Internship report

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S0124133
2011-2012

Summary

The improvement of the housing conditions has been a major issue since the end of Apartheid in South Africa. In this perspective quantity was more important then quality. Since 2000 PEER Africa is developing a new type of subsidized houses, where the quality of living is taken into account as well.

Via a set of 10 interventions, the design of the standard RDP houses has been modified and now claimed to be an improvement. During this research a methodology is developed to find data that can state this claim next to the soft data of "feeling". As a method, multiple embedded case studies are proposed to better compare the different houses and different designs and to find an answer to the research question:

Are the iEEECO interventions leading to an improvement of the quality of living inside the build houses?

The route to the answer on this question was via quantitative data, like temperature measurements, weather data, electricity usage. Also questionnaires were used, to explain changes occurring in the retrieved data, via learning the habits of the people, like when they cook and how long, or if they use any electrical equipment.
Unfortunately, due to a time limit, and due to delays of delivery of the equipment no actual data is collected from the installed equipment.

From the time spent in the case study houses, observations are made and conclusions are drawn, resulting in a positive answer on the research question, although not stated with facts.

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Acknowledgements

Researching the interventions in the iEEECO™ houses was a different experience for me. I have to thank Douglas Guy and Thami Eland from PEER Africa for the support they gave me in Witsand. Also I want to express my gratitude to the housing committee members, Fundiswa and Thato, for introducing me in the community and to help carrying out the research as well as doing the translating work.

A special word of gratitude is for Councillor Barbara Rass and her personal assistant Wendy Rass. They have taken me into their house for the time I did do my research. They also helped me to stay focused and even to introduce me to important contacts, like the mayor.

From the University of Johannesburg I have to thank professor Annegarn for this internship placement. A special word of appreciation is for James Robinson and Mati Mattinga, who supported me from a distance and helped to arrange my stay.

List of acronyms and abbreviations

Abbreviation	Meaning
EEECO	Energy and Environmentally Cost Optimized
iEEECO	Integrated Energy and Environmentally Cost Optimized
MERVC	Monitoring, evaluation, reporting, verification and certification
PHP	Peoples Housing Programme
RDP	Reconstruction and Development Programme
WHO	World Health Organization

1 Introduction

The purpose of the project is to design and test an embedded performance monitoring, evaluation, reporting, verification and certification (MERVC) system, which will provide benchmark reference data, relating to the performance of specific sustainable energy, environment and residential empowerment interventions. The report outlines the approach, design and (anticipated) outcomes of the project.

What is the baseline situation?
The improvement in the living conditions of the poorer part of society is of the South African government with specific responsibilities resting with what is now called the National Department of Human Settlements. There is a "welfare oriented" national housing subsidy scheme, which started during the Mandela Administration that aims to provide low income South Africans with new and 'decent' housing opportunities.
The housing sector also has what is called the informal sector, which is made primarily of informal units constructed by residents themselves, often in unsafe and illegal settings. The current living conditions in informal settlements are characterised by defective energy and environmental profiles including flammable materials and extremely dense housing layouts and orientations which cater to a pattern characterized by dangerous domestic use of energy. There are often no services, a lack of proper sanitation and no official connection to power and water supply.
One of the major problems of the shacks is the thermal performance of the buildings and the indoor air pollution created by the use of defective open flame systems. The thermal performance of the building is typically defined by the indoor temperature, humidity and mould formulation[1].
During summer the outside temperature can rise up to 35^{0}C and during winter drops till 4 or 5 ^{0}C in Atlantis. The inside temperatures can be as much as 5 to 10 degrees more to the extreme inside the informal units. This is caused by a number of factors including the lack of insulation and finishing of the building envelope. This temperature during winter along with the economic profile of the stakeholders leads to unsafe heating and cooking conditions. These conditions include illegal and unsafe electricity connections, which are the major cause of shack fires[2]. The government built houses are developed via the Reconstruction and Development Programme (RDP) and are an improvement compared with the informal dwellings, but still can be seen to mirror the energy profile of to the shack in order to create a comfortable living environment. The business as usual construction of government formal houses and the lack of policy enforcement, highlight the necessity of improving the design and implementation of integrated informal settlements and low cost houses in energy efficient units, of which the iEEECO™ – units are an example.

[1] See Southern Coastal Condensation Area Specification (SCCPA) which is a region along the coast which has high mould formulation
[2] The fire in Witsand on the 30st of May 2011 illustrates these risks, resulting in 9 shacks burned down and 1 casualty.

