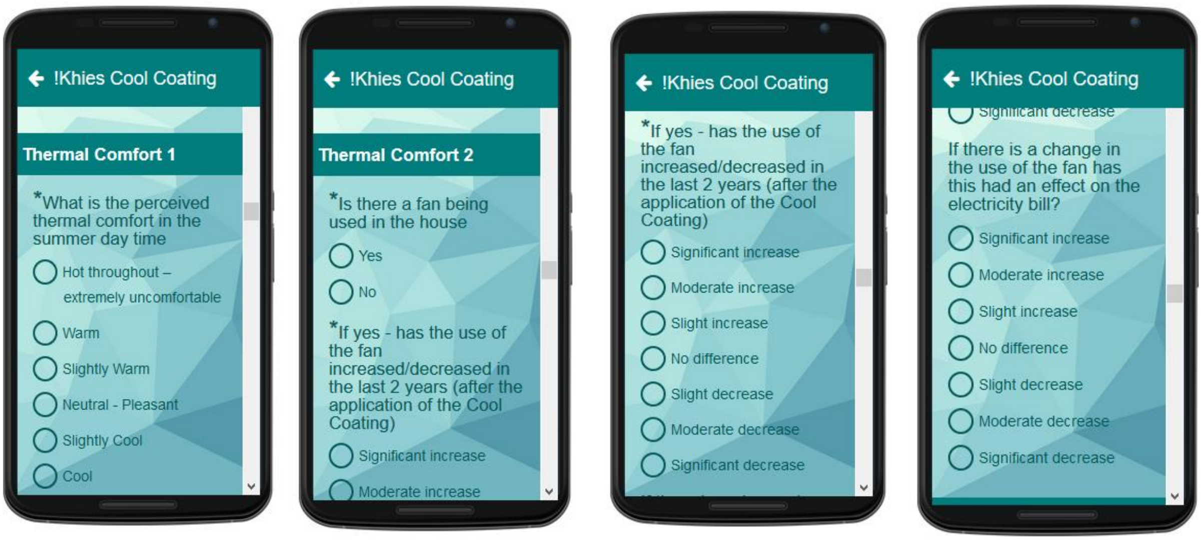

Figure 29: In this section the households perceived thermal comfort and behavioural changes in summer.

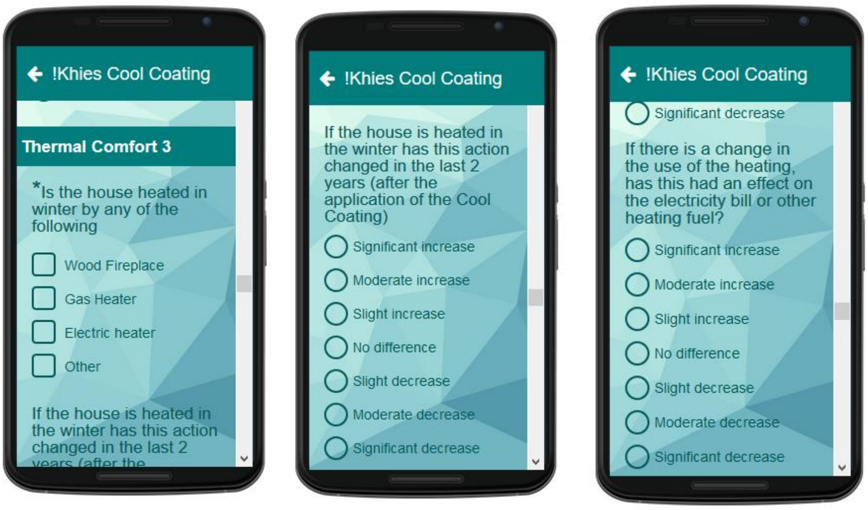

Figure 30: In this section the households perceived thermal comfort and behavioural changes in winter.

The Health of the Household Data Section is shown below in Figure 31.

