Sustainable RDSM strategy for South Africa

Mr GW Taljaard

9342001

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Summary

Title:	Sustainable RDSM strategy for South Africa
Supervisor:	Prof. E.H. Mathews
Department:	Mechanical and Aeronautical Engineering
	University of Pretoria
Degree:	Masters in Engineering (Mechanical)

An estimated 20% of South Africa's population is currently housed in low cost dwellings. These dwellings are extremely energy inefficient and it has been shown that these households spend almost 20% of their disposable income on heating in winter. This situation is undesirable for both the home owners and ESKOM who must ensure an unusually high electricity demand especially on winter nights. Some of the people don't use electricity for heating but fire and this contributes to the high levels of pollution in these communities.

By ensuring better energy efficiency in these houses the demand for electricity will decrease and the pollution levels will obviously decrease as well. The process that strive to reduce this electricity demand is called Residential Demand Side Management (RDSM) and is strongly supported by ESKOM. This dissertation investigated the international experience concerning RDSM and some of the possible steps that could be taken to establish an RDSM program in South Africa.

It was discovered that the two most important steps relevant for South Africa would be to install ceilings in low cost dwellings and to install insulation in middle income and low-income households. Various computer simulations using *QUICKcontrol*, a thermal design software package, was done to assess the effect that these steps would have on energy usage.

Before any decisive steps could be taken to install these products in houses, it was important to hear what the public thought of the low-cost ceiling concept. It was

decided to conduct a Socio Ecor he public opinion and the response towards the low cost ceiling turned out to be extremely favorable. The participants supported the idea of a low cost ceiling but the access to the ceiling might still prove to be difficult.

Through experience it was found that people often don't want to invest in a certain product if the only benefit is a slight monetary saving. It has become necessary to investigate other aspects concerning the ceiling and insulation that would encourage people to buy into the concept. This line of thinking led to the "Comfort" study.

The finding that insulation will ensure that almost three times more people are satisfied with their indoor situation is quite significant. The improvement of the indoor aesthetics if a ceiling is installed in a low-income dwelling is also an important consideration when a decision has to be made to install the product. This type of information could persuade people to purchase these products to the benefit of themselves, ESKOM, the insulation manufacturer and the environment.

Opsomming

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Titel: Sustainable RDSM strategy for South Africa

Promotor: Prof. E.H. Mathews

Departement: Meganiese en Lugvaartkundige Ingenierswese
Universiteit van Pretoria

Graad: Magister Ingenieurswese (Meganies)

‘n Benaderde 20% van die Suid-Afrikaanse bevolking woon in lae koste behuising. Hierdie behuising is baie oneffektief sover dit energie aangaan en daar word geraam dat hierdie huishoudings tot soveel as 20% van hul spandeerbare inkomste aan verhitting in wintermaande spandeer. Hierdie situasie is nadelig vir beide die huiseienaars en ESKOM wat aan ongewone hoë elektrisitetseise moet voorsien, veral in wintersaande. Sommige van die mense gebruik nie elektrisiteit nie, maar ‘n ander vorm van verhitting soos vuur wat grootendeels bydra tot besoedeling in die areas.

Deur die huise meer energie effektief te maak kan die vraag na elektrisiteit daal en die besoedeling kan natuurlik geminimeer word. Die proses wat gevolg word om veral die elektrisiteitsaanvraag te verminder word “Residential demand side management” (RDSM) genoem en word veral deur ESKOM sterk ondersteun. Die verhandeling bemoei hom met die ondersoek na die internasionale ervaring van RDSM asook die moontlike stappe wat geneem kan word om dit in Suid-Afrika suksesvol te vestig.

Daar is gevind dat die twee belangrikste stappe wat geneem kan word om RDSM effektief te implementeer is om plafonne in lae-koste behuising te installeer en om isolasie in middelinkomste huise sowel as lae-koste huise te installeer. Verskeie simulasies met behulp van *QUICKcontrol, termiese* ontwerp sagteware, was gedoen om die stappe se effek op energieverbruik te simuleer.

Voordat daar egter op groot skaa[illegible]es te implementeer moet die mark se gevoel omtrent die voorgestelde produkte getoets word. Daar is besluit om 'n Sosio Ekonomoese studie te loots en die reaksies van die publiek was belowend. Die deelneemers het duidelik te kenne gegee dat hulle ten gunste van die voorgestelde lae-koste plafon is. Sommige van die probleme ten opsigte van koste en toeganklikheid tot die plafon moet egter nog gefinaliseer word.

Verder is daar ook bevind dat mense nie altyd sal inkoop in die RDSM stappe net om geld te spaar nie, veral omdat die besparings ten opsigte van die RDSM stappe in die algemeen maar min is vir die individuele huishoudings. 'n Ander moontlikheid wat mense miskien sal ooreed om wel in te koop is as daar gewys word dat die mense se lewenskwaliteit noemenswaardig sal verbeter. Die behaaglikheidstudie of "Comfort"-studie is met die doel voor oë gedoen.

Die bevinding dat drie keer meer mense tevrede met hulle binnenshuise temperatuur toestand sal wees is noemenswaardig. Die verbetering in die estetiese toestand van 'n lae-koste woning as die plafon geinstalleer word, is ook 'n belangrike oorweging as besluite gemaak moet word. Die tipe inligting mag dalk meer mense oorreed om isolasie te installeer tot voordeel van hulle self, ESKOM, die isolasie maatskappy en die omgewing.

Chapter 1: Introduction to Residential Demand Side Management (RDSM)

ABSTRACT

Chapter 4 – RDSM Option: Insulation – Effect on comfort

APPENDIX D: EXAMPLE OF C

APPENDIX E: EXAMPLE OF MEASURED DATA: HOUSE 1

APPENDIX F: PARTISIPANTS IN COMFORT STUDY

Chapter 1

Introduction to Residential Demand Side Management (RDSM)

ABSTRACT

In South Africa, the residential sector currently contributes more than 20% to the national peak electricity demand. This value is increasing on a yearly basis due to the electricity supply to especially low cost houses. The problem is worsened by the fact that low cost houses are energy inefficient. A lot of expensive energy is therefore wasted on indoor heating.

The purpose of this chapter was to conduct a literature survey on the field of residential demand side management (RDSM). This chapter had to investigate the international experience and had to establish which of those experiences are applicable to South Africa.

From the literature survey, it was clear that the residential sector could contribute significantly to peak load reduction when compared to the commercial and industrial sectors. It was also clear from other countries that the governments and large organisations took interest in DSM programs and supported them financially and with legislation that promoted DSM measures.

This whole study is dedicated to investigate RDSM in South Africa and to find certain sustainable actions that could be applied to the South African market. The actions considered had to take into account both the low and middle-income sectors.

Chapter 1: Introduction to Residential Demand Side Management (RDSM)

1. Background

The domestic sector is one of the largest electricity consumers in South Africa [Surtees and Bluff (1)]. Almost 29% of municipal electricity are used by households alone. This figure is expected to increase to 37% by the year 2015 [Surtees (2)]. One of the reasons for this expected rise is the recent "electricity for all" drive by the government.

This has a significant impact on the peak demand for electricity. A reduction in the peak demand is needed to forestall the building of new power stations. If the energy efficiency in low cost houses can be bettered, it will have a significant impact on the peak electricity demand.

The environment will also benefit from these savings. Studies indicate that South Africa's contribution to the additional radiation load on the global atmosphere through emissions is roughly 1.2% [Scholes and Van Der Merwe (3)]. This is particularly high when considering the South African fraction of the world's economy and population.

Electricity generation accounts for a large portion of these unwanted greenhouse gasses, especially in South Africa where we rely mainly on coal power stations for our electricity (3). Effective energy management is the cheapest alternative to decreasing pollution in the energy industry [Neetling and Dutkiewicz (4)].

Viable methods to reduce electricity consumption, especially in the low-income domestic sector are thus needed. This study focuses on available literature regarding this sector and suggests a simple [illegible] to achieve the objective of reducing electricity consumption.

2. What is Residential Demand Side Management ?

"Demand-side management (DSM) is the planning, implementation, and evaluation of utility activities designed to encourage customers to modify the timing and level of their electricity consumption" (5).

The aims of DSM are:

i) to reduce the energy consumed through conservation and improved efficiency;

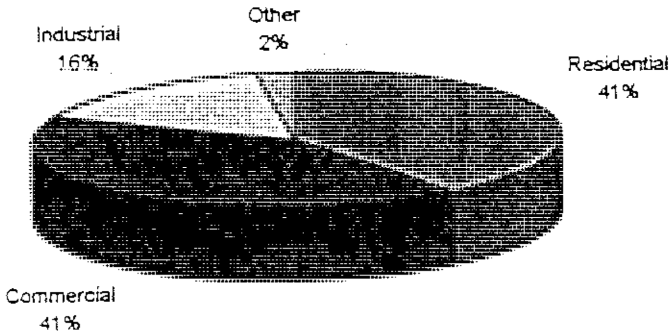
ii) to improve the efficiency of the generating and distributing system, by reducing the peak-to-average load ratio. DSM therefore targets both energy use in kWh as well as peak load in kW, or kVA.

In the modern world, with the highly industrialised economy based on reliable and affordable energy supply, DSM has also become an important national and global policy issue. In most developed countries governments take an active interest in regulating the supply and demand of energy. For a short history of DSM see [Gellings (6)] and for an overview of the whole field of DSM see [Gellings and Chamberlin (7)].

The "demand side" of the electricity market can be divided in the industrial, commercial and residential sector. In each sector the typical use of electricity is different. Most studies indicate that the opportunity for demand management in the residential and commercial sectors are substantial even though the largest single consumers are in the industrial sector.

The pie charts in figure 1 shows the actual energy savings, and the actual peak load reductions, in the United States in 1994 due to DSM (8). Sales to re-distributors, which includes the residential s[...] alities was 66421 GWh in 1995, which forms 43.3% of total [...]

(a)



(b)

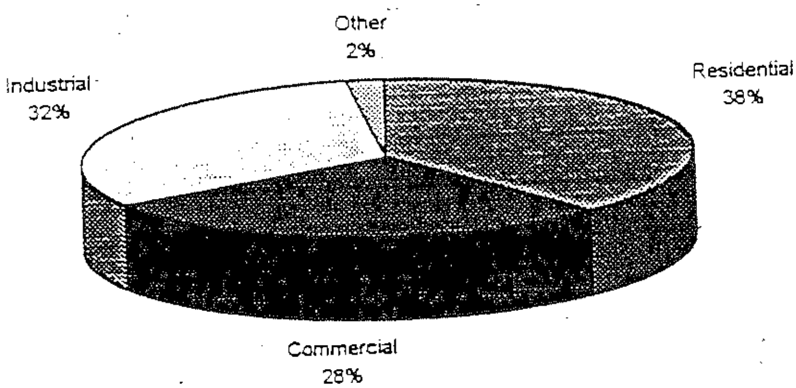


Figure 1 : a) Energy Savings and b) peak load reductions achieved in the various sectors in the United States in 1994 (8)

The first target for demand management is often a few large inefficient industrial consumers since the impact to cost ratio of a DSM program decreases with the number of consumers in the target group. The use of electricity in the commercial sector is usually constant during normal office hours so that this sector can contribute towards energy savings to the extent that efficiency improvements are possible.

Residential consumption, on the [illegible]ws large peaks during the morning rush and in the afternoon [illegible]r the natural target for load shape management. Improvements in residential energy efficiency are also possible so that the aim of residential demand-side management (RDSM) is to improve the load factor and to reduce demand. Mielczarski (11) gives an overview of RDSM.

3. Purpose of this study

The purpose of this study was to conduct a literature survey on the field of residential demand side management (RDSM) and to assess the need for such a strategy in the South African context. This study must form a basis for a DSM strategy to reduce the peak demand of the residential sector in South Africa. The DSM strategy will be formulated in a follow up study.

Before such a strategy can be formulated it is necessary to evaluate the experiences of utilities in other countries. Countries such as the USA, Great Britain, Sweden etc. all have ongoing RDSM programs. A lot could be learned from their experience and therefore this study will briefly look at the literature available from these countries.

The development of a DSM program consists of the following steps:

- identification of DSM options and viability tests,
- implementing a cost effective program based on a selection of most beneficial options, and
- continuous monitoring to evaluate the performance of the program.

Often the technical evidence is overwhelming, but still people are not interested in implementing these suggestions. It is therefore up to the marketing departments to make the product or strategy more "appealing" to consumers. This is often the case in energy efficiency since the m[illegible] for a consumer is relatively small.

This study looks at the both the savings potential and the comfort improvements a DSM program promises. This will equip marketing people with another piece of information that could help them sell the product. This information might not necessarily be of use to ESKOM, but if the strategy succeeds because of this information, it is well worth looking into.