Figure 1 Current situation

Figure 2 Result of shack fire

Figure 3 iEEECO - unit

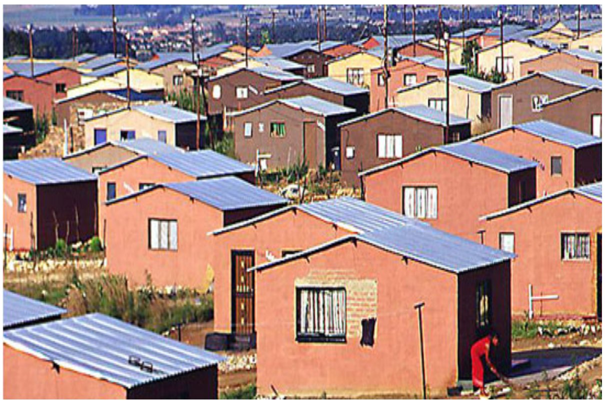

Figure 4 Standard RDP-house

1.1 Introduction to the iEEECO™ interventions

1. Modified site plan: The original town plan was modified by PEER Africa to accommodate north facing units and to minimise the impact of shadows created sub-optimal placement of buildings and obstructed sun angles.
2. Window placement: all houses have large north facing windows in order to optimize the use of solar energy and thermal comfort throughout the year.
3. Shading design: all houses have a north facing roof overhang of 600 mm in order to block solar energy during the summer and allow the solar energy to enter in the winter.
4. (Insulated) ceilings: to maintain indoor temperature conditions for a longer period of time e.g. during the summer a lower indoor temperature and during winter a higher indoor temperature. Another benefit of the ceilings is that they avoid mould growth on the indoor walls.
5. Concrete floors: material with a high thermal mass, which leads to a storage of solar energy during the day and releases this energy slowly during the night. This leads to a more balanced temperature during day and night when it is warmer and cooler respectively.
6. Supply of curtains: a good use of curtains during daytime and night-time could help to raise the thermal comfort. The open curtain is enabling the sun of entering the house, while the closed curtain insulates the weakest point of insulation: the window. Leading to less energy leaving the house during the night-time.

7. Energy efficient lighting: Natural lighting increases via the north facing orientation, CFLs are encouraged and now PEER has introduced LED lights.
8. Water efficiency and storm water recovery and reuse: PEER also introduced showers and solar water heaters.
9. Safe cooking: PEER also introduced safe paraffin cook stoves.
10. Peoples Housing Programme (PHP): the decision-making tasks are in the hands of the community. This could lead to a better understanding and acceptance of the previous mentioned interventions. A second advantage is that PHP is empowering the local community and increases the entitlement to the project

1.2 Introduction to Witsand

The informal settlement of Witsand is located in the Western Cape province of South Africa, close to the City of Atlantis and part of the City of Cape Town Metro. The majority of the inhabitants of Witsand are black Africans, originated from the Eastern Cape "Transkei" provinces. This is in contrast with Atlantis, a city build during the "Apartheid-era" for coloured people, who still form the largest share of the city. The settlement was officially formed during the 1980s on the land of a farmer, but the real growth happened in 1994. The special allocated industries during the Apartheid-era are gone, leaving a high amount of unemployment in the area; figures vary between 60 and 70 percent.
PEER Africa signed an agreement with the community and then Blaauwberg administration that selected the Witsand settlement in 1999, to develop and function as a showcase for the rest of the country for an integrated energy and environmentally designed human settlement, targeting the RDP-housing community. The focus is energy and climate/environmentally efficient and cost effective.
In Witsand, the build units are built in construction phases and show various different designs. Besides major differences like one versus two storeys or the orientation of the building, smaller variations between the designs occur, for example the size of the windows or the presence of a solar geyser. The new designs are expected to perform differently than the previous mentioned interventions.