Figure 31: Has there been any changes in the general health of the family over the past two years

The Technology Perception Data Section is shown below in

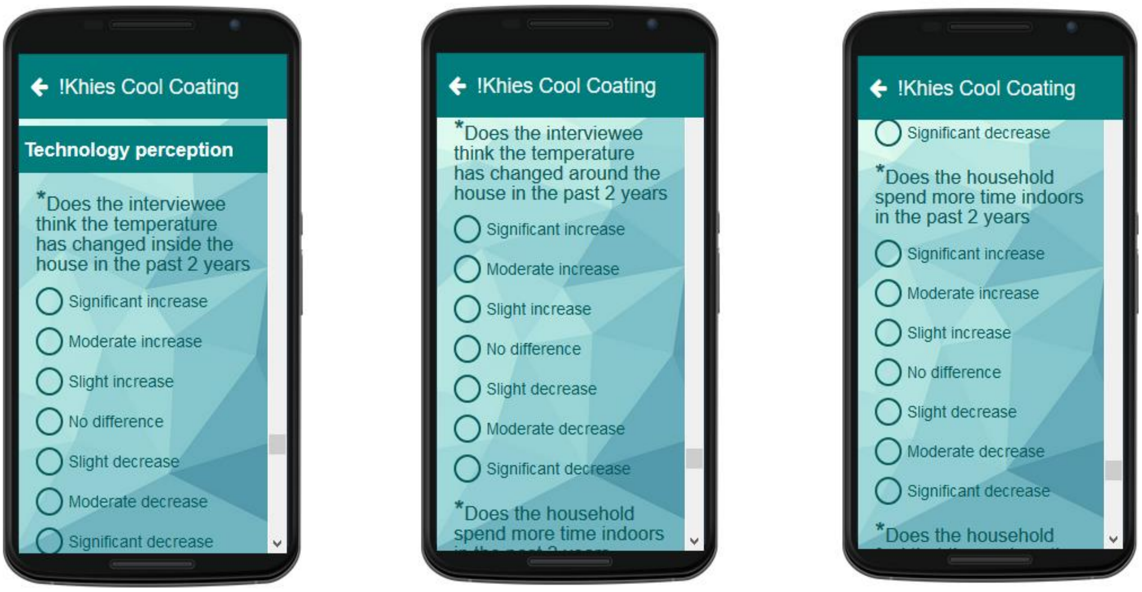

Figure **32** and Figure 33**.**

Figure 32: The interviewees perception of the technology and behaviour changes relevant to the technology was recorded in this section (1 out of 2).

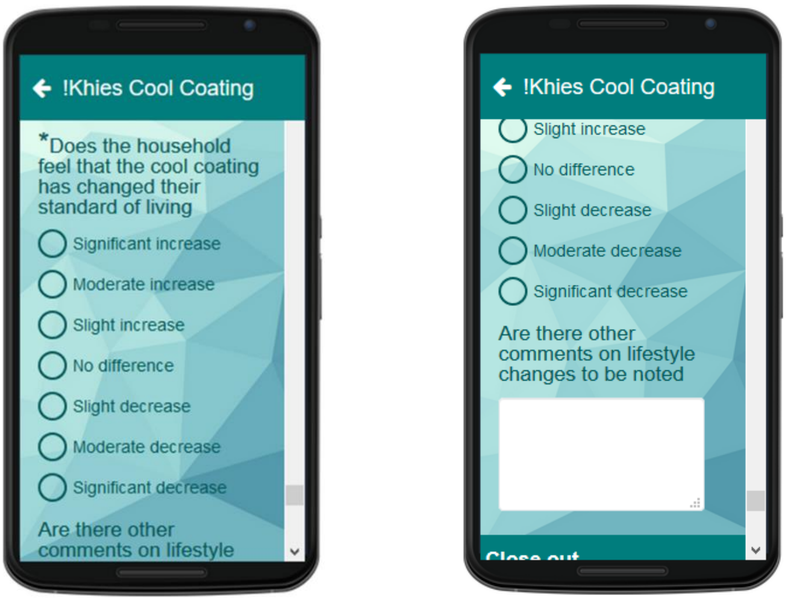

Figure 33: The interviewees perception of the technology and behaviour changes relevant to the technology was recorded in this section (2 out of 2).

Close Out Data Section is shown below in Figure 34.