In this study, the focus is on the reduction of the residential peak demand and improving the energy efficiency of especially low cost houses. However, in the residential sector, with a large number of small customers, technical issues alone can not decide between various alternatives.

Another very important aspect is the patterns of behavior of the customers. Even the most effective strategies will never succeed if the cooperation of the inhabitants isn't gained. Consumer behavior is reviewed and the effect of different behavior in the same house is investigated.

4. Literature Survey

To minimise the uncertainty and risk which is inevitably associated with issues where customer behavior is an important variable, this study attempts to gather together relevant international experience. It is true that many of the results achieved abroad are not directly applicable to local conditions because of differences in the climate, physical properties of homes, and behavior of consumers.

Nevertheless, it is highly likely that options, which were too costly abroad, will be even more expensive here. Furthermore, the physical properties of houses in colder climates, and the behavior of building residents there, are likely to compensate for the difference in climate. With the [illegible] overseas experience together with local experience can be searched for guidance.

5. International Experience with RDSM

Conservation is a global issue and recognised as such all over the world. The risks and uncertainties involved in DSM have forced utilities to share hard gained experience. To foster global co-operation and the exchange of knowledge many international bodies were constituted in the last half-century.

The most important international bodies are probably the International Institute for Energy Conservation (IIEC), World Energy Council (WEC), the World Energy Efficiency Association (WEEA). Most of these bodies have Internet WEB sites. They can be accessed conveniently through the IIEC WEB site at *http://solstice.crest.org*. These international bodies have active research and information dissemination programs.

The IIEC "works at three different levels: development of energy policy; design and implementation of efficiency programs; and capacity building through training and education." They drafted a master plan for DSM in Thailand in 1991 and assisted in Chile, Mexico, the Philippines, Central and Eastern Europe. Officials of the IIEC visited South Africa in 1995 and reported on the current local situation (12).

International cooperation has created the propitious situation where experience in one country, and the efficacy of a DSM option tried by one utility is generally freely available to others. The current situation is one where the mass of available data is rapidly becoming overbearing.

In the available international literature, the well documented experience of the more than 3000 utilities in the United States of America form a very important body of knowledge. Gellings and Chamberlin reviews international DSM activity (7) but do not discuss the residential sector North America, the United Kingdom and other leading countries will be reviewed.

5.1. North America

In the United States of America the United States Department of Energy (U.S.D.O.E.) takes a very active part in fostering electricity conservation and DSM in all 50 states. In 1979 the United States Government passed the National Energy Policy Act (NECPA) and assigned the Department of Energy to implement it. It requires major utilities to investigate and implement programs that would allow residential customers to save energy (13).

The Department of Energy started ongoing programs in many of the Federal research laboratories to investigate RDSM options. The utilities have also formed the Electric Power Research Institute (EPRI) for their own mutual benefit. EPRI has a very active DSM research program and information is supplied through a WWW server which is accessed through *http://www.epri.com*.

The U.S.D.O.E., through the Energy Information Administration (EIA), gathers annual statistics on consumers as well as energy suppliers that are freely available. The survey on Housing Characteristics (14), which is based on data from the 1993 Residential Energy Consumption Survey (RECS) gives detailed information on residential energy use in the United States.

The state of Demand-Side Management Programs in the U.S. can be gathered from the fact that in 1993, 8% (7.6 million) of U.S. households indicated that they had participated in the past year in a RDSM program. Of the 89.1 million non-participating households, 45% (40.0 million) reported that RDSM programs were not available to them.

The participation figures imply at 19% of the targeted households actually participated i

Energy savings in all sectors in 1993 are reported at 45,294 million kWh and the actual peak load reductions at 23,069 MW. In 1994 the DSM cost to the utilities was USD 2716 million and the energy savings increased to 52,483 million kWh, which represents 1.8% of total annual electric sales. The actual peak load reduction increased to 25,001 MW, approximately 4 % of the total peak load in the United States. Energy efficiency programs accounted for 46.6% of the actual peak load reduction in 1994.

Direct load control and interruptible load programs accounted for 43.7% of actual peak load reduction (15). The energy savings in the residential sector is reported at 19,241 million kWh, about 40% of energy saving in all sectors [8, Table 4]. The peak load reduction for the residential sector is reported at 8,851 MW, which is 38% of the total reduction for all sectors [8, Table 14]. These figures clearly indicate the importance of the residential sector, in relation to the commercial and industrial sectors.

The publications on the End-Use Load and Consumer Assessment Program (ELCAP), of Pacific Northwest for the Bonneville Power Administration, form an extensive and detailed body of information. In this study in the late eighties, extensive measurements took place in 454 residential structures and 140 commercial buildings.

The ELCAP project involves end-use sub-metering of all household electrical consumption in 13 end-use classifications (16). There are several different housing types, roughly representative of the in 1983 existing single-family, detached, owner-occupied housing stock with electric space-heating equipment although many houses also contain wood stoves. In figure 6 the division of annual loads in 11 categories are shown. The figure shows that *heating loads* far exceeded the other categories.

5.2. United Kingdom

The privatisation of electricity generations and distribution companies in the United Kingdom has resulted in a `Pool Pricing' mechanism. The price of electricity is determined by the pool and may vary considerably within and between days (17). Although there is strong evidence that the pool price is also affected by the domestic load, domestic customers have simpler tariff structures, such as `Economy 7', which supplies cheap electricity for seven hours each night.

In the year ending March 1996 the domestic sector sales was 36% of the total sales of 280,000 GWh and generated 44% of the total revenue. In 1990 the domestic sector became the largest sector although the services sector shows a steady increase since 1975. The Electricity Supply Industry in the UK is represented by the Electricity Association (EA).

According to EA, electricity companies are currently committed to some 300 individual energy efficiency projects. More than half is designed specifically to assist the elderly, people with disabilities, or those on low income. The total energy saving will amount to more than 4,000 GWh. Electricity companies offer free advice on energy efficiency to all their customers.

There is also an Energy Saving Trust of which every electricity company is a founding partner. The UK Electricity Industry has a "uniquely detailed datafile of in-practice energy use in buildings" and has provided extensive support to local authorities on housing projects.

In the United Kingdom energy efficiency is officially encouraged through the Energy Efficiency Best Practice Program of the Department of the Environment (DOE). The program is managed by The Building Research Energy Conservation Unit (BRESCU) of the Building Research Establishment (18).

Best Practice supplies a wide ure on energy efficiency in buildings in the form of energy good practice guides. The literature also includes several good practice case studies. In UK school awareness campaigns were found to be a particularly effective method of information dissemination.

5.3. France

According to Gellings and Chamberlin [7, p.181] the widespread use of electrical heating in France (25% of the total number of homes), explains the high sensitivity of consumption to temperature in winter. Thirty percent of electrical energy consumption is attributed to the domestic sector. Electricite de France (E.D.F.) "have progressed farther towards pricing energy at its true economic costs than most any country." The E.D.F. provides two financial incentives for promoting thermal insulation:

- .An incentive of 1500FF/home is paid if a new installation meets given standards.
- For homes already using electricity for space heating the utility pays 25% of energy saving investments up to 2000FF/home.

The French tariffs are discussed by Lescouer and Galland(19). Under influence of the tariffs the daily load curve has flattened out considerably and the daily load factor of the busiest day was 90% [in 1987] in comparison to 85% ten years before. In this period the development of electrical heating increased the seasonal peak so that the flattening of the daily shape is all the more remarkable.

5.4. Sweden

An overview of the Swedish Energy Efficiency Program is given by Söderberg et al.(20). Sweden decided in a referendum to close all its nuclear stations by the year 2010. Half its electricity is at present nuclear so a tremendous conservation effort is required. DSM in Sweden is also discussed by Gellings and Chamberlin [7, p.224].

Recent electricity price increas[illegible]d to a system where the customer is being offered a consultant service to enable him to achieve the best possible energy utilisation. This requires two-way communication between customer and supplier. Stork and Bohjort(21) investigates various communication channels. They state that "the introduction of a technical customer communications system creates new ways of working actively on the energy market."

5.5. Germany

In Germany private households are responsible for 28% of the electrical energy consumption [7, p.169] and the daily load curve in winter is markedly influenced by outdoor temperatures. Time-of-use tariffs are applied as a rule to domestic consumers.

In a notable long term project the energy conservation in 18 occupied solar homes was measured to determine actual savings (22). The study proved that solar homes have considerably lower heating energy requirements than those which meet only legal requirements in Germany. The average annual heating energy consumption was 95 kWh/m^2 compared to the 250 kWh/m^2 of the standard German housing stock. The study further confirmed that solar energy could only be used effectively in houses with a high degree of thermal insulation.

5.6. Japan

Japan probably has the world's most energy efficient economy. This may largely be attributed to the high cost of electrical energy and the strong conservation culture. Gellings and Chamberlin [7, p.202] states that one of the reasons for Japanese efficiency is the widespread use of heat pumps in the commercial and residential sector. In Japan a vigorous campaign of advertising, promotion and education is coupled with tax incentives for new energy efficiency measures.

5.7. Canberra, Australia

Morris and Johnson(23) describes the development, construction and operation of an energy efficient home in Canberra. In the Australian Capital Territory almost half of electricity sales are for household use. The Canberra climate is cool and temperate with a mean maximum summer temperature of 27.5C and a mean minimum winter temperature of -0.5C. (Appears very similar to South African highveld climate.)

The typical energy use in the Canberra household is 52% for space heating, and 27% for water heating, with a typical three person annual energy consumption of 51 GJ. Electricity holds the major share of the energy supply sources although both gas and oil are available. Fire wood has also made a comeback for space heating and accounts for 16% of delivered energy. There is little incentive for DSM.

The Australian electricity industry is represented by the Electricity Supply Association of Australia (ESAA). They promote energy efficiency "workshops, seminars, literature and conferences and by participating in regulatory processes on minimum energy performance standards for appliances, plant and equipment, appliance labeling, and energy efficient housing." They have a research program on energy efficient buildings which focuses on advanced glazing techniques.

Mielczarski(11) gives an overview of DSM in Australia. He states: "There are still many barriers to DSM in Australia which are currently preventing the widespread implementation of DSM activities. They include:

- lack of understanding about demand management;
- perceived loss of revenue and lack of a utility incentive mechanism;
- the perception that DSM is a community service obligation;
- the perception that DSM is linked to environmental issues only."

"However, the picture is rapidly ch ıent of Australia promotes energy efficiency by a labeling s gy performance standard, and a commercial building energy code.

6. Conclusion

Now that a broad view of the international experience has been gained, it is important to focus on the South African situation. The South African market differs a lot from the typical western market, but it was beneficial to see which options were considered in these "advanced" countries. Options not considered abroad due to for instance cost, will obviously not be viable in South Africa either.

The size of the low-income sector in South Africa is probably the most obvious difference between South Africa and developed nations. This situation must therefore be considered in more detail before a RDSM program is developed for this country.

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Chapter 2

RDSM Savings potential for South Africa

ABSTRACT

The purpose of this chapter was to evaluate the South African experience regarding residential demand side management (RDSM) and had to assess the shortcomings of RDSM in the South African market. To do this the housing situation in South Africa was investigated as well as the local energy consumption patterns.

Using this information, thermal simulations using NewQuick, a thermal design software package, were done for typical low-cost dwellings around South Africa. These simulation results were compared to those obtained from the literature and found that they substantiated the findings of other researchers.

It was found that in South Africa the savings potential in especially low-cost houses is huge. By installing ceilings in these houses, their energy efficiency could improve by up to 70%.

From the simulations, it was clear that the success of these energy efficiency measures is largely dependent on the occupant behavioral patterns. This implies that education on the nature of energy efficiency coupled with the installation of new energy efficient products is necessary and vital.

1. Background to thermal efficiency

1.1. Introduction

From the studies reviewed in Chapter 1 it can easily be seen that a large part of peak electricity consumption in South Africa is due to space heating in winter. From a thermodynamic point of view, the use of high quality energy, such as electricity, to provide heat is wasteful and should be avoided. To improve thermal efficiency in houses, the wasteful loss of heat must therefore be minimised.

1.2. Thermal Efficiency

From the point of view of thermal efficiency, the most important characteristic of a building is the thermal resistance between "inside" and "outside". This includes the thermal conduction resistances of the walls, roof, windows, doors and floor. The thermal resistance is mainly a characteristic of the material of construction. Other factors to consider are the thermal mass of the building and the infiltration rate.

The thermal mass is an indication of the ability of a structure to store thermal energy. It is closely related to the actual mass or weight of the structure. Infiltration characterises the leakage of outside air into the building, concomitant with the leakage of the same amount of inside air to the outside. If the inside and outside air temperatures differ, infiltration causes thermal energy to be carried in or out.

