

Action Research Project in progress

1

Research Topic: 'The impact of cool roof paint on indoor thermal comfort in low- income housing, and related potential job creation opportunities: the case of Cosmo City - Johannesburg, South Africa'.

Research Question: "What is the potential impact of a cool roof paint intervention on indoor thermal comfort in existing low-income housing within Johannesburg's climatic conditions and what would be the potential of related green-job opportunities?"

Literature Review

2

- Akbari, Menon & Rosenfeld (2009) highlight negative environmental impact of the Urban Heat Island effect on global warming and climate change. They contend the Cool Roofs Programme can mitigate the situation.
- Uemoto, Sato, & John (2010:17) state that the ‘use of highly reflective “cool” coatings helps maintain lower exterior surface temperatures of roofs ... and consequently contributes to increased indoor thermal comfort’.

Rationale and Problem Statement

3

- ANC built 2.8 million low-income houses
- Majority of inland houses inadequate passive thermal control interventions such as insulation or ceilings - direct increase in exposure to poorly mediated temperatures in summers.
- Santamouris, Pavlou, Synnefa, Niachou and Kolokotsa, (2007: 859) '[l]ow-income households in ... less developed countries suffer from serious indoor environmental problems such as heat stress, lack of comfort and poor indoor air quality'.
- Butera, (1998: 39) indicates human body requires 'to maintain a constant internal temperature around $37\pm 0.5^{\circ}\text{C}$, otherwise the functionality of important organs like liver, spleen, etc., may be severely damaged'.

Rationale and Problem Statement (cont.)

- State budget will be spent on its housing backlog and not on the retrofit of millions of ceilings.
- The unintended consequence of an absence of ceilings coupled with high conductance corrugated iron and fibre cement (typically used in low-income housing), have had a significant negative effect on indoor thermal comfort.
- The current research is assessing the potential of CRP on low-income house roofs which provide 'reflectivities of 75 to 80 per cent ... which means that only 20 to 25 per cent of the sun's energy is absorbed into the roof' (Facilitiesnet, 2004:1) to mitigate indoor thermal discomfort created by the absence of ceilings.