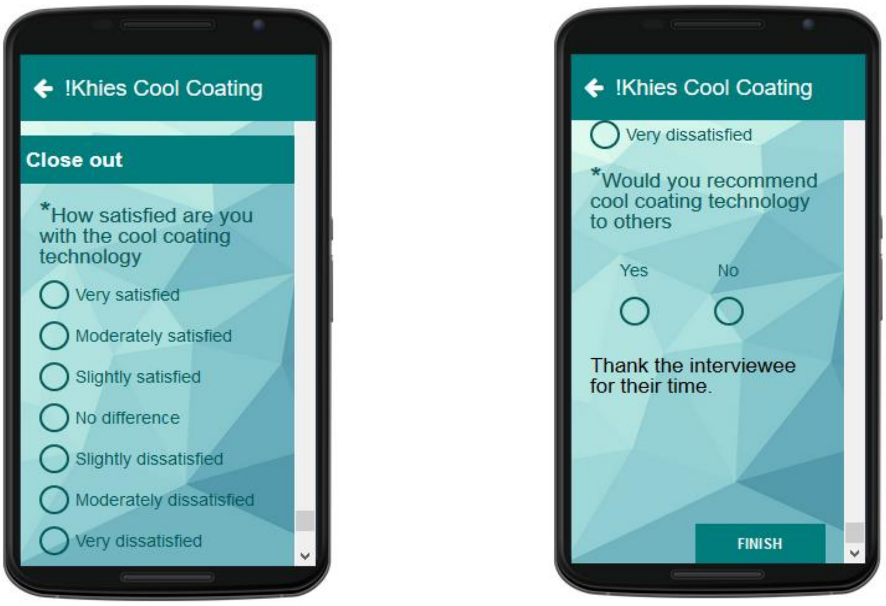

Figure 34: In this section we captured the interviewees final sentiment on the technology and whether they would recommend it.

APPENDIX B – Survey Demographics

Number of surveys	282									
Number of CC homes	178									
Number of non-CC homes	104									
Total										
Demographics										
	Male	Female								
Sex	93	189								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	Avg
Age	0	11	40	44	48	51	64	19	5	47.97518
	Child	Parent	Grandparent	Other						
Role in household	55	163	63	1						
	Less than 1 year	1 - 2 years	3 - 5 years	More than 5years						
Living Duration	0	4	6	272						
	Original building	Has extensions	Has additional buildings	Has Roofed Terrace	Is Tiled	Has Ceiling	Has Fan			
Building Structure & Features	163	119	44	71	63	16	89			
Demographics CC	Male	Female								
Sex	59	119								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	Avg
Age	0	4	23	23	31	36	45	14	2	49.74719
	Child	Parent	Grandparent	Other						
Role in household	24	104	43	0						
	Less than 1 year	1 - 2 years	3 - 5 years	More than 5years						
Living Duration	0	2	2	174						
	Original Building	Has Extensions	Has additional buildings	Has Roofed Terrace	Is Tiled	Has Ceiling	Has Fan			
Building Structure & Features	85	93	25	39	41	7	64			
Demographics non-CC	Male	Female								
Sex	34	70								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	Avg
Age	0	7	17	21	17	15	19	5	3	44.94231
	Child	Parent	Grandparent	Other						
Role in household	24	59	20	1						
	Less than 1 year	1 - 2 years	3 - 5 years	More than 5years						
Living Duration	0	2	4	98						
	Original Building	Has Extensions	Has additional buildings	Has Roofed Terrace	Is Tiled	Has Ceiling	Has Fan			
Building Structure & Features	78	26	19	32	22	9	25			

Table 2: Demographics and statistics of survey participants

APPENDIX C – Measurement Data Analysis

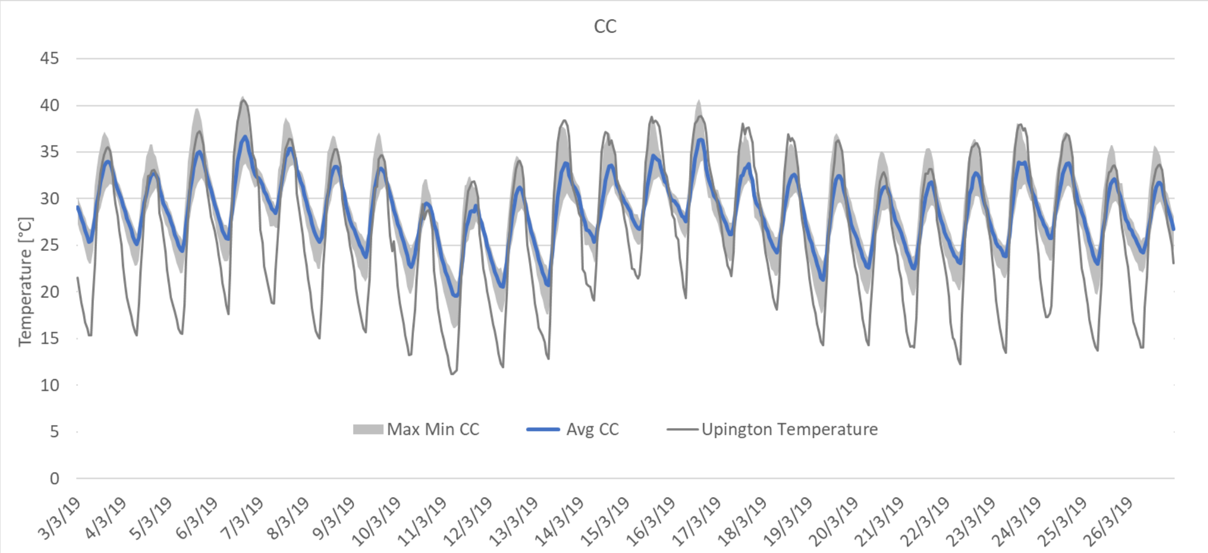

Figure 35: Average hourly temperature profile of cool coated homes with Upington temperature as reference