For a given building, the total amount of thermal energy required to maintain a comfortable interior temperature depends on the outdoor air temperature and the amount of solar energy penetrating through the windows. Inside sources of thermal energy, such as people and machines, also play a significant role.

1.3. Climate Influences

The other part of the data required to predict indoor energy consumption is the weather, which plays the role of a forcing function. The most usual method for calculating the influence of the weather is the degree-day method [(1), (2)] which assumes energy flow is directly proportional to the average difference between indoor and outdoor temperatures. The degree day method is a steady state method which should not be used where the indoor temperature varies significantly [2, Chapter 28.7]. For an introductory discussion on degree-day methods see [Thumann (3)].

In this study, a design day approach is used to estimate savings. This means a hourly data for the 24 hours of the day is used as input to the simulation model to calculate the hourly heat flows. To simulate seasonal changes one day for every calendar month is used so that a simulation for a full year actually consists of results for 12 representative days.

The design day approach is not ideal for energy savings estimates since design days are chosen to be statistically extreme. The design day would tend to yield over optimistic estimates of savings. A better approach would be to use an average day or to use the actual measured data of a representative day.

For peak load estimation the design day is ideal since it is designed to agree with statistically extreme weather. The main advantage of the design day method is that data for local conditions was compiled by the CSIR and are readily available.

1.4. Insulation and ceiling effe

Many studies in the United States and Europe indicate that weatherising methods, such as prevention of infiltration through roof, windows and doors are cost effective RDSM measures. However, these methods are usually applied in conjunction with insulation and fitting of double pane windows.

In South Africa houses are extremely leaky but weatherising is not very beneficial because energy losses are determined by the smallest of the resistances in Figure 3 : The single node model avoids the conduction equation and attempts to represent the building zone with a single heat storage capacitance.. It is often the windows, doors and large surface structures that have the least resistance.

Envelope insulation should be targeted at the whole envelope as well as infiltration. To increase the thermal resistance of the ceiling when the large windows effectively forms a thermal short-circuit serves little purpose. This is mainly true for suburban houses, but the focus of this study is on low cost houses and in these houses the infiltration through the roof due to the lack of a ceiling is huge.

The windows in these houses are generally small and there are relatively few windows compared to the situation in suburban houses. These factors make the addition of a ceiling in these houses a viable RDSM option. The significance of a ceiling will be discussed later in the next chapter.

2. Housing Situation in SA

2.1. Introduction

To evaluate the energy usage in South Africa meaningfully it is necessary to investigate the housing situation in the country. Although a lot of literature are available from other countries, these studies can not be used to accurately predict the possible savings in South Africa.

The main reason is due to the high level of formal and informal low cost houses in South Africa. Some of the other reasons are the difference in the South African climate compared to that of the developed countries. It must be remembered however that some of the strategies implemented in these countries could be implemented here with a varying degree of success. Studies done by Lombard (13) concentrated on these aspects.

2.2. Local Housing

To do simulations successfully reasonable assumptions have to be made regarding the housing situation in South Africa. The information is hard to come by and often the information is not in the right format. This has the implication that various sources had to be consulted and deductions had to be made from what was available. The result might not be exact, but if the assumptions are realistic the final answer will be a good representation of the actual situation.

The statistical profile of housing in South Africa is described in the White Paper of the Department of Housing (4, x 3.1). According to the analysis, there were 8.3 million households in South Africa in 1996. The average household size is about 5 people. The population in 1995 is projected at 42.8 million with a projected annual growth rate of 2.27% per annum.

This implies an average increase on people per annum. If the average size of households s w houses will be required per year. Approximately 66% of the population is urbanised and 61% of the urban households live in formal households. Approximately 1.5 million urban informal housing units exist and they are increasing at a rate of about 120,000 per annum. There are also approximately 1.06 million squatter houses nationwide, which are increasing at a rate of about 150,000 per annum.

Van Rensburg's survey (5) included physical characteristics of "first world" type houses in South Africa. SAtoZ (6) gives statistics of the physical construction of houses according to household type.

Since the physical characteristics of these categories are not well defined in SAtoZ. To reduce the number of categories it was decided, to divide houses in South Africa into five typical constructions. They are:

- Flats are dwellings in multi-storey buildings. They do not have ground contact or roofs exposed to the sun. They are not really included in this study because their thermal characteristics are unknown.

- Traditional huts are customary made with adobe walls and thatch roofs. Very few have grid electricity.

- Shacks are informal low-cost housing usually made from corrugated iron plates.

- Formal low-cost houses are "matchbox" types with brick walls and corrugated iron roofs.

- Middle-income houses are suburban housing of various kind. They have brick walls and corrugated iron or tile roofs.

2.3. Household Types

The tables in SAtoZ give the numbers of dwellings of each type for the seven categories of household types which are used as the basic consumer categories throughout SAtoZ. The seven categories are:

- Farm Labour Households. There are 45,000 rural farm labour households, each comprising about 5 people. Dwellings have three rooms on average. About 15% have electricity. Household income is about R460 per month.

- Rural Settlement Households. There are over 3 million rural settlement households, each consist typically of 6 persons. They live in traditional huts (50%) matchbox types and shacks. About 12% of the homes have electricity. Household income is about R900 per month. They are subsistence farmers.

- Emergent Farmer Households. There are 18,000 emergent farmer households. They are very similar to rural settlement households except that they are dedicated farmers.

- Established Farmer Households. There are 55,000 established farmer households. The average number of persons per households is 2.8. The average dwelling has 11 rooms and almost all are connected to grid electricity. Average household income is R8000 per month.

- Urban Informal Households. There are 1.4 million informal structures, 67% are made of corrugated iron. The average size of the household is 4 persons. About 25% of the households are electrified. Average household income is R800 per month.

- Township Households. Th p households of between 5 and 6 people on average ellings are matchbox types. Roughly 73% of the houses are electrified. Average monthly income is R1440.

- Suburban Households. There are 2.5 million suburban households. The typical household comprises 4 persons. The average monthly income is R5500.

The household categories correspond roughly to income groups. The Living Standard Measure (LSM) categories relate to household types as depicted in Figure 1

P11 LSM (LIVING STANDARD MEASURE)	TOTAL	LD TYPE: FARM LABOUR	RURAL SETTLEMENT	EMERGENT FARMER	ESTABLISHED FARMER	URBAN INFORMAL	TOWNSHIP HOUSE	SUBURBAN HOUSE
THIS TABLE IS BASED ON ALL ADULTS 16+ (EXCLUDING HOSTEL DWELLERS AND LIVE-IN DOMESTIC WORKERS)	100	6	41	0.3	0.5	13	13	27
NUMBER IN 000's	23 372	1 334	9 507	66	113	3 077	2 976	6 299
	%	%	%	%	%	%	%	%
LSM (LIVING STANDARD MEASURE): LSM 1	15 (3 561)	32	33	1	0	0	0	0
LSM 2	15 (3 531)	32	29	24	0	10	1	0.1
LSM 3	17 (4 007)	19	23	16	0	39	9	1
LSM 4	12 (2 823)	14	10	15	0	26	24	3
LSM 5	13 (2 927)	1	3	9	12	20	39	14
LSM 6	10 (2 371)	2	0.8	1	26	6	23	22
LSM 7	11 (2 449)	0	2	0	63	0.1	3	34
LSM 8	7 (1 704)	0	0	0	0	0	0.6	27

Figure 1 : Living Standard Measure (LSM) category versus household type(6)

The number of houses of every ... es of households, in each province is given in Table 1.

Table 1 : Number of Houses in South Africa according to house type. Based on data from [6].

Households	Total	Flats	Suburban	Matchbox	Shacks	Huts
Eastern Cape						
Farm Labour	39060	0	12000	12000	10060	5000
Rural Settlement	759750	3500	86934	24449	112641	532226
Emergent Farmer	0	0	0	0	0	0
Established Farmer	5720	0	5720	0	0	0
Urban Informal	120330	0	0	0	120330	0
Townships	181000	0	0	181000	0	0
Suburban	173250	22082	151168	0	0	0
TOTAL:	1279110	25582	255822	217449	243031	537226
Free State						
Farm Labour	82460	0	19089	7593	30432	25346
Rural Settlement	91170	0	19090	7593	0	64487
Emergent Farmer	0	0	0	0	0	0
Established Farmer	8840	0	8840	0	0	0
Urban Informal	106960	0	0	0	106960	0
Townships	90500	0	0	90500	0	0
Suburban	148500	0	148500	0	0	0
TOTAL:	528430	0	195519	105686	137392	89833
Gauteng						
Farm Labour	13020	0	4733	0	8287	0
Rural Settlement	60780	9230	30000	0	21550	0
Emergent Farmer	0	0	0	0	0	0
Established Farmer	2080	0	2080	0	0	0
Urban Informal	508060	0	5000	0	503060	0
Townships	280550	0	0	242303	38247	0
Suburban	866250	60000	806250	0	0	0
TOTAL:	1730740	69230	848063	242303	571144	0
Kwa-Zulu-Natal						
Farm Labour	47740	0	20000	10000	8935	8805
Rural Settlement	668580	7000	132971	30000	198609	300000
Emergent Farmer	10800	0	0	1894	0	8906
Established Farmer	5200	0	5200	0	0	0
Urban Informal	360990	0	0	0	360990	0
Townships	108600	0	0	108600	0	0
Suburban	470250	43165	427085	0	0	0

Table 1 : Number of H[...]ording to house type.
Base[...]

Households	Total	Flats	Suburban	Matchbox	Shacks	Huts
TOTAL:	1672160	50165	585256	150494	568534	317711
Mpumalanga						
Farm Labour	52080	0	12188	12686	20044	7162
Rural Settlement	243120	0	20000	17660	105460	100000
Emergent Farmer	2340	0	0	2340	0	0
Established Farmer	5200	0	5200	0	0	0
Urban Informal	40110	0	0	0	40110	0
Townships	45250	0	0	45250	0	0
Suburban	99000	0	99000	0	0	0
TOTAL:	487100	0	136388	77936	165614	107162
Northern Cape						
Farm Labour	26040	0	10317	12000	3723	0
Rural Settlement	30390	0	10317	13000	7073	0
Emergent Farmer	0	0	0	0	0	0
Established Farmer	5720	0	5720	0	0	0
Urban Informal	13370	0	0	6992	6378	0
Townships	18100	0	0	18100	0	0
Suburban	49500	0	49500	0	0	0
TOTAL:	143120	0	75854	50092	17174	0
Northern Province						
Farm Labour	43400	0	10000	10000	15647	7753
Rural Settlement	759750	0	98735	296660	124355	240000
Emergent Farmer	4860	0	0	0	0	4860
Established Farmer	4160	0	4160	0	0	0
Urban Informal	13370	0	0	0	13370	0
Townships	27150	0	0	27150	0	0
Suburban	49500	0	49500	0	0	0
TOTAL:	902190	0	162395	333810	153372	252613
North West						
Farm Labour	52080	0	14837	15000	12474	9769
Rural Settlement	364680	0	40000	185000	50273	89407
Emergent Farmer	0	0	0	0	0	0
Established Farmer	7280	0	7280	0	0	0
Urban Informal	40110	0	0	3681	36429	0
Townships	81450	0	0	81450	0	0
Suburban	74250	0	74250	0	0	0

Table 1: Number of Hc … rding to house type.
Based

Households	Total	Flats	Suburban	Matchbox	Shacks	Huts
TOTAL:	619850	0	136367	285131	99176	99176
Western Cape						
Farm Labour	69440	0	25000	15000	29440	0
Rural Settlement	30390	3635	6121	8300	12334	0
Emergent Farmer	0	0	0	0	0	0
Established Farmer	8320	0	8320	0	0	0
Urban Informal	147070	0	0	19888	127182	0
Townships	63350	0	0	63350	0	0
Suburban	569250	23000	546250	0	0	0
TOTAL:	887820	26635	585691	106538	168956	0

Unfortunately SAtoZ does not list the access to electricity according to house type, but according to household type. It can however be assumed that the probability of access to electricity decreases in the order: Suburban type, Semi detached, Flat, Matchbox, Back yard zozo, Shack, Traditional hut. Now the number of houses with grid electricity can be calculated based on this assumption.

It is important to make these assumptions in order to do the calculations of the potential savings in energy. These assumptions and results are discussed in detail by Lombard (13).

3. Domestic Energy Con

3.1. Introduction

South African weather is the envy of the world. The climate is very moderate with summer peaks seldom exceeding 30°C and winter lows almost never below 0 °C over large parts of the country. In South Africa residential space heating and cooling requirements are modest compared to most of the northern hemisphere.

The winter is very brief and heating is only required for two to three months of the year. This happy circumstance has unfortunately allowed the construction of houses in South Africa with almost total disregard to the influence of the weather. In consequence South African houses often face the wrong way, have no insulation and are very leaky.