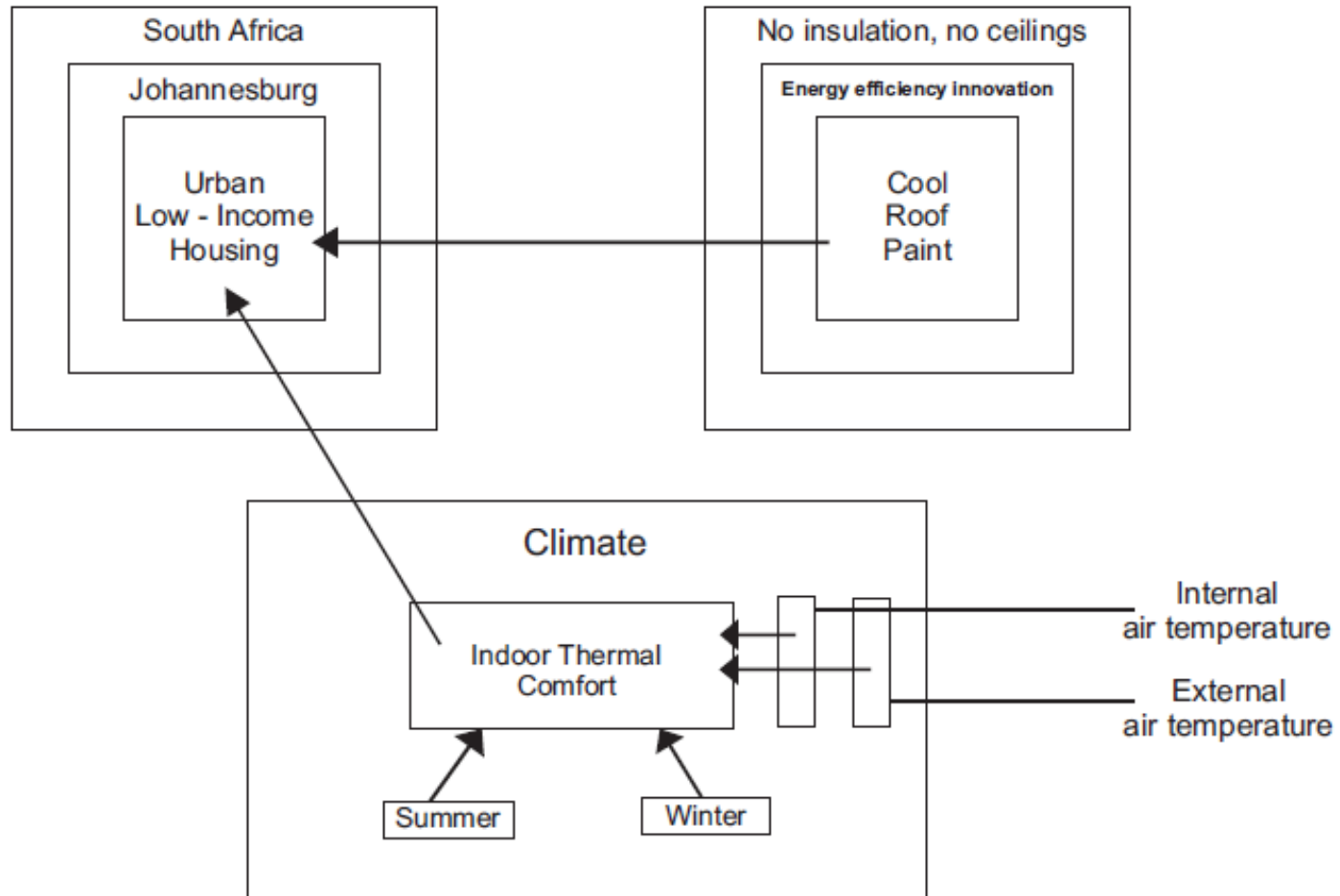
Research Aim

5

- to quantitatively measure and compare indoor comfort factors such as the air temperature, radiant temperature, air speed and relative humidity in four test low-income houses.
- subjective factors of metabolic rate and clothing level will also be taken into account.
- to measure the extent to which a passive cooling innovation such as cool roofs paint is able to reduce the solar gain drawn through the roof to habitable space to moderate indoor thermal comfort.
- to evaluate the potential of CRP to create jobs for skilled, semi-and unskilled workers in painting & paint manufacturing and related application industries.