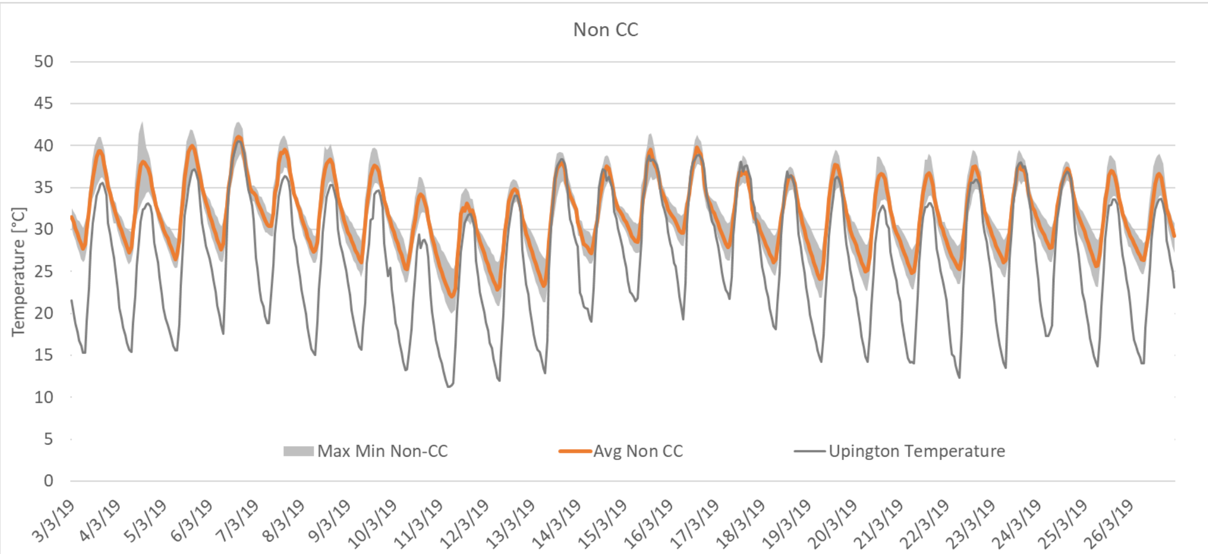

Figure 36: Average hourly temperature profile of non-cool coated homes with Upington temperature as reference

Figure 35 and Figure 36 show the average hourly temperature profile of the measured cool coated and non-coated homes as well as the spread between minimum and maximum recorded values of the individual loggers. Ambient temperature data for Upington weather station is included for reference. It can be seen that the temperature spread is largest for the daily minimum and maximum temperatures and that the spread especially for the maximum temperature of the cool coated homes is significantly larger than for the uncoated homes. It should also be noted that the minimum temperatures measured at night are substantially higher than the corresponding ambient temperature which is to be expected based on heat retention and reduction of air flow at night (doors and windows in living area closed).