To make up for these defects excessive heating energy is required during the short winter. Due to their low first-cost, portability and overall convenience, most electrified households soon acquire one or more electrical heaters. This high heater saturation in the residential sector is evident in ESKOM's load profile (7, 8).

Electricity use and conservation in South African homes are reviewed by Du Toit and Liebenberg (9) and Rossouw (10). Du Toit and Liebenberg warns: "Because of the long lifetime of buildings and appliances, timely intervention is now imperative. South Africa now stands before a challenge that cannot be ignored."

3.2. Electrical Space Heaters

The number of electrical space heaters for the different household types are given in SAtoZ. To estimate the number of heaters per house type it is assumed that only electrified houses have space h ability of a house having a heater decreases with the quali .

Information supplied by Holtz(11) shows that appliance ownership is strongly related to income. In some provinces, there are more electrical space heaters than houses; in these cases, the extra heaters were allocated to the suburban types.

Since there are more houses with ceilings than heaters, the assumption that the higher income households own the appliances has the implication that no houses without ceilings have heaters. This means that these houses can not contribute to electricity savings. While this conclusion is reasonable in light of the socio demographics of South Africa, it must be verified.

Electricity use in the low-income group is described by Forlee(14) and Surtees(12). According to Forlee space heating appliances are owned by 49.5% of a sample of SOWETO homeowners. Space heating contributes 23.6% to the evening peak and 13.1% to the morning peak. The average consumption per space heating appliance is 5.35 kWh/day in winter.

3.3. Low Cost Households

The study done by Lombard (13) indicate that residential electrical energy consumption occurs mainly in two types of houses: in the low-income group matchbox types, and in the middle income group suburban houses and flats. Typical electricity consumption patterns in these two groups have been studied by Forlee(14).

The number of low cost households with access to electricity are expected to increase drastically in the near future as a result of the "electricity for all" drive of the government. This will put additional strain on the electricity demand with a real possibility that electric heaters will become more popular in low cost households.

3.4. Middle-income Households

Electricity use in the middle- and high-income groups was studied by Van Van Rensburg (5) and Breytenbach (15). Van Rensburg's data is summarised in the study done by Lombard and will not be repeated in this study. Most of this study focuses on the low cost housing because this is where the biggest potential saving lie.

4. Simulations and savings

4.1. Savings Potential of Thermal Efficiency Options (Literature Survey)

Van Wyk (16), Holm and Van Aswegen (17) and Sellick (18) studied the thermal performance of low-cost housing. Holm and Van Aswegen found that the interior comfort in 3 informal houses was greatly improved when the dwellings were lined with reflective insulation. About 50% reduction in fuel consumption was recorded in the year after installation of the insulation.

The insulation was very well received by the occupants. The cost of the insulation was R1200 per dwelling. Sellick reports on a similar study where no decrease in energy consumption could be detected. Van Wyk studied energy efficiency in both formal and informal houses. He defines two categories of informal housing:

- ultra low-cost housing are constructed by the owners themselves from corrugated iron sheets, plywood or cardboard;
- informal houses are houses which do not comply with building regulations;

For efficiency calculation he defines a standard informal low-cost house as a house with walls and roof of corrugated iron, with a concrete floor and floor area 41 m^2.

Five building modifications were investigated to determine the potential impact on thermal efficiency. The modifications considered are: various building materials, building orientation, exterior colour, ventilation control and insulation. He found that the most effective way to improve the corrugated iron houses is to install thermal insulation. According to his calculations up to 75% saving in energy consumption in winter is possible.

In the formal low-cost housing stigated the effect of the same 5 variables on modificatic well as designs for new houses The results are shown in Figure 2. Van Wyk calculated that the installation of a ceiling with insulation in these houses could reduce heating energy consumption in winter by 75%. The electrical energy savings is 535 kWh per year.

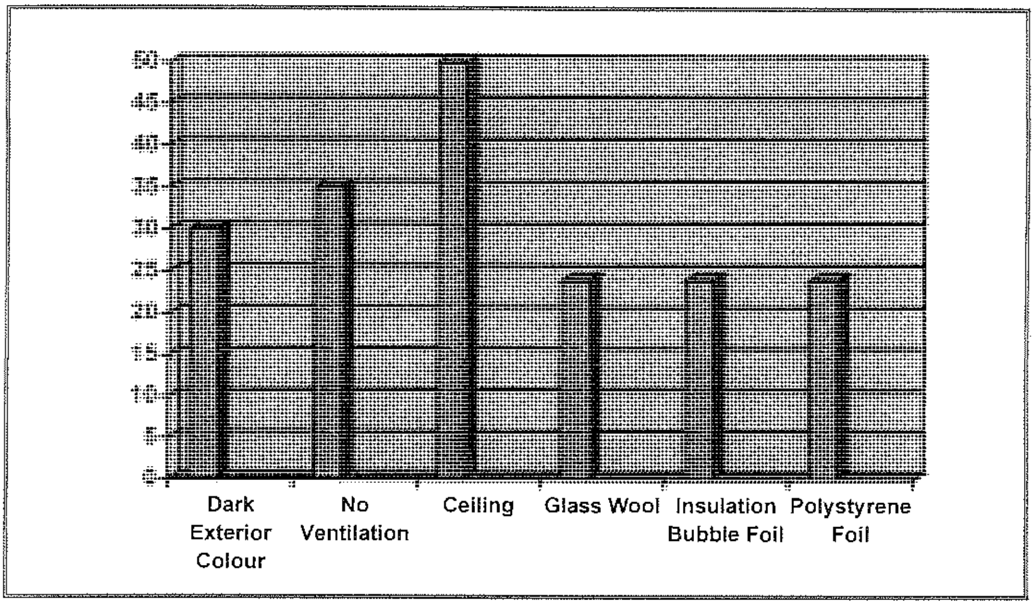

Figure 2: Energy Savings (%) for various retrofit options to formal low cost houses (16)

Taylor and Kleingeld continued with this study and found that installing insulation is the most viable method to improve thermal efficiency. "The greatest benefit of insulation is that once installed, no further effort is required. The energy savings are still realized, even if the house is sold to new owners. Indoor comfort is also improved in both winter and summer. Unfortunately, an initial capital outlay is needed."

The energy consumption in the shack and matchbox is based on the assumption that inhabitants will try to keep the indoor air temperature of their dwellings above 16 °C. The calculation for the suburban house assumes the occupants will attempt to keep the indoor air tempera ... and Kleingeld concluded that the installation of insulation ...

4.2. Simulation Model

A simple model which reasonably explains the thermal behaviour of a building is the model of Mathews, Richards and Lombard (19) which was derived with one overriding objective: to use a single node for all of the thermal mass.

The model represents the envelope with the R_o, C and R_i elements in the network of figure 2. The other elements in the figure are T_{sa} the outside effective sol-air temperature [K], Q_{ir} radiative loads distributed over interior surfaces [W], R_a interior surfaces effective film resistance [K/W], Q_c interior convective loads [W], R_v ventilation resistance [K/W] and T_o temperature of ventilating air [K].

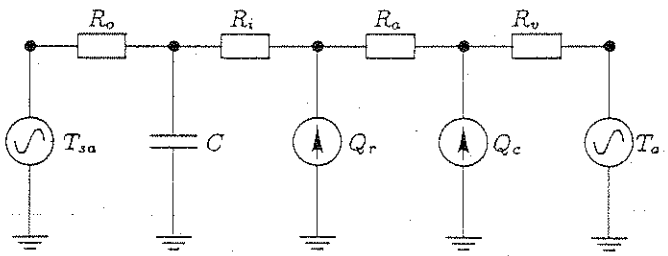

Figure 3 : The single node model avoids the conduction equation and attempts to represent the building zone with a single heat storage capacitance.

From this model the influence of various thermal sources and construction properties are easily explained. The temperature of the interior air is the temperature at node *i*. The thermal resistance of the envelope is represented by the R_o + R_i. It increases with wall and ceiling insulation but is often limited by the low resistance of the windows and doors.

The thermal capacitance of influence the average temperature but has an impact on the amplitude (the load factor) and phase of the swing. Radiative sources of thermal energy, represented by Q_{ir} consist of penetrating solar energy through the windows and also internal sources such as lighting fixtures which carries thermal energy to interior surfaces.

Convective loads, such as convective space heaters, directly heat the interior air. They are represented with Q_c. Infiltration and forced ventilation reduces the value of R_v so that the interior air temperature comes closer to the exterior air temperature T_o.

This basic model was improved upon by Van Heerden and Mathews(20). This model was verified by comparing the results from 70 case studies. The improved model predicted the indoor temperatures to within an accuracy of 2% of the measured values. This model is discussed in more detail in chapter 4.

It is far less easy to establish the accuracy of energy consumption predictions. To measure real energy flow in an actual building is almost impossible. It requires accurate measurement of the temperature over many surfaces. Also needed is accurate measuring of the rate of air flow in and out of the building. In addition, the amount of energy coming in through the windows, cracks and doors must be measured. This is only practicable in specially constructed test buildings.

However, it may be assumed that a model which predicts interior temperatures well, will also predict energy flows reasonably. Mathematically, the energy flow estimate is just the inverse of the indoor temperature prediction and the accuracy of the energy flow estimate should be directly related to the accuracy of the temperature prediction.

This assumption is inherent in all engineering models for predicting thermal response of buildings. This therefore enables us to use the mathematical model to predict energy usage and savi[...] This principle was used in the simulations done for this stu[...]

4.3. Discussion of simulation results

The potential savings obtained by Taylor and Kleingeld are shown in the table below (old). The author of this study also did similar simulations to estimate the potential savings and these results are shown (new).

Table 2 : Calculated space heating energy savings predicted by simulations due to installation of insulation in shacks (Monthly Saving [kWh])

Region	Old	New
Bisho	180	480
Bloemfontein	120	480
Cape Town	660	600
Durban	600	660
East London	720	780
George	660	540
Jan Smuts	300	480
Kimberley	240	360
Mmabato	180	540
Phalaborwa	660	720
Pietersburg	240	420
Port Elizabeth	660	720
Pretoria	240	540
Upington	240	480

Some confusion regarding the savings could arise from the results obtained as shown in the table. It becomes clear when we look at the assumptions in more detail. The difference in savings between the two columns arises when the usage patterns of the heaters are changed. The two patterns were decided on intuitively.

The first point of confusion is the usage patterns decided on. Taylor and Kleingeld assumed that when the indoor temperature drops below 16°C the heater is switched on and left on right [illegible]dless of what the indoor temperature has become.

The author also assumed that the heater is switched on when the temperature drops below 16°C. When the people go to bed at night (22h00) the heater is switched off if the current indoor temperature is above 16°C. If the indoor temperature is below 16°C at 22h00 the heater is left on throughout the night.

In the first scenario, the heater is left on until 10h00 in the morning when the indoor temperature generally rises above 16°C. In the second scenario, the heater is switched on at 05h00 when the people are assumed to wake up and switched off again when the indoor temperature rises above 16°C.

It is important to remember that the savings shown are the possible savings that can be achieved if the people have heaters in their homes and they conform to the scenarios as stated above. It is quite possible that people in warmer climates like Phalaborwa don't have any heaters in their possession.

The second point of confusion is the question of why people in Phalaborwa can save more than people in Bloemfontein, when heaters are used more extensively in the colder climates like Bloemfontein. This trend can be attributed to the influence of the insulation on the indoor temperature in warmer climates. The results of some of the *NewQuick* simulations are given to explain this occurrence.

Table 3 : I[illegible]laborwa

Time	Outdoor	Indoor	Indoor (uninsulated)
01h00	9.5	17.92	12.35
02h00	8.8	17.52	11.74
03h00	8.1	17.16	11.13
04h00	8.1	17.06	11.1
05h00	7.5	16.76	10.57
06h00	7	20.83	9.91
07h00	6.7	20.98	10.44
08h00	11	17.76	14.86
09h00	16.3	20.45	21.42
10h00	20	22.55	24.87
11h00	22.2	23.91	27.82
12h00	23.8	24.7	29.11
13h00	24.9	25.89	30.18
14h00	25.1	26.56	29.83
15h00	25.4	26.97	29.05
16h00	25.3	26.84	27.43
17h00	23.9	26.51	24.95
18h00	19.9	21.68	19.61
19h00	16.9	29.1	19.11
20h00	14.3	20.31	16.39
21h00	13.3	19.67	15.56
22h00	12.6	19.31	14.96
23h00	12.1	19.05	14.53
24h00	11.5	18.76	14.02

Previously the indoor temperature in an uninsulated shack would drop below 16°C regardless of the climate. This would then cause the people to switch their heaters on. With the insulation installed, the indoor temperature in the warmer climates doesn't drop below 16°C before 22h00 and it is therefore not necessary to use a heater at all! This results in a very big "possible" saving.