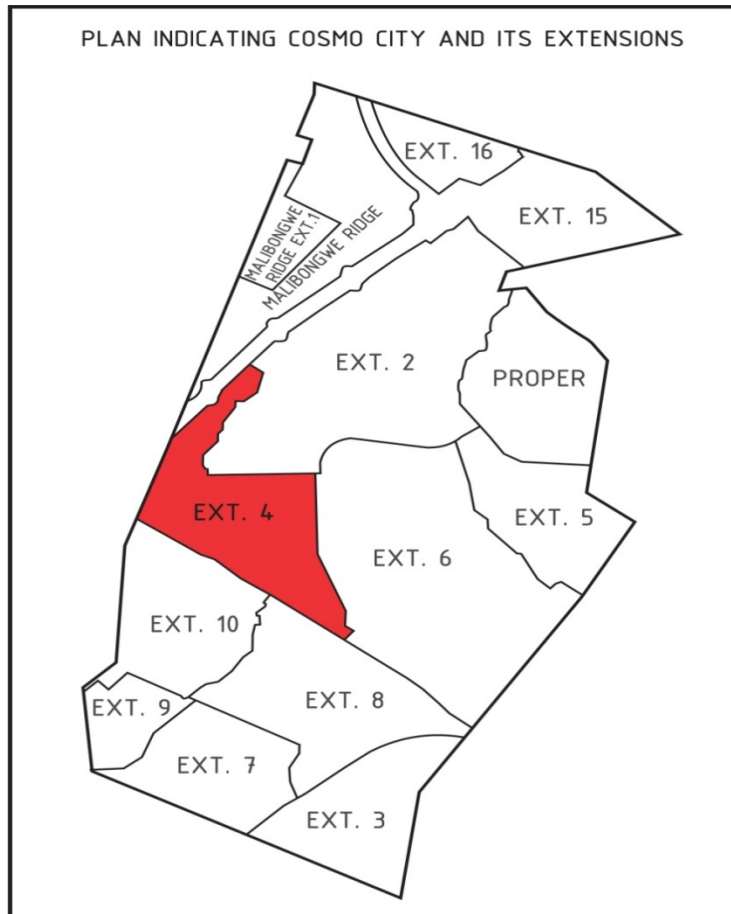
Theoretical Framework

6



Research Context: Extension 4 of Cosmo City

7



Lies 25 km north west of the Johannesburg CBD



- Broke ground in 2005 and houses about 70 000 residents

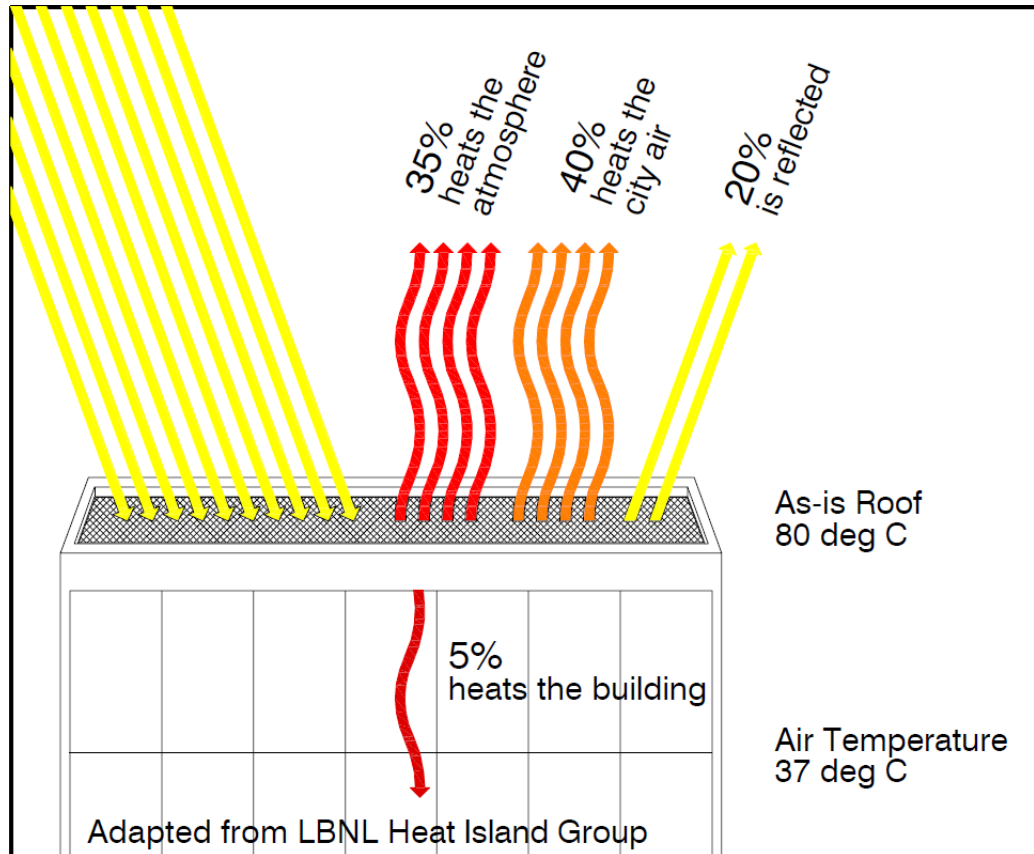
Cosmo City, Extension 4 Low-income Housing