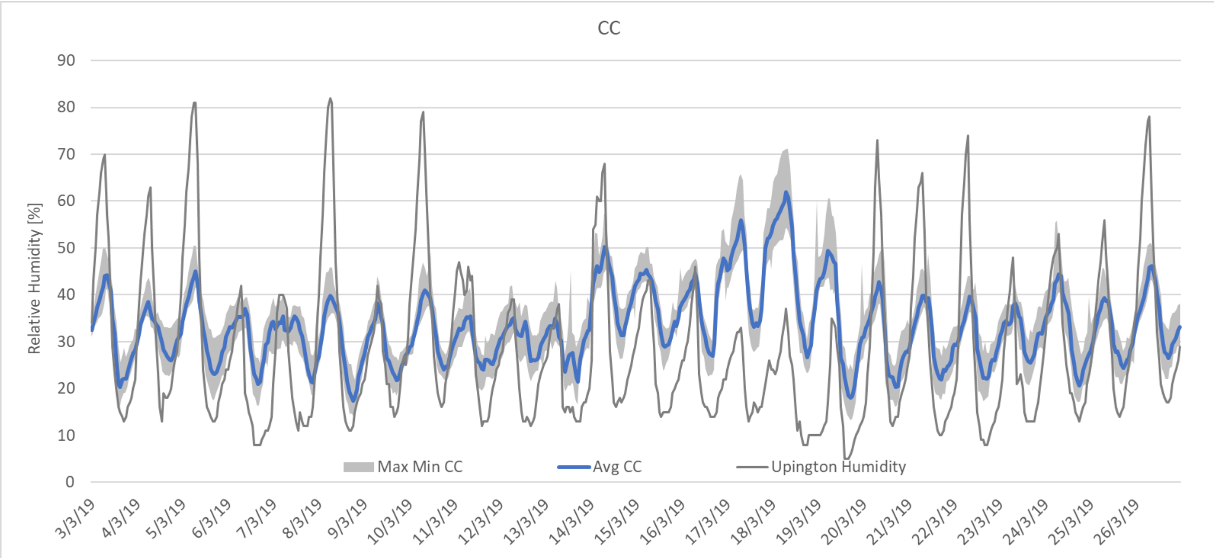

Figure 37: Average hourly humidity profile of cool coated homes with Upington humidity as reference

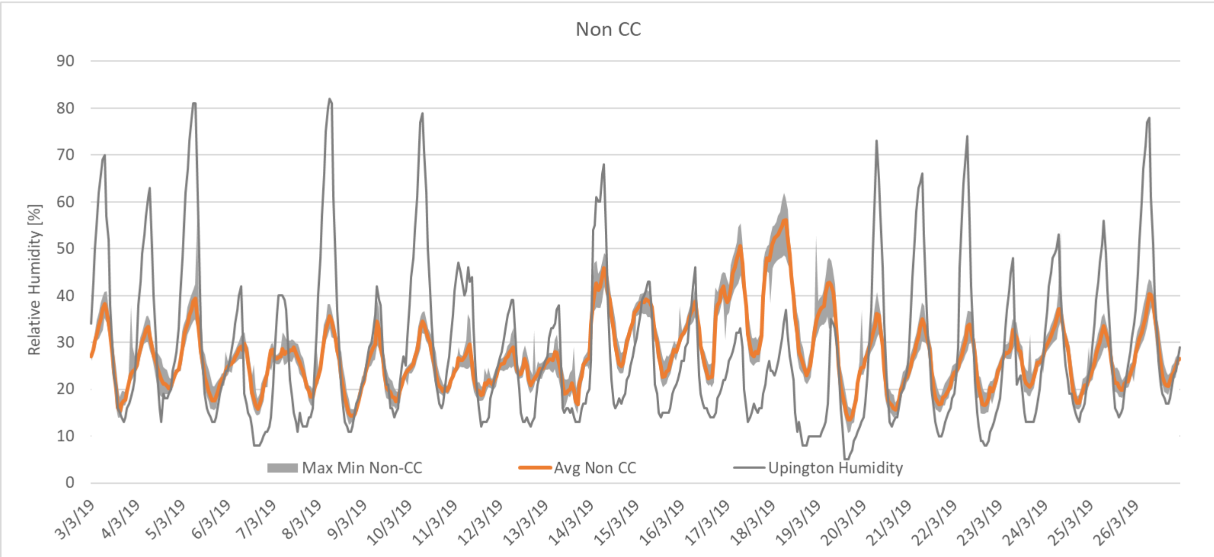

Figure 38: Average hourly humidity profile of non-cool coated homes with Upington humidity as reference

Figure 37 and Figure 38 show the average hourly relative humidity profile of the measured cool coated and non-coated homes as well as the spread between minimum and maximum recorded values of the individual loggers. Relative humidity data for Upington weather station is included for reference. It can be seen that the relative humidity spread is largest for the daily minimum and maximums and that the spread especially for the maximum humidity of the cool coated homes is significantly larger than for the uncoated homes. This is attributed to the corresponding temperature ranges shown above as the temperatures directly influence the relative humidity. It should also be noted that the relative humidities measured do not correspond well with the data from Upington weather station. This is to be expected as the relative humidity is influenced more than temperature by local weather conditions (e.g. rain showers).