In Bloemfontein, the effect of the insulation is not as great because the outdoor temperature drops a lot lower than in Phalaborwa. This means that the indoor temperature will drop below 16°C even with insulation installed. Thus the heaters will always be used and the savings are a lot lower than in the warmer regions.

Table 4 : I nfontein

Time	Outdoor	Indoor	Indoor (uninsulated)
01h00	2.1	12.07	4.64
02h00	1.1	11.56	3.79
03h00	0.5	11.21	3.27
04h00	0	10.91	2.83
05h00	-0.5	15.81	2.39
06h00	-0.8	14.91	1.9
07h00	-1	14.78	1.7
08h00	1.4	16.16	5.15
09h00	5.9	18.6	10.54
10h00	9	20.53	14.66
11h00	11.1	16.53	16.35
12h00	12.7	17.29	18.1
13h00	13.9	18.28	19.21
14h00	14.6	19.21	19.55
15h00	15	19.81	19.12
16h00	14.8	19.97	17.78
17h00	13.6	19.99	16.75
18h00	9.4	19.81	10.5
19h00	6.9	27.2	10.41
20h00	5.7	19.17	7.68
21h00	5	18.75	7.09
22h00	4.5	18.53	6.67
23h00	3.9	13.03	6.16
24h00	3.3	12.63	5.65

It can however be seen that when insulation is installed the indoor temperature rises above 16°C when the heater is switched on and stays above 16°C until 22h00 when the people go to bed. This will then encourage them to switch the heaters off until the morning when they wake up. This is a vast improvement from the uninsulated case where the temperature doesn't rise above 16°C even if the heater is switched on.

4.4. Importance of consumer b

As can be seen from the results obtained in the previous section the behavior of consumers will have a major effect on the savings achieved regarding the ceiling. Two intuitive behavior patterns were selected in the previous section, but consumer behavior does not always follow the rigid assumptions this study suggests.

Gellings states "Customers purchase electricity to satisfy a need for energy, not to meet utility demand growth". According to Ester(21), theoretical and empirical evidence suggests that (energy) policy acceptance is a function of at least three factors:

- The degree in which individual freedoms are affected,
- The degree of social control,
- The possibilities to elude social control.

This makes behavioral science indispensable for RDSM. "If one looks at energy conservation research as a whole one is forced to conclude, that the dominant research focus is on technological innovation, whereas there are only relatively few studies on behavioral innovations."

Hitchcock(22) quotes more clearly: "Buildings per se do not consume energy; rather people living and working in buildings use energy." Thus, conservation is in the first instance based on changing patterns of behavior. Educating people to adapt their lifestyles and simultaneously providing and advocating better options is the key to success.

5. Conclusion

From this chapter, it is clear that there is a great opportunity to save energy and money by just implementing simple energy efficiency measures. From all the possibilities the use of a ceiling and insulation in low cost housing showed the biggest improvement in energy efficiency with up to 75% reduction in energy consumption in low cost houses.

Since the Formal and the Informal Low cost housing sector is the least efficient residential energy user it is imperative that this sector must be addressed before the problem becomes unmanageable. A problem that does exist at this stage is to find a way to make the energy efficiency measures more affordable. This aspect must be addressed in the next chapter.

From the simulations, it was clear that the success of these energy efficiency measures is dependent on the occupant behavioral patterns. It is clear that by switching a heater off once people go to bed, when the indoor temperature is above 20 °C, instead of leaving it on regardless of the temperature, up to four times less energy could be used. This implies that *education* coupled with the installation of new energy efficient products is necessary and vital.

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Chapter 3

RDSM Option: Low-Cost Ceilng - A Socio Economic Study

ABSTRACT

It is clear from the previous chapter that one of the best ways to implement an RDSM strategy in South Africa is to fit the low-cost dwellings with ceilings and insulation. Before this can be done it is crucial to assess the needs of the people living in these dwellings and to establish how they would react toward such a low-cost ceiling being installed in their homes.

To accurately gauge the market's opinion a Socio Economic study had to be undertaken. The reaction of the market was evaluated by means of the following criteria: Acceptance of the low cost ceiling, access to the low cost ceiling and affordability of the ceiling. The market's awareness of the benefits of a ceiling was also tested.

The best way to obtain reliable opinions on these aspects was to conduct a market survey. TEMM International conducted such a market survey at a site where the people could view the installed low cost ceiling in a typical low cost house. The questionnaires that were used were compiled with the assistance of CEMCO (Center for human advancement in psychosocial context.).

With the results of the survey in mind, some useful deductions can be made regarding the implementation of the ceiling in low cost houses. It was clear that the community would accept the ceiling into their homes without much reservation. It was clear that the price per square meter aimed for in the original specifications was very realistic and that the community seems to be able to afford the ceiling. The issue that needs further attention is the community's access to the ceiling.

It is clear that the community will find it difficult to transport the materials needed to install the ceiling since very few of them have access to privately owned vehicle. The conclusion reached is that the low cost ceiling's success will depend on whether or not a major sponsor like an insulation manufacturer can become involved with the supply and distribution of the ceiling material.

1. Background

1.1. Introduction

An estimated 20% of South Africa's population is currently housed in low cost dwellings (1). Studies have shown that these dwellings are very energy inefficient and that the inhabitants can spend up to 20% of their disposable income on winter heating (2).

Another important issue is that the government plans to build 3 million new affordable houses over the next 10 years, in order to meet the growing demand for houses in South Africa (3). If these houses are based on the existing designs currently seen in many low-income communities, they too will be inefficient.

Previous studies have evaluated different measures that can be applied to existing or new low cost housing to make them more energy efficient. The results summarised by Weggelaar (4) substantiates the findings from the previous chapter and can be seen in Figure 1. From this it is clear that fitting a ceiling in a low cost house has the greatest impact on energy efficiency in that house.

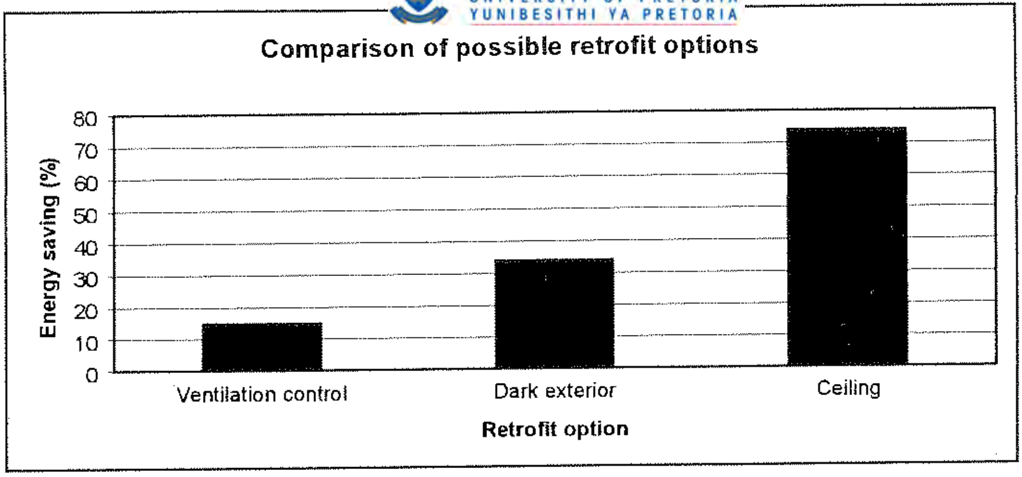

Figure 1 : Comparison of possible retrofit options

1.2. Product description

For the low cost ceiling to become viable, it had to measure up to certain criteria. Firstly it had to be affordable, secondly the method of installation had to be easy, thirdly the installed ceiling had to improve the indoor aesthetics and lastly the ceiling had to be durable. Weggelaar considered various designs and material combinations before he finally decided on the following product (4).

It was decided to use a 'roll' of material such a polyminium as the ceiling material. This material was chosen because of its stiffness (Does not stretch much), tear resistance and appearance (has a white base). The benefit of a material that can be rolled up is that it improves the ease of transportation and reduces the storage difficulties.

The method of fixing the polyminium to the wall is shown in Figure 2. The conduit pipe is inserted between the wooden block and the ceiling material to tighten it. This method of installing a ceiling was chosen due to its simplicity and has proven to be extremely effective. This concept has been patented(). The total cost of an installed ceiling was estimated at R10.50 per square meter().

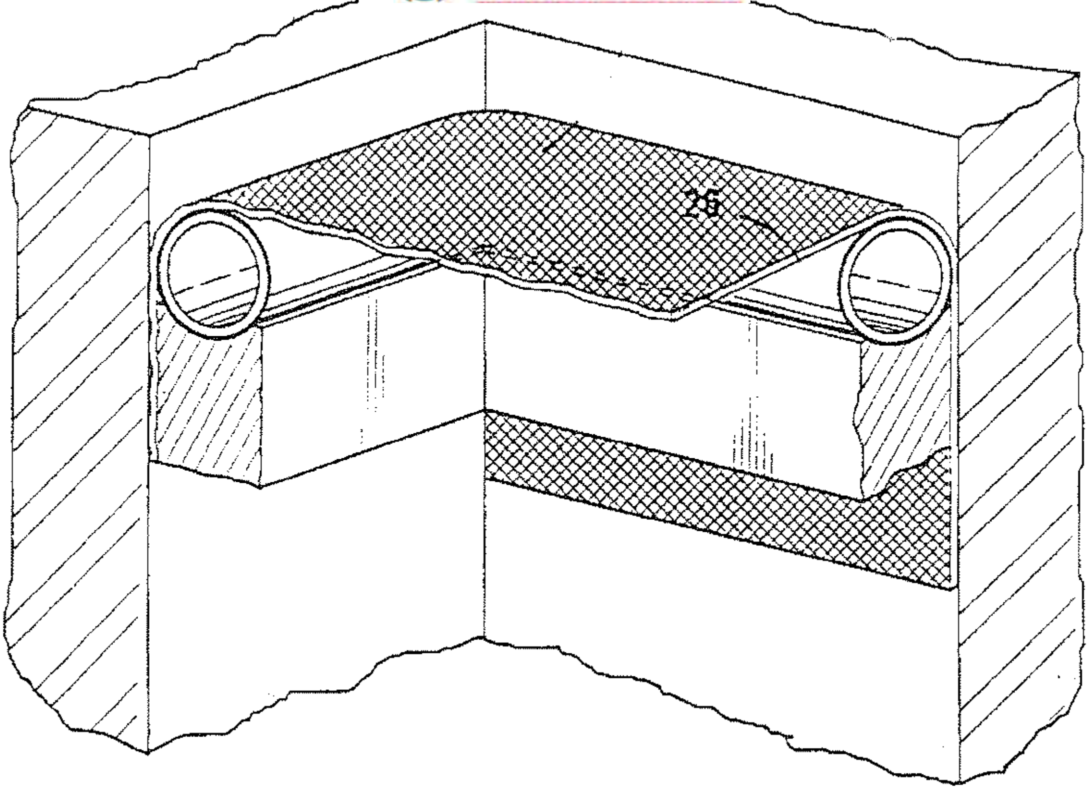

Figure 2 : Basic concept of low cost ceiling

A further improvement on this design was the addition of a layer of insulation on top of the ceiling material as seen in Figure 3. This will obviously improve the thermal performance of the ceiling, but the exact costing when done on large scale must still be done. It is expected to keep the total costs to under R20 per square meter, but this will be dependent in the insulation manufacturer, Owens Corning.

Figure 3 : Insulation is improvement on design

2. Socio Economic Study

2.1. Introduction

An important aspect of this study was to see how the market (low-income community) would react to the low cost ceiling concept. The designers of the ceiling and all the sponsors were satisfied with the initial concept and were confident that the rural community would accept this ceiling. This however had to be proven.

The reaction of the market was evaluated by means of the following criteria: Acceptance of the low cost ceiling, access to the low cost ceiling and affordability of the ceiling. The market's awareness of the benefits of a ceiling was also tested.

The best way to obtain reliable opinions on these aspects was to conduct a market survey. TEMM International conducted such a market survey at a site on the University of Pretoria's grounds. The people could view the installed low cost ceiling in a typical low cost house while they completed the questionnaires.

The questionnaires that were used were compiled with the assistance of CEMCO (Center for human advancement in psychosocial context.). These questionnaires targeted the acceptance, access, affordability and awareness of the low cost ceiling. The questionnaires are included in Appendix A.

2.2. Methodology of the market survey

It is important to obtain an accurate view of what the needs of the target market is and what the opinion is on the proposed strategy. It would be a useless exercise to develop a strategy that people aren't going to implement or a strategy that the market are not satisfied with. The planned strategy is the whole process of getting the ceiling installed in houses.