8



When solar radiation strikes an “as-is” roof

9

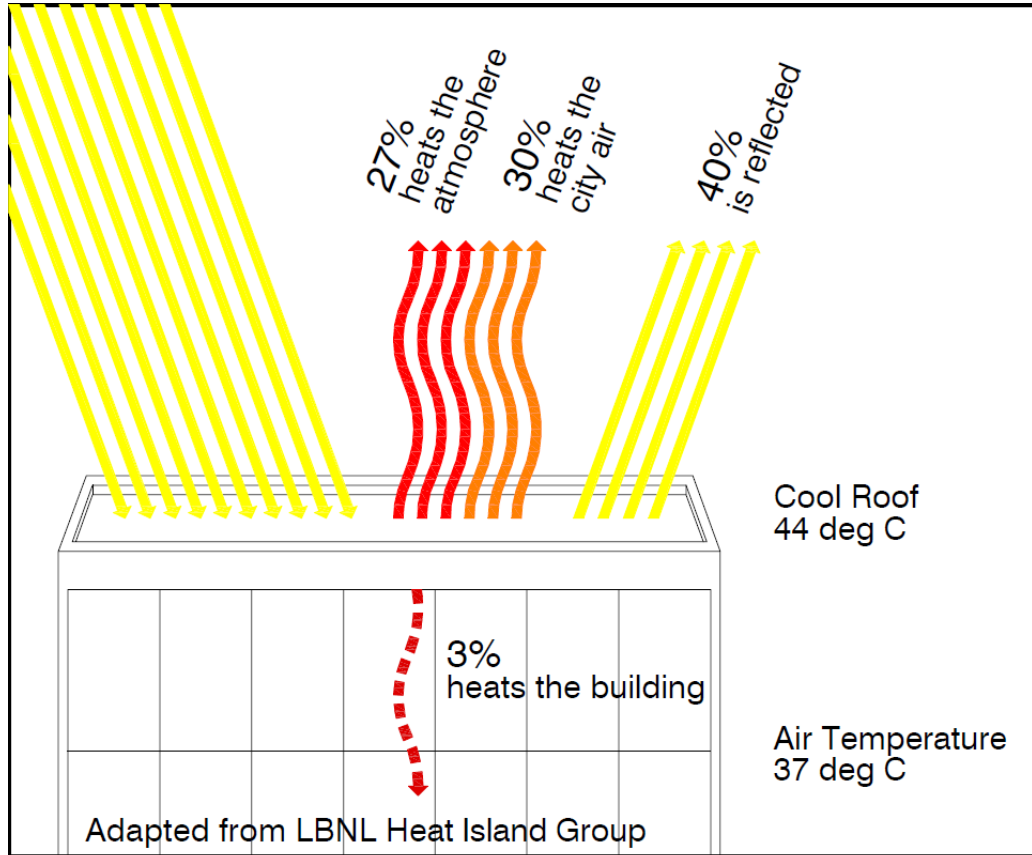


WHEN SOLAR RADIATION STRIKES AN "AS-IS" ROOF

- Dark surfaces such as the “as-is” roof maximise solar absorption which increases the flow of heat from the roof into the building.

When solar radiation strikes a “cool” roof

10



WHEN SOLAR RADIATION STRIKES A "COOL" ROOF

- Cool roof paint contains infrared reflective pigments with properties causing a reduction in absorption of incoming short-wave solar radiation coupled with a decrease in outgoing long-wave thermal emissivity (Gaffin, Imhoff, Rosensweig, 2012).