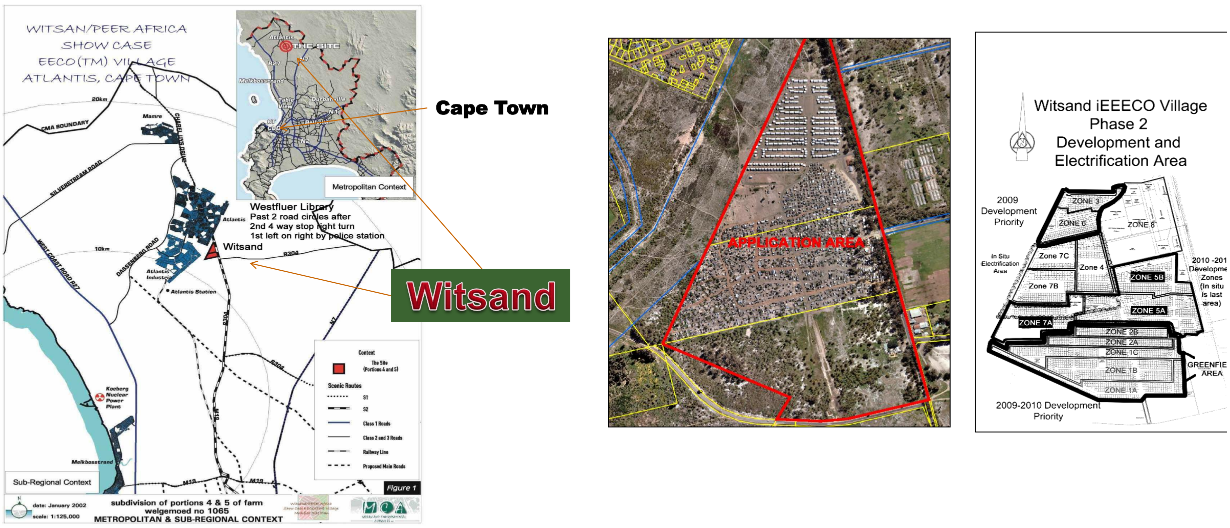

Figure 5 Location and situation of Witsand

Name	Description	Amount
iEEECO™ Double storey semidetached north facing [iDSS]	North facing 40/50 m^2, build in 2010 (phase 1+), smaller double pane thermal, windows solar geyser, shower only vaulted insulated ceiling, pergola	1
iEEECO™ Single story semidetached north facing [iSSS]	North facing 45 m^2, build in 2010 (Phase 1e), solar geyser, ceiling, plaster, electrified, 600mm Overhang North face	1
iEEECO™ Single storey north facing GAP [iSSNG]	50 m^2, build in 2009 (phase 1+), GAP-house, ceiling, Vaulted insulated roof, alternative partition walls using Gypsum board and steel frames, LED lights, Hybrid PV system and solar water heater.	1
iEEECO™ Single storey north facing [iSSN]	36 m^2, build in 2005 (phase 1),	2
iEEECO™ Single storey west facing [iSSW]	36 m^2, build in 2005 (phase 1)	1
Masiphumelele [Mas]	44 m^2, build in 2010, design ignores the use of solar energy.	2
Shack	15-50 m^2, build in 1993-2011	2

Table 1 - Unit description

2 Research Question

PEER Africa is under the assumption that the taken interventions, as mentioned in section 1.1, increase the quality of life within the houses, compared to standard RDP houses. During this research an answer should be found therefore to the following question:

Are the iEEECO interventions leading to an improvement of the quality of living inside the build houses?

3 Literature Research

Research on the benefits of energy efficient housing in South Africa is not unique. Multiple reports have been written about the different projects nationwide over the past decade including a number of papers about PEER Africa projects including the Kutlwanong EECO Village Project in Kimberley, the All Africa Games Project in Johannesburg and the Kuyasa Project in Cape Town.

However, the goal of this study is to prove the benefits of the iEEECO methodology and its resultant unique style of design in the Cape Town SCCCPA Climatic region. Comparisons between the different studies can be drawn after the measurements, however a big pitfall is that the situations (geographical, climate, social economic) and the used methodology (type of measurements, questionnaires) are so different that comparing the outcomes will require a number of assumptions and extrapolations.

Possible comparable reports are:

- *"Quantifying benefits of energy efficient house design through monitoring of specified air quality and household energy activity" by M. Wentzel.* Describing air quality and energy consumption via measuring and surveying. [1]

- *"Energy efficient housing in South Africa" by W.Klunne.* An overview of projects nationwide including four in the Western Cape province. However there is no actual data given, since it's based on the assumptions of the project leaders. [2]
- *"Witsand iEEECO™ village assessment of thermal performance of iEEECO™ units" by D. Guy.* Monitoring the temperature in an informal dwelling and in an iEEECO™ unit during the winter of 2007. [3]
- *"Best Practices in Building Healthy Communities- A consolidation of lessons learned in the housing development process" by Maggie Becker, Shivahn Fitzell & Christine Royer.* A descriptive overview of different housing projects within South Africa including a comparison between the projects. [4]

4 Methodology

The road to the answers for the problems in chapter 2 has been supported by different methods. These methods are described in this chapter. First the methods to research the aspects concerning the indoor climate are discussed, secondly regarding the outdoor climate. The third part of the methodology is describing the road to find answers on the energy and water usage of the homeowners.