As mentioned above, a good w al opinion is to conduct a market survey. The questionnair ssistance of CEMCO, was used in the resulting market survey and updated for the second survey where necessary. Both questionnaires are included in Appendix A.

The focus of the market survey was on determining what the opinion of the community was regarding the low cost ceiling. The questionnaire deals with the community's acceptance, access and awareness of the proposed ceiling and the strategy to introduce it in the community. Further, it determined what the affordability of the strategy would be to the average citizen living in an underprivileged community.

The market survey was conducted at a site where the low cost ceiling was installed in a typical low cost house, similar to the one seen in Figure 4. This was done to exhibit the low cost ceiling and to get the people's first impressions of the product. Only half of the roof area was covered by the ceiling to accentuate the difference in aesthetics between a house with and without a ceiling.

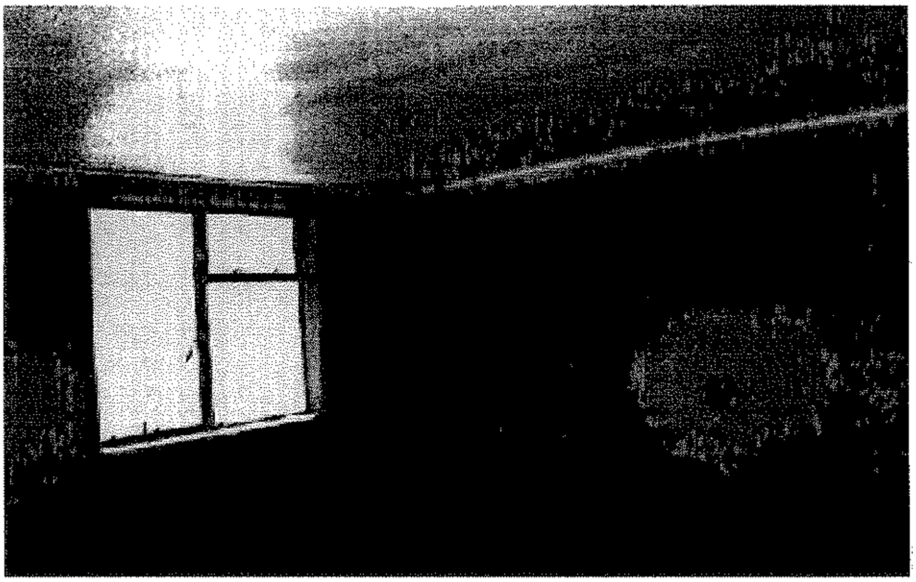

Figure 4 : Typical low cost ceiling installation in a formal low cost house

Two separate surveys were don e about three weeks apart. This gave TEMM Internationa e responses to the first questionnaire and to consult CEMCO on any changes that needed to be made to the questionnaire.

Changes were made to questions where there could have arisen some confusion i.e. where the people didn't understand some of the terminology. The second questionnaire was translated into Afrikaans to accommodate some of the people who felt more comfortable with this language. The Afrikaans questionnaire is also included in Appendix A.

2.3. Results obtained from the market survey

The two surveys were evaluated separately and the responses to each question were tabulated in Microsoft Excel. The various results will be discussed in the following sections. A complete printout of the results is included in Appendix B.

3. Access of home owners ng

3.1. Introduction

It must be determined how the strategy will be made accessible to previously disadvantaged people. If it is too difficult to access, people might not consider the strategy viable.

3.2. Results from market survey

The market survey was conducted as stated previously (Section 2) and the following questions were asked to form an idea of how accessible the people from the rural communities are. These questions specifically targeted their means of transport and the distances they have to travel to obtain material from a central distribution point in their respective communities.

- Where do you currently live? (Township.)
- How far do you live from your nearest business center (hardware store)?
- What type of transport do you use to do shopping with?
- Do you have your own car?

It was found that on average the people lived more than 30 kilometers from a suitable dispensing point (Average of survey 1 and survey 2). The modes of transport also vary greatly as can be seen by the following two charts. It is clear to see that for the average person from this community it would be difficult to transport large quantities of material since very few have access to a private vehicle.

If a do-it-yourself package is developed and marketed, it is important to consider the transportation limitations of the average citizen of an underprivileged community. The low cost ceiling however holds a major advantage over a conventional ceiling in that it can be rolled up and be packa nat than the gypsum board type ceiling.

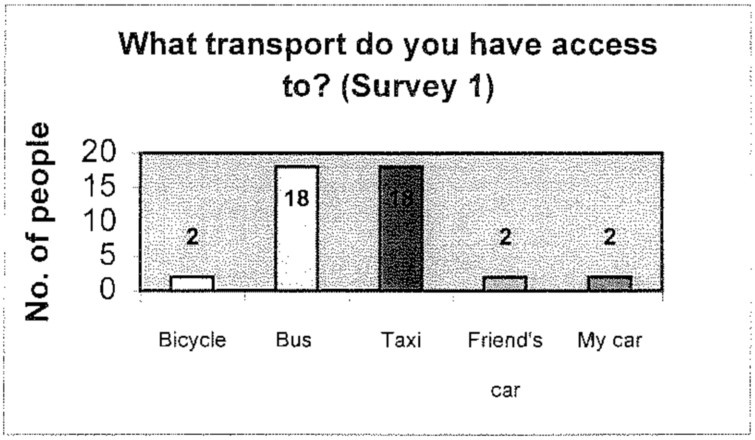

Figure 5 : Transportation: Market Survey 1

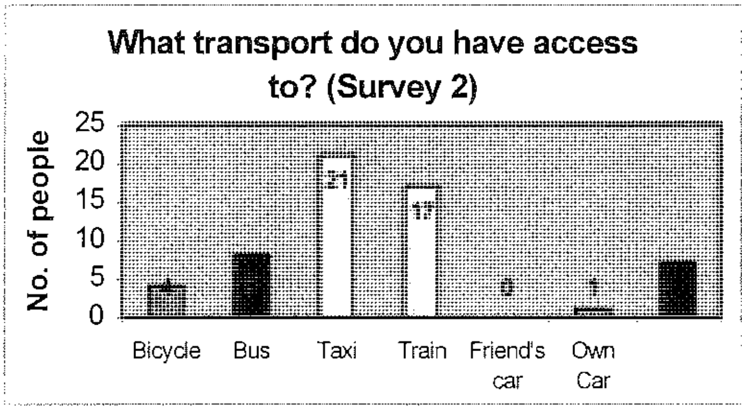

Figure 6 : Transportation: Market Survey 2

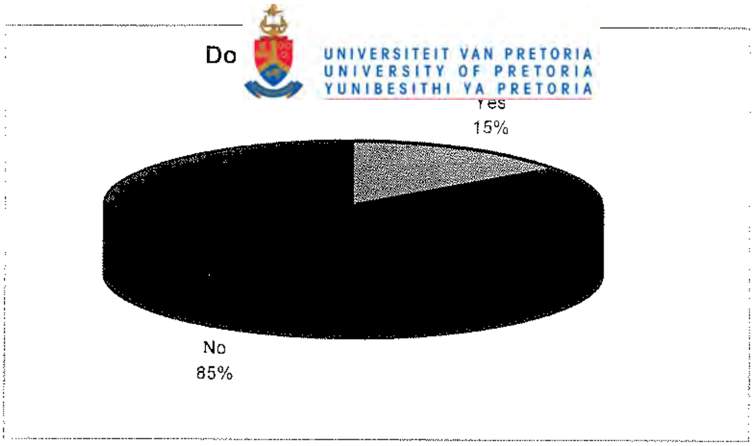

Figure 7 : Transportation: Market Survey 2

3.3. Other options available

- Government involvement

If the strategy can be supported by a large sponsor such as the government, it will become a lot easier to make the strategy more accessible to the disadvantaged communities.

The RDP program is already accessing the appropriate communities. If this program can be used as a launching pad to include the ceiling into all the newly built houses, it would take the responsibility of obtaining the ceiling out of the hands of the community.

Further, a distribution center could be set up in these communities to supply the material to the houses that do not have ceilings (Retrofit option). The market survey indicated that a large percentage of existing houses don't have ceilings.

- Business involvement

TEMM International is endeavoring to make the accessibility of the ceiling much easier to the underprivileged communities. The author had contact with Owens

Corning and have discusse ssibility with one of their consultants. They have show ved in distributing their own material based on the low cost ceiling installation method and thus improving the accessibility of the strategy.

Their involvement would be an ideal scenario, because a large insulation manufacturer like Owens Corning will be able to guarantee the constant supply of material and as a bonus they already have and extensive distribution network throughout the country. It is easy to understand why involvement of an established company is necessary to implement the strategy quickly.

3.4. Recommendations regarding the access to the strategy

It is clear to see from the Market Survey that people from the rural will find it difficult to transport large quantities of material. Thus, to achieve the desired level of accessibility one needs to have an established distribution network in place. This can then cater for people in the remotest of areas without too much effort. By taking the ceiling to them, you are making accessibility easy for the community.

This implies the cooperation of a large and influential sponsor. An ideal situation will be to have the sanction of the government and the investment potential of a company that can benefit from this venture like Eskom or Owens Corning (Insulation Manufacturer).

4. Acceptance of low cost

4.1. Introduction

For the strategy to succeed the home-owners must be convinced that whatever proposal is made will be worth their while. The community must be satisfied that for instance the low cost ceiling will contribute to the improvement of their living standards. It had to be determined whether or not the market will accept the low cost ceiling.

4.2. Results from the market survey

The following questions were asked in the market survey to ascertain the public opinion of the low cost ceiling. The answers to the questions are shown in graph form just below the questions. Only selected questions are shown below. The rest of the questions can be found in Appendix B.

- Do you like the appearance of the ceiling you have just seen?
- What did you like most about the ceiling?
- Does the ceiling make your house look better on the inside?
- Does the ceiling increase the indoor brightness?
- Do you think this product will last for a long time?
- Would you want to change the ceiling's appearance the installation method?