Selection Criteria for Pilot Project

11

Summer: February, March, April
Winter: May, June, July



The test houses will have:

- same orientation
- similar number of occupants per household
- similar daily behaviour & activity patterns
- 40 sq.m in size
- each house on a separate plot

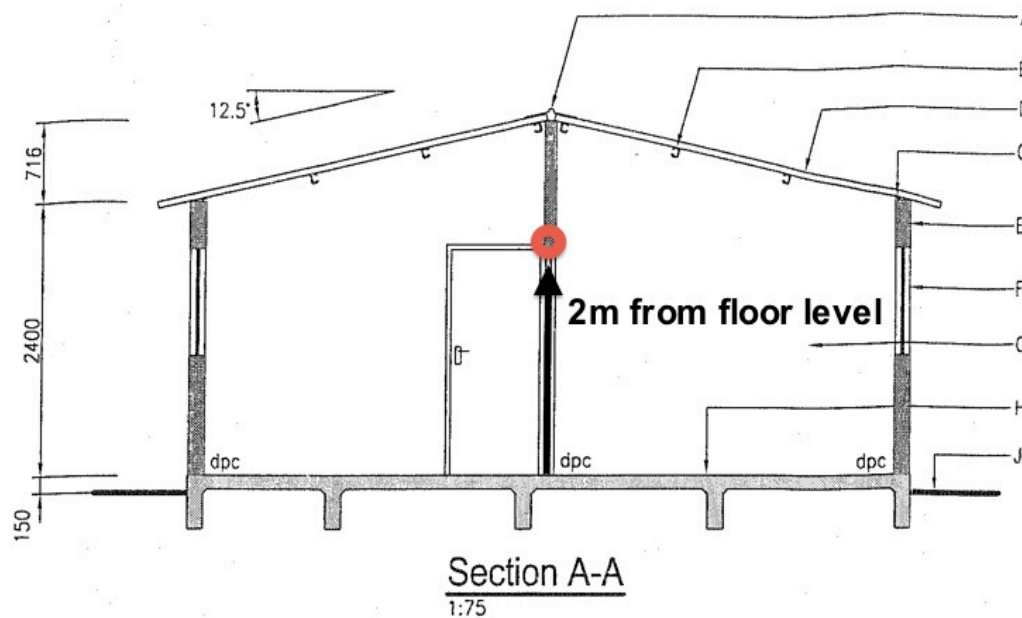
Methodology

12

- Demonstration test of indoor thermal comfort, four test houses at Cosmo City configured:
 - ▣ House 1: 'As-is' roof surface and no ceiling
 - ▣ House 2: 'As-is' roof surface with ceiling
 - ▣ House 3: New, conventional type roof coating and no ceiling
 - ▣ House 4: Cool roof coating and no ceiling

Methodology (cont.)