4.1 Indoor climate

The interventions given in section 1, affect the performance of the building as well as the behaviour of the people living in the building. The lowest temperature for instance, leads to a different heating requirement, health and safety risk and change in behaviour different from a person in a warm unit. The actual effect can be measured by measuring various indicators of thermal comfort in the different house designs described in Table 1.
The major effect that is expected from using the solar energy, via a north facing orientation and the roof overhang, is a more stable and comfortable indoor temperature. This can be verified via the following experiments:

- Measuring the temperature at 50 cm and 200 cm above the floor in the living room and the largest bedroom, during seven days and nights. Taking into account the household beneficiary profile and energy consumption patterns linked to these profiles.
- Measuring the inside and outside temperature of all 4 walls and the floor and ceiling, insight is obtained into the differences in indoor and outdoor conditions and in north and south perspectives. Doing this with an infrared temperature-gun at three moments in the day, before sunrise, at the peak of sunshine and after the sun has gone down, the variations of temperature over a day can be tracked.

The effect of the ceilings can be split into two parts, a higher minimum temperature at the coldest point of the house and a lower humidity at this point. The temperature part is already covered whereas the humidity data will be gathered as follows:

- Measuring the humidity at the south facing wall at 50 cm above the floor and at the ceiling. In order to overcome the household difference and energy use, the same measurements should take place at the north facing wall. The height of 50 cm has been chosen because the increase of humidity is expected during the night, when people tend to be sleeping.

The third indoor effect is the light intensity. A change in fenestration design can help stabilizing the indoor temperature but can affect the amount of light in the house in a negative way. Measuring this effect can be done via:

- Measuring the light intensity in the living room and finding of a correlation with the indoor temperature in this room.[3]

The last aspect of the indoor quality that is assumed to be different is the air quality. A different temperature leads to a different heating pattern, leading to a change in gas content of the air. The type of heating and the amount of energy used is discussed in the section about energy usage. The content is also influenced by the airflow[4] in the house, mixing the indoor gasses in a different way. The gas that is causing the highest threat for the health, is carbon monoxide (CO) linked to defective cook stoves and space heaters while particulates have a long-term impact on the respiratory system. This is given by the fact that families cook everyday and in winter there is also the added space heating load in the evening and the gas is hard to detect, since it is colourless, odourless, non-irritating and tasteless.

- Using a gas content meter in a central point of the house, the average amount of CO can be measured. The World Health Organisation (WHO) has set a maximum that is safe to life in:
    - 100 mg/m^3 (87 ppm) for 15 minutes
    - 60 mg/m^3 (52 ppm) for 30 minutes
    - 30 mg/m^3 (26 ppm) for 1 hour
    - 10 mg/m^3 (9 ppm) for 8 hour

  The values of this standard should be compared when the data is retrieved.

4.2 Outdoor Climate

Besides measuring the indoor conditions, the current outside conditions must be known, in order to draw conclusions on the effect of the iEEECO™ interventions on the indoor conditions. Since the houses are in an acceptable close range of the Koeberg Nuclear Power Plant weather station, 15 km, this data can be used safely.
All the gathered data has to be placed in perspective. For instance the houses (top structures) all cost less than R100, 000 (average of R75, 000/$10,000); finding an optimisation between costs and quality. Hence this is an example of PEER Africa’s cost optimisation principle.
Another aspect, which has to be taken into account, is the habits of the people in the houses. One example is the opening of doors during summer and winter, to show that the people are at home. Both instances influence the indoor temperature and comfort in a negative way during winter and can have a cooling benefit and health benefit during other times because of the increased ARC.

4.3 Tracking of off/on grid energy & water usage during end of summer and winter period

The Witsand iEEECO™ Model project has now advanced to what PEER Africa calls Phase 5. This is the energy and environmental systems implementation phase and it takes into account different interventions regarding the type of settlement, the grid connections, and the domestic use of energy.
The second part of the proof is based on investigating the assumption that the iEEECO™ interventions improve the living conditions and could be found in a change of energy and water consumption. Since not all the targeted development zones are connected to the electricity and water grid in the same way, the following actions are considered in order to gain the complete picture:

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[3] Room layout will also be considered. Some units have a north facing orientation and some have a southern orientation for the lounge and master bedrooms.
[4] Note PEER recommended vaulted ceilings vs flat ceilings under truss in Phase 2.