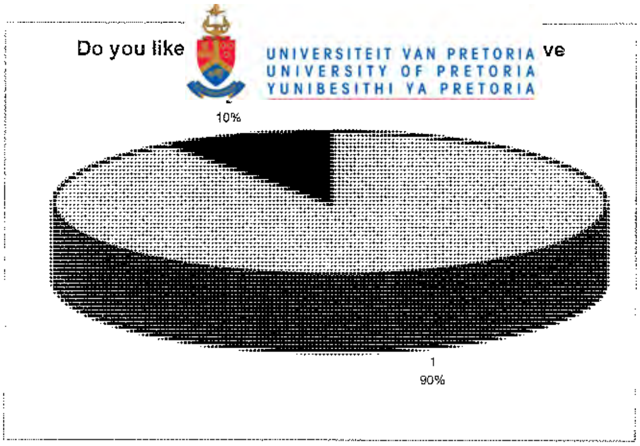

Figure 8 : Appearance: Market Survey 1

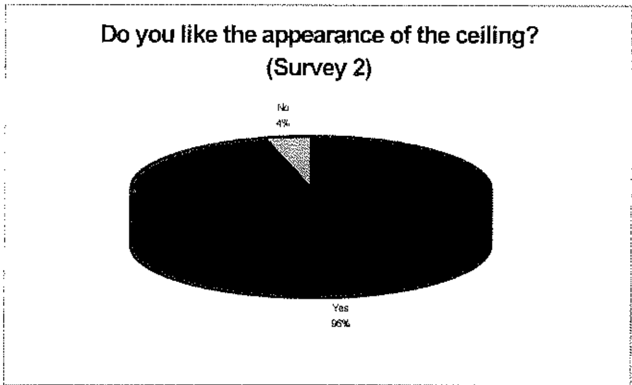

Figure 9 : Appearance: Market Survey 2

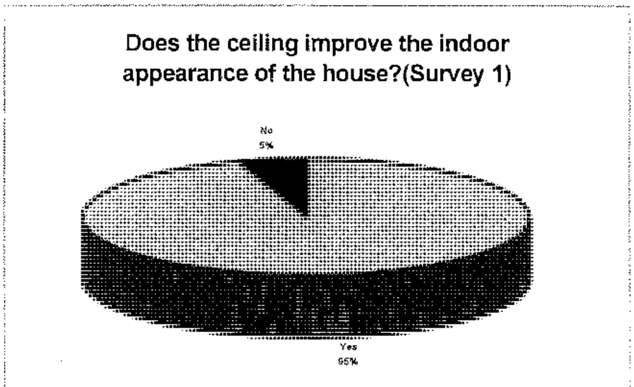

Figure 10 : House Appearance: Market Survey 1

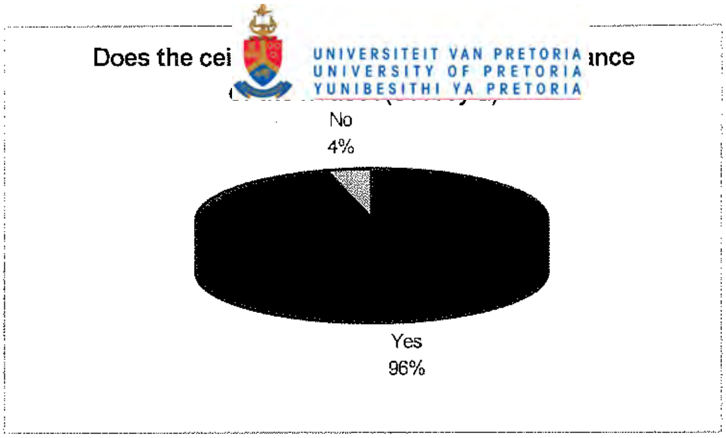

Figure 11 : House Appearance: Market Survey 2

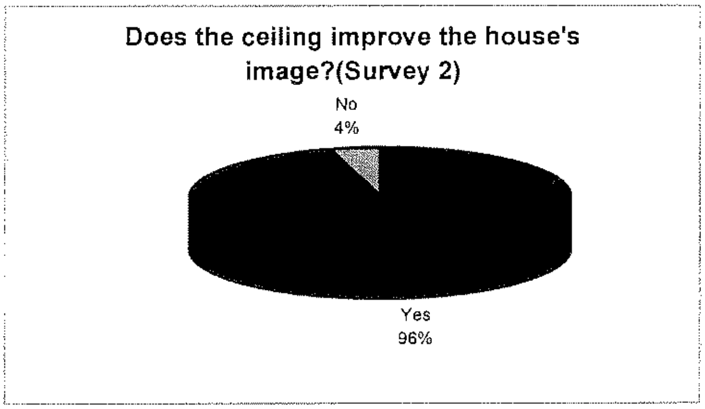

Figure 12 : House Image: Market Survey 2

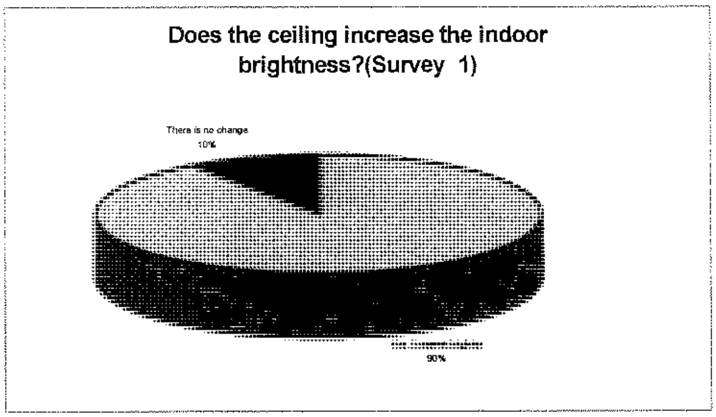

Figure 13 : Indoor Brightness: Market Survey 2

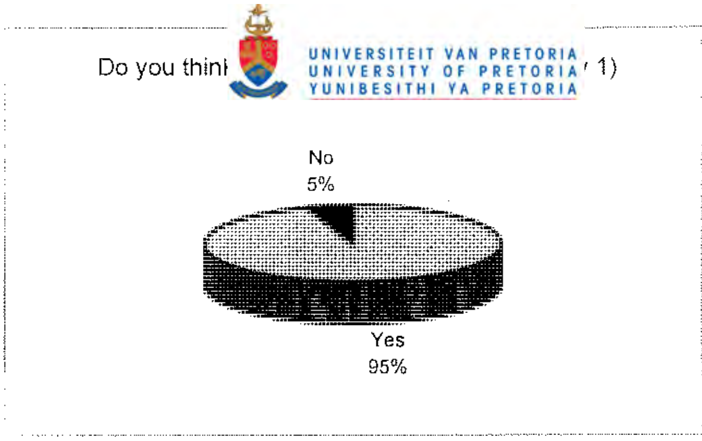

Figure 14 : Durability: Market Survey 1

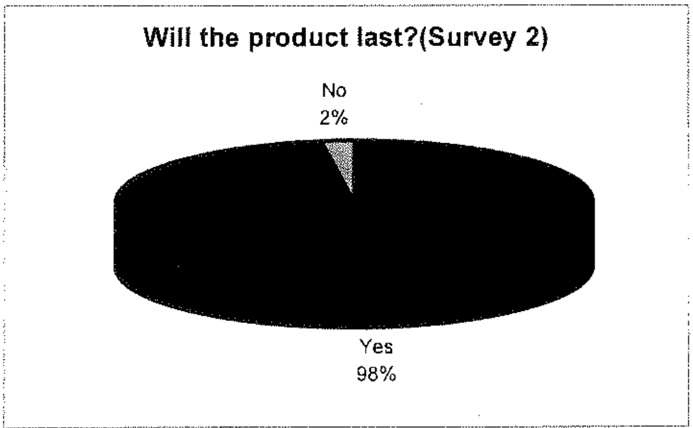

Figure 15 : Durability: Market Survey 2

4.3. Impact on the indoor lighting requirements

The scientific evidence will not convince the community to accept a certain proposal or strategy, but it could confirm the general feeling regarding indoor brightness. The reason for a brighter interior is due to the reflection from the shiny white ceiling. The light in the room is also a little more evenly spread with the result that the whole area appears brighter and is therefore more aesthetically pleasing.

4.4. Impact on comfort inside a

Various studies have been done to determine the effect of a ceiling and insulation on the indoor comfort and temperature of buildings. Simulations using NewQuick confirm that the indoor situation does improve. The energy savings due to the incorporation of a low cost ceiling has been evaluated by TEMM International and an article was published with these results confirming the savings potential of installing ceilings in formal low cost houses (Mathews, E.H. and van Wyk, S.L., 1996).

4.5. Impact on infiltration

One of the design specifications stated that the issue of infiltration has to be addressed. It was found that with the ceiling properly installed the infiltration from the roof into the living area was eliminated (4).

An added benefit of this aspect is the significant reduction in dust being blown into the living areas, especially during windy and dry days. This implies an improvement in the living quality of the resident.

4.6. Impact on waterproofing

The ceiling material in itself is waterproof and can not be damaged by small amounts of water dripping onto the ceiling. It is however recommended that the leaks in the roof must be fixed. The water has to go somewhere and if too much water penetrated the roof, the water will collect on the ceiling, causing it to put too much weight on the wall mountings.

4.7. Acceptance of strategy by industry

It is clear from the market survey that the community would welcome and accept the low cost ceiling into their homes. The question now arises of whether or not the stakeholders would accept the ceiling concept. Discussions with various parties including Owens Corning were h ost ceiling. These people were all exposed to the low co m showed interest in the potential of the product (Appendix C).

Two developers were invited to view the low cost ceiling, but unfortunately only one could make the trip before the completion of this report. The feedback received from Deon van den Berg (Private developer & Quantity Surveyor) can be summarised as follows:

- Mr. Van den Berg found the aesthetics to be acceptable
- The ceiling in his opinion would be an asset to a low income house
- The price of R 15.00 per square meter is reasonable
- He thought the installation procedure would be easy enough for do-it yourself purposes
- As a developer he would like to see this ceiling included in all newly built low cost houses

From this reaction it seems that the industry will also support the implementation of the low cost ceiling in formal low cost houses.

4.8. Recommendations regarding acceptance

From the market survey, it is clear that the general opinion of the community is that the low cost ceiling will have a significant impact on their living standards. This belief is backed up by numerous studies and simulations done by TEMM international.

It is recommended that this aspect of the strategy should be concentrated on when a marketing plan is devised. The improvement in the quality of life is something every person will identify with. The more aspects you can quote that this strategy will improve on the better.

5. Affordability of low cos

5.1. Introduction

Underprivileged areas are, by nature, low income areas and it is therefore of the utmost importance that the strategy's cost must be kept to a bare minimum. If the costs involved prove to be high, even after limiting the expense, programs must be in place to accommodate people with a low income.

5.2. Results from market survey

Before the decision can be made on whether or not the costs involved with the strategy are too high it must be determined what the community can afford. The following questions in the market survey were asked specifically with this in mind.

- Would you buy this ceiling?
- How much would you be prepared to pay for this ceiling material and to have it installed in a room the same size as this one?
- If the instructions and material were freely available would you pay to have the ceiling installed or would you install it yourself?
- If you can't afford to pay cash to buy this ceiling, how much would you be able to pay per month?