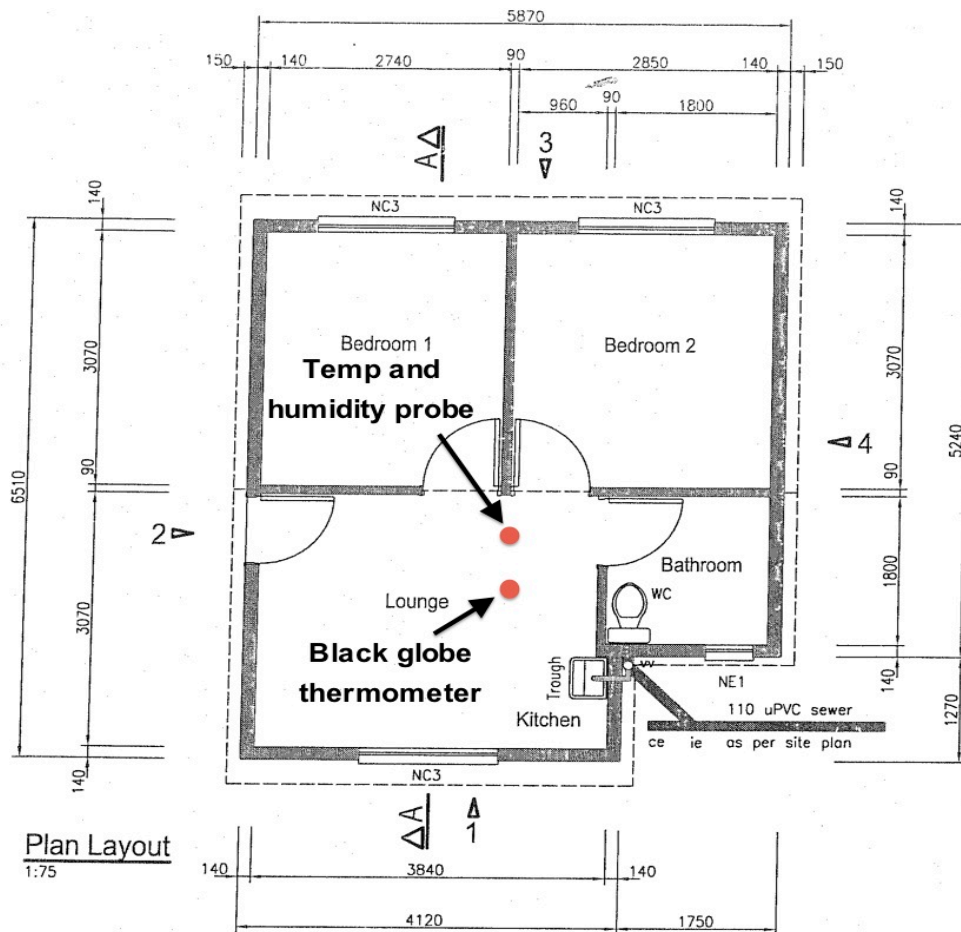
13



- A week-long ‘as-is’ baseline data set of temperature and humidity readings logged at 2.0m above floor level, of each test house.

Methodology (cont.)

14



A typical layout plan of a BNG house

- Temperature and humidity probes have been secured in the same location.

Meteorological data

15



- **Lux level**
- **Temperature**
- **Relative humidity**
- **Dew point**
- **Rainfall**
- **Barometric pressure**

Thermal comfort levels determined by ASHRAE 55-2010 standard using the primary six factors:

16



- Metabolic rate,
- Clothing insulation
- Air temperature

- Mean radiant temperature
- Air speed
- Humidity

Job Creation

17

South Africa highest levels of economic inequality.

- Global recession coupled with macro-economic policy, created insufficient jobs
- National Development Plan indicators, (2012: 98) unemployment rate among black youth population at 65% - 'could pose a serious threat to social, political and economic stability'.

Green & Job Creation Funds

18

Cross cutting government sectors:

Energy, Environmental, Human
Settlements, Science & Technology.

Private Sector: Paint manufacturing &
related application industries

Job Creation for unskilled and semi-skilled youth in the Green Economy

19



House 3

Cleaning and repairing of roofs before painting

Job Opportunities for unskilled and semi-skilled youth

20



House 4

Painting the
roof with
Cool Roofs
Paint

Comparison of ceiling insulation with cool roof paint

21



House 2

‘As-is’ roof surface with installed ceiling

Comparison of conventional and cool roofs

22



House 3: Newly painted conventional roof coating and no ceiling



House 4: Cool roof coating and no ceiling

Indoor Thermal Comfort

23

Preliminary average temperatures on a particular summer's day

With conventional roof: 36.5deg. C (inside house)
31.5deg. C (outside)
Roof Sheet 62.0deg. C

With cool roof: 31.4deg. C (inside house)
31.5deg. C (outside)
Roof Sheet 38.0deg. C

With ceiling: 30.5deg. C (inside house)
31.5deg. C (outside)
Roof Sheet 62.0deg.C

Financial Costs (including labour)

24

- Installation of a ceiling: R 6000
- Painting of cool roof: R 1800
- Painting of conventional roof: R 900

Thank you for your attention

25