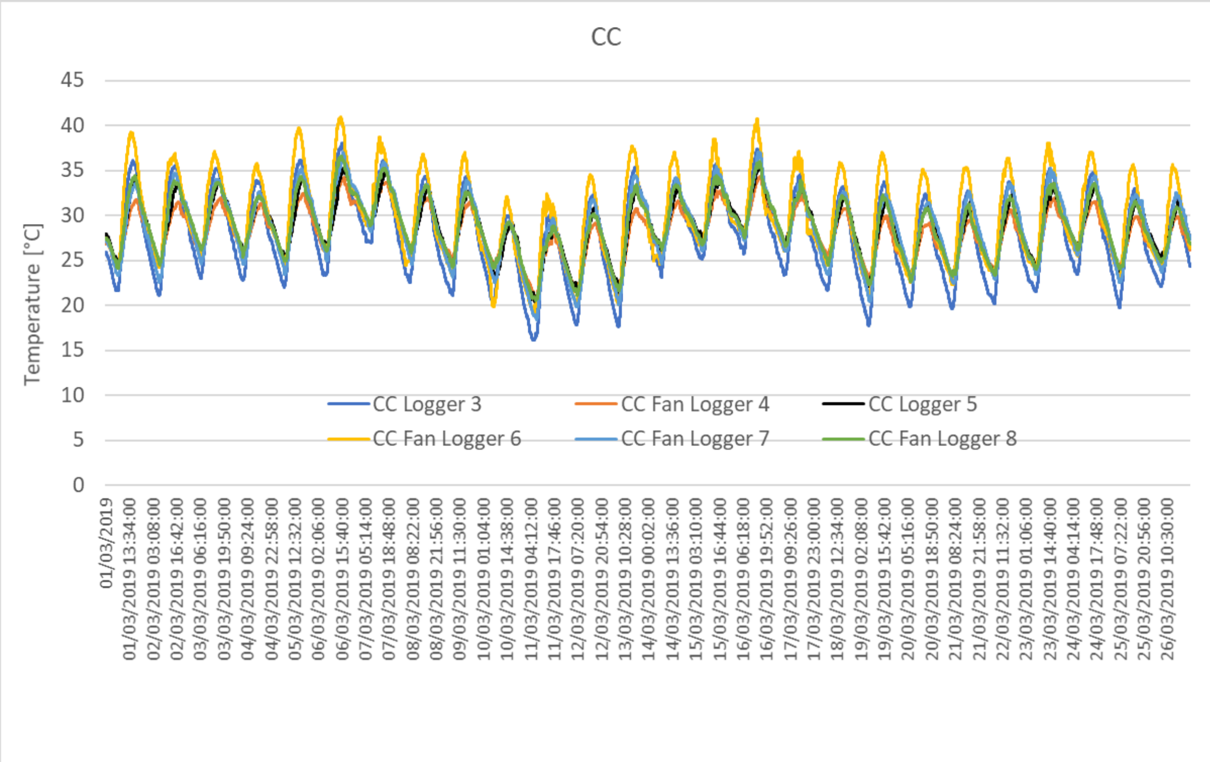

Figure 39: Full temperature data set of loggers in cool coated homes indicating fan usage where applicable