- Use of a meter to measure energy and water use. In case no meter is present, the installation of a meter could be considered.
- Illegal energy use in the shacks can be estimated by a survey of electrical equipment in the shack and the average electricity use of this equipment.
- Use of the questionnaires filled in after leaving the shacks and moving to an IEEECO^{TM} unit.
- Use of a questionnaire "to measure" the energy usage and source of the households, since not all the energy used is electricity. (Appendix A and B)
- Installing a water meter at the general tap in the shack-area. For every tap an amount of users/households is known and therefore an average consumption per household can be extracted from the measurements.

To understand and explain sudden changes in the measured data a clipboard will be provided for every household. On this, the times of cooking and the different types and amounts of immeasurable energy sources, will be noted down, as mentioned above. Besides the given numbers, the feeling of comfort will be questioned. Since not everyone is rating in the same way, several site visits will be made to do observations of the current situation in every household in order to make better comparisons between the different units.

5 Results

Due to the limited amount of time for the internship and the time required to obtain the measurement equipment, no results can be discussed since no data was obtained during the internship.

From the actual data collection description, not all required equipment was delivered and therefor not all described parameters could have been collected. There was a lack of carbon monoxide meters, humidity meters and the water section is also being disregarded.

6 Conclusions and recommendations

6.1 Conclusions

Since there are no results, no official conclusions can be drawn. However, during the stay inside the community observations have been made. These observations are compared with the interventions mentioned in section 1.1.

Interventions 1 till 6 do have a direct influence on the temperature. From the visits to the shacks, the Masiphumelele houses and the different iEEECO™ houses during the same day, the iEEECO™ houses turned out to be the most comfortable. This was the case during the mornings, where the houses where feeling warmer, and during the afternoon, where the houses were significantly cooler. Without the data, it is impossible to distinguish which of the six interventions is more favourable then the others. This is the case, besides for intervention number 6. The usage of curtains is not explained to the homeowners and not all the houses are supplied with curtains. From the six interventions it is also expected to have the leased effect.

Intervention number 7 is the lighting situation. All iEEECO™ houses are designed to face with their living room towards the streets. Since there are two sides on a street, only 50 per cent of the living rooms face northwards, giving only these houses the benefit of extra sunlight. This benefit is larger in a living room then in a bedroom, since in the bedroom the total need of light is less.

Intervention number 8 could not be measured nor observed. Only at the houses in the most recent phase solar water heaters are installed, however they are facing the west.

Intervention number 9 is not observed at all.

Intervention number 10, the Peoples Housing Programme, is theoretically very good since the community gets involved in the process of design and construction. However only in the small community of Witsand, one housing committee turned out to be insufficient. Due to personal affairs and family affairs, the community is split up and a second committee separated from the original housing committee. This shows how complex the situation is. A second point of attention is that the housing committee is really actively involved, and does try to involve the rest of the community via meetings, however the people outside the committee do not really care in what kind of house they life, as long as it is better then their current living conditions.

6.2 Recommendations

Since the equipment has been installed, the data should be collected and processed. The different iEEECO™ designs can be compared as well, using only the observations, these differences turn out to be small.

The factor of time is also important to improve. Via conducting measurements over a longer period, preferably one year, “incidents” can be ruled out and a better-founded conclusion can be drawn.

7 References

1. Wentzel, M., *Quantifying benefits of energy efficient house design through monitoring of specified air quality and household energy activity.* Journal of Energy in Southern Africa, 2006. **17**.
2. Klunne, W.J., *Energy efficient housing in South Africa*, 2002.
3. Guy, D., *Witsand iEEECOTM village assessment of thermal performance of iEEECOTM units.* 2008.
4. Becker, M., Fitzell, S., Royer, C., *Best Practices in Building Healthy Communities*, 2008.

Annexes

A. Cooking and Heating Questionnaire

Cooking / Heating schedule

House number:…………………………….

Household composition:………………………………………………………….

Cooking / Heating	Date	Time Start	Time End	Fuel Type

COMMENTS: ………..

B. Energy / Electricity Usage Questionnaire

Energy / Electricity Usage

Date:……………………………………………

House number:…………………………….

Household composition:……………………………………………………….

Electrical Appliances

Type	Watt	Amount	Hours/Day	Total Usage
TOTAL USAGE:				

OTHER SOURCES AND USAGE OF ENERGY:

Heating: ………

Cooking: ……..

Others: ………..

COMMENTS: ………………………………………………………………………………………………………..