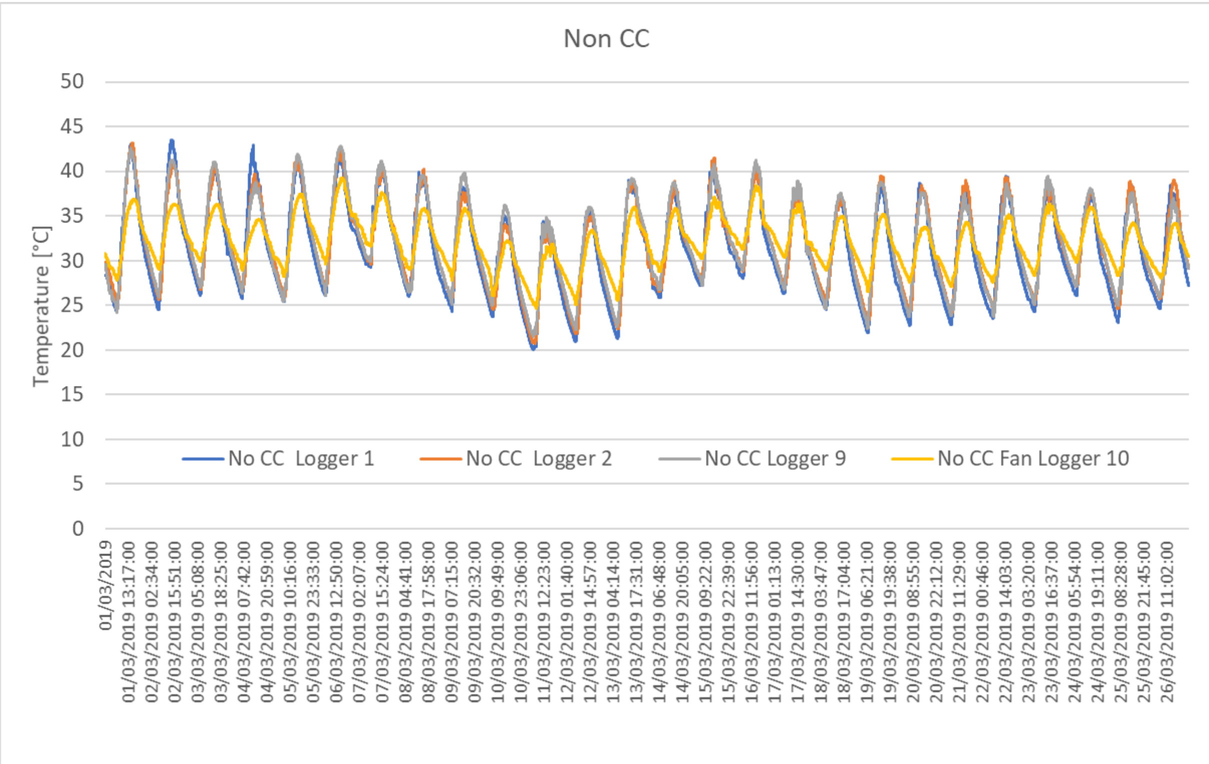

Figure 40: Full temperature data set of loggers in non-cool coated homes indicating fan usage where applicable

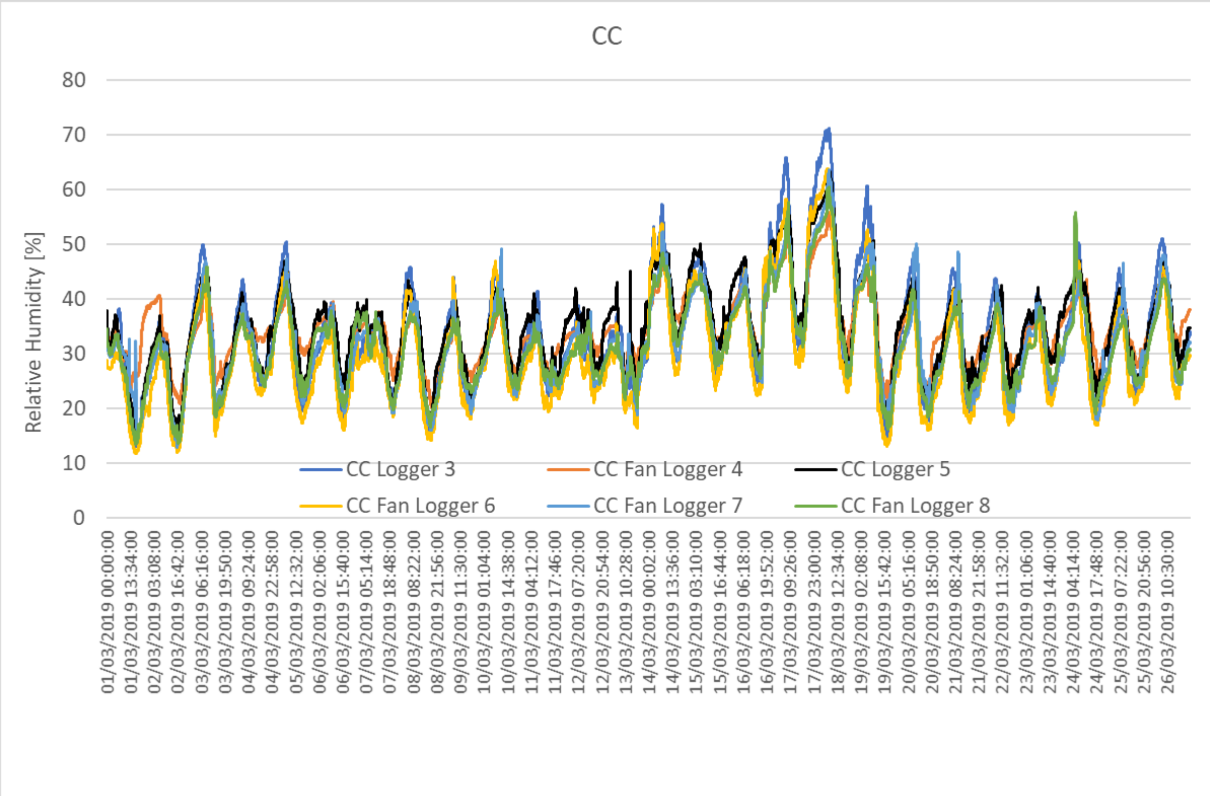

Figure 41: Full humidity data set of loggers in cool coated homes indicating fan usage where applicable

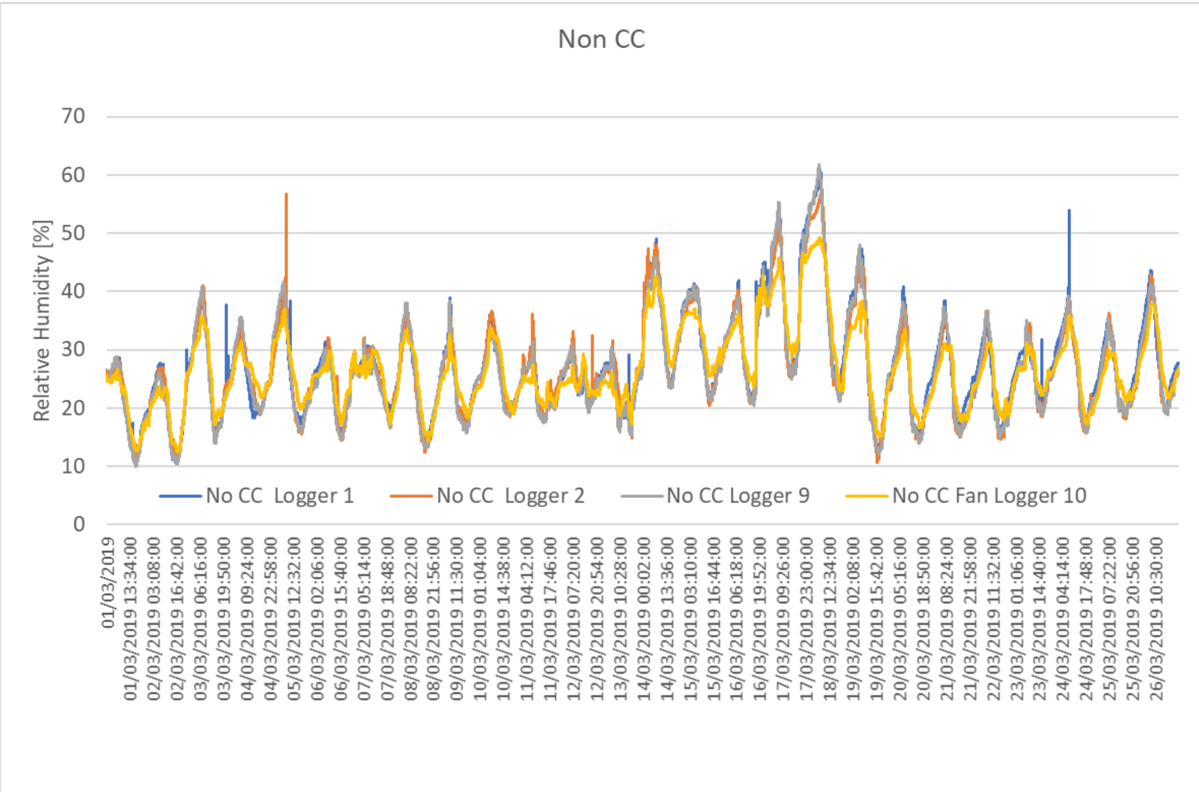

Figure 42: Full humidity data set of loggers in non-cool coated homes indicating fan usage where applicable

Figure 39 to Figure 42 show the full logger datasets over the measurement period in order to ascertain whether fan usage has a significant impact on the measured temperatures as thus needs to considered separately as an external factor in the quantitative data analysis.

Taking both coated and uncoated homes into account, no systematic influence of the temperature profiles can be attributed to the usage of fans. In Figure 40 it appears as though the fan may have a moderating effect on the extreme temperatures when compared to the other data sets, however comparison with Figure 39 reveals that here the effect seems to be the opposite with the maximum temperatures occurring in homes with fans. As the exact usage of the fans could not be established in the measurement period in the scope of this work, it should be noted that a systematic effect of fan usage on measured indoor temperature cannot be ruled out but will be subject to specific factors in each individual home (e.g. positioning of fan relative to doors and windows and opening of these).

The fluctuations in relative humidity are mainly attributed to the corresponding fluctuations in temperature ranges shown as the temperatures directly influence the relative humidity. Moist air at a higher temperature will have a lower relative humidity given the same amount of absolute humidity in the air.