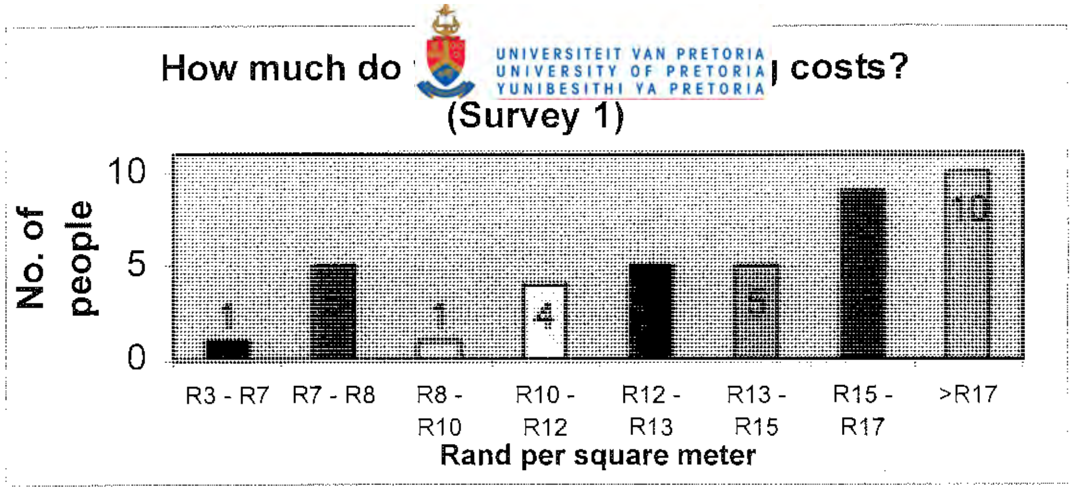

Figure 16 : Perceived Cost: Market Survey 1

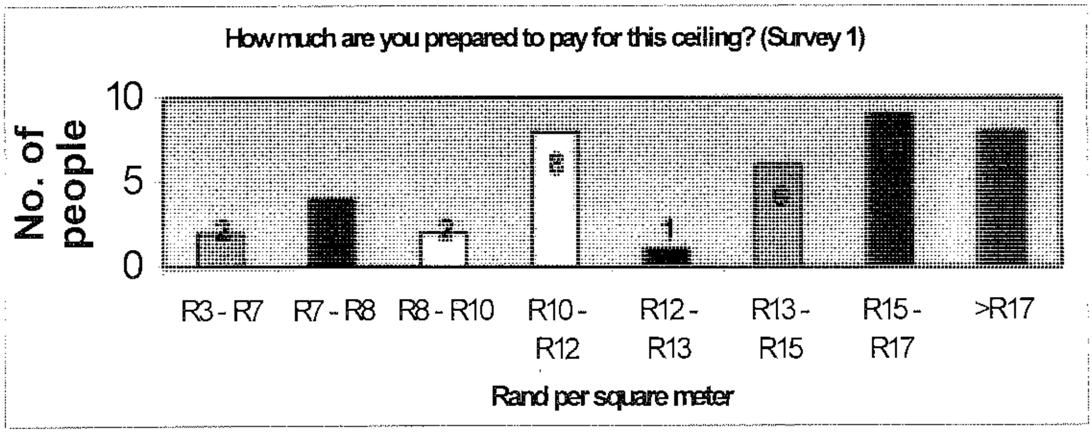

Figure 17 : Willingness to pay: Market Survey 1

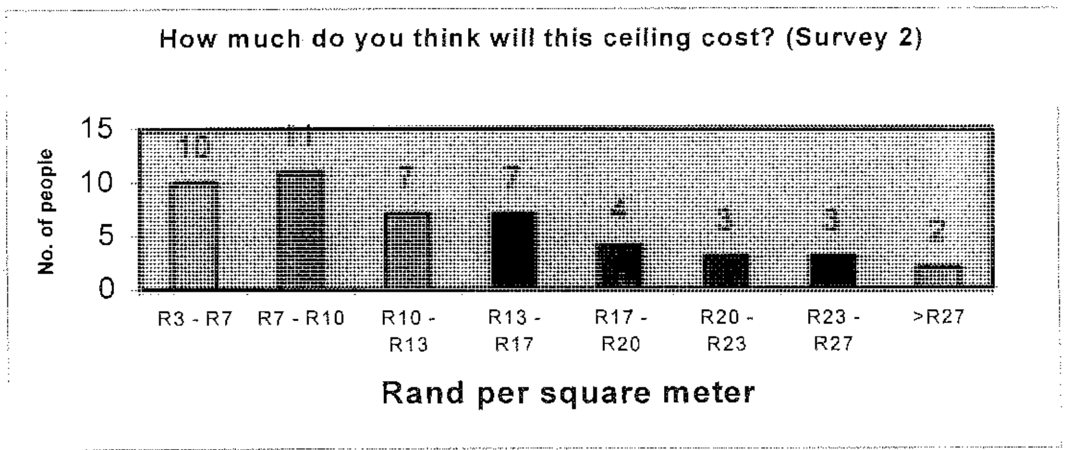

Figure 18 : Perceived Cost: Market Survey 2

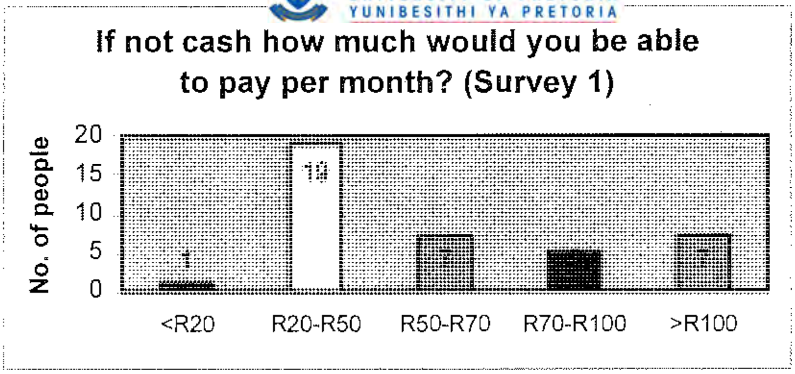

Figure 19 : Monthly instalments: Market Survey 1

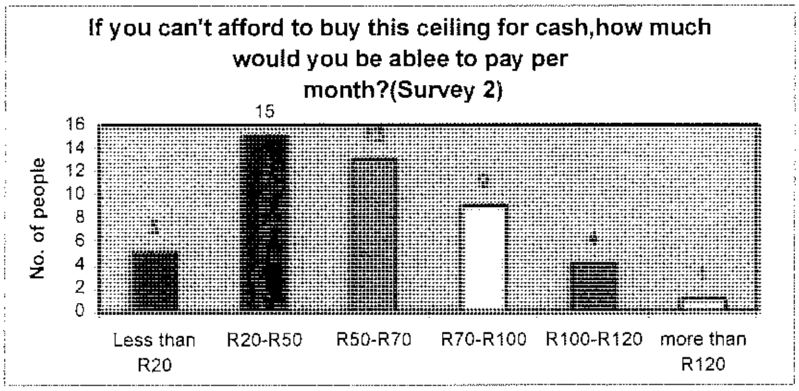

Figure 20 : Monthly instalments: Market Survey 2

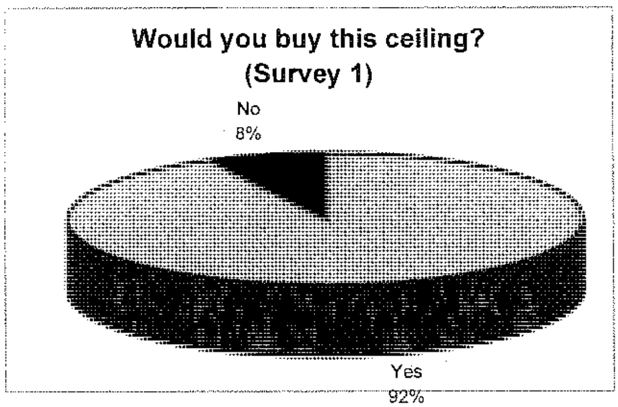

Figure 21 : Willingness to purchase ceiling: Market Survey 1

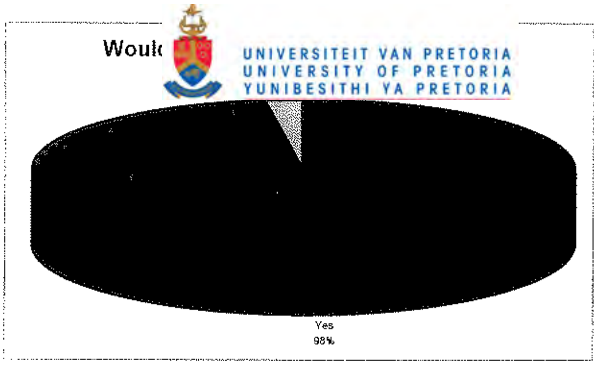

Figure 22 : Willingness to purchase ceiling: Market Survey 2

From the surveys, it is clear that most people will want to buy the ceiling. One aspect that will influence the decision of buying the ceiling is obviously the price of the ceiling. The market survey asked how much people were willing to pay for a ceiling installed in a 15 m^2 house (Survey house).

The answers were evaluated and adapted to show the amount people were willing to pay per square meter. It is clear that most people are willing to pay more that R10.00 per square meter. This is a very realistic and attainable value. The low cost ceiling will cost around R15.00 per square meter if no further sponsors are obtained.

Many of the people from the community will however not be able to afford the cost of a total installation in one payment. It was therefore asked how much they could afford per month and these values should be considered when the product is marketed.

Half of the people in the survey indicated that a monthly payment of more than R20.00 but less than R50.00 would be acceptable. The other half indicated that a payment of more than R50.00 was attainable. In some cases, they were willing to even pay more than R100.00 per month.

- Government involvement

The government can play a huge role in the affordability of this strategy. By supplying subsidies to approved families or low interest loans or even sponsoring the process of equipping newly built houses with the low cost ceiling the disadvantaged community will be benefited greatly. If the minimum specification of housing projects could be raised to include a low cost ceiling this will force developers to include the ceiling cost in the total price making, funding for the ceiling easier.

- Eskom

Eskom will benefit from the implementation of the strategy due to less energy being used by new homeowners. It would therefore be in their interest to motivate the community to apply the strategy by sponsoring or subsidising every household whom implements the energy efficient measures.

- Business

TEMM International has had discussions with the suppliers (Appendix C) of the ceiling material and they are all willing to reduce their normal retail prices quite significantly. This however, will just be possible if the volumes of low cost ceilings that will be installed are large. The amount of ceilings to be installed will depend greatly on the success of the government's and Eskom's involvement in the strategy sponsorship.

If an insulation manufacturer can become involved in the implementation of the strategy the price of the material could be cut even further since the company would know that they would be selling huge volumes of material. Using the existing distribution network o minate the initial cost to set up such a network, thus keep ole low level.

- Foreign aid

Various aid organisations across the world have funds available to assist third world countries in improving health and living conditions of underprivileged people. Organizations such as DANSET and Global Environmental Fund (GEF) and even the Worldbank are organisations that come to mind.

The participation of such organisations are heavily dependent on the attitude of the government and the national electric utility (Eskom). Thus, the cooperation of these people must be obtained first.

6. Awareness of ceiling b

6.1. Introduction

Even the most useful strategy might never be implemented if people aren't made aware of the strategy and the implications thereof on their monetary situation and their quality of life.

6.2. Results from market survey

Since this strategy still has to be implemented, there will obviously be no knowledge of the strategy. The low cost ceiling is also a newly developed product and thus no one will have any knowledge of the benefits of this product. What the market survey attempted to learn was what the perception was over ceilings in general.

Only one question was asked and the people had to give their own answer. The question was: Why do you think it is important to have a ceiling in your house? The responses varied a lot, but some of the most common answers were:

- It keeps the house cool in summer and warm in winter.
- It looks good
- It keeps dust out
- Reduces noise through roof
- Looks brighter inside etc.
- (Rest of the answers are given in Appendix B)

From these answers, we can deduce that significant proportions of the people do understand what the advantages are of having a ceiling in your home. It can however be deduced that a lot of them are not aware of the real thermodynamic reasons, but they like the ceiling anyway because of the esthetical qualities.

Both of these aspects (aesthet will appeal to the market. Therefore, both of these aspects must be used in a marketing and awareness campaign if the new strategy is introduced. The thermodynamic benefits (savings in energy) will appeal to some, but the marketing campaign should not be built around this aspect. The reason for this is that the actual improvement for a low cost house does not seem to be large, but for ESKOM, the collective result is quite significant.

6.3. Further actions that must be taken

The author believes the cooperation of a big sponsor is necessary to increase the awareness of the general population regarding the strategy and the low cost ceiling. It would be ideal if whole communities could be persuaded regarding the advantages of the low cost ceiling.

7. Implementation in low cost housing

7.1. Introduction

The development of a low cost ceiling can not stop here. It is necessary to introduce the ceiling into homes where people live. The laboratory results and the feedback from the Socio Economic study were satisfactory, but a whole new set of problems will arise as soon as the ceiling installation starts.

Ivory Park in Midrand has been identified as a suitable location for the first installations. Starting in Ivory Park has various benefits. The first is that Ivory Park is close to all the role players in the development of the low cost ceiling i.e. ESKOM situated in Midrand, University of Pretoria in Pretoria and Owens Corning in Springs.

A further benefit in Midrand is that there exists an organisation that are specifically looking at strategies and products to improve the living standards of the residents through environmentally friendly means. This organisation, *Midrand EcoCity*, has taken a keen interest in the low-cost ceiling project.

7.2. Suggested Action plan for further work

A suggested action plan is now discussed. Various actions with their effects are mentioned.

	Future Actions	**Effect**
1	Decide on the exact material needs of the strategy	Enable sponsor to budget and give suppliers time to ready all the material for use.
2	Reach agreement between insulation manufacturer, Eskom and the government on financial commitments	Roles are identified and responsibilities are assigned. (Influences affordability)
3	Identify the houses and areas that has to be	Enables contractor to focus, and determines

	targeted with initial installation (C from Eskom)	the responsible parties must e and funds. (Access)
4	Contact an independent contractor to do actual installations	The use of their technical expertise and equipment is beneficial.
5	Compile the marketing pamphlet using the marketing intelligence obtained through this study	Start of good public relations, which is important for the strategy to succeed. (Awareness and Acceptance)
6	Install ceiling in "show houses" and hand out pamphlets in the relevant community	Will give community peace of mind regarding strategy. (Improves Awareness)
7	Ensure that the material is available	Important, if not done the project might be delayed when the final go-ahead is given
8	Proceed with Large scale installation	This is the end goal of the project. If this part is successful then this study was a success and the authorities can then proceed with confidence to implement the strategy elsewhere.
9	Try to get media coverage for the "pioneering" development in that area	Increase awareness in other parts of country

This is a suggested strategy and there might be some differences in approach depending on the developer and contractor used. Some of the steps of the strategy have been completed and they are briefly discussed below.

The author want to stress the importance of the involvement of an insulation manufacturer like Owens Corning or a big sponsor like an international aid organisation. The author believes that this project can only become a quick success if this can be achieved. If not, the process of introduction into the market will be a tedious one.

7.3. Identification of suitable candidates

The first ten candidates were identified with the assistance of Mr. Russell Baloi (Midrand EcoCity). The households were chosen with three things in mind:

1. The houses had to be spread [illegible] to maximise the exposure of the ceiling
2. The home owners had to be willing to let their homes act as "show" houses after installation
3. The houses had to be typical formal low cost dwellings similar to the ones subsidised by the government

7.4. First installations

At the time this study was concluded only one household had been fitted with the new low cost ceiling. As expected some initial teething problems were experienced, but all of them have been overcome. The next step is to appoint a professional contractor who will take responsibility for the next nine installations after which the design will be reviewed and improved if necessary.

8. Conclusion

From the above discussion, we can see that the idea of a low cost ceiling is quite popular with the underprivileged community. It is however important to approach the whole implementation and introduction of the ceiling into the market with caution. As soon as people become negative for any reason what so ever, it will be extremely difficult to sway the public perception to accept the strategy.

It is clear that people from the rural community like the proposed low cost ceiling and most of them would consider buying the ceiling if the price is below R15 per square meter. A big problem however, is to give them access to the ceiling. This problem could be overcome if an industrial partner with an established distribution network become involved.

The level of education of the community regarding the benefits of a ceiling must be evaluated. If the people know more, they might be more easily persuaded to purchase a ceiling. It is however important to find more appealing information to get people involved.

One subject that has to be investigated is the increase in comfort when ceilings and insulation is installed. It was found that the installation of insulation is the second most effective action that could be taken in South Africa to save energy. But often the monetary implications are not enough to convince people to purchase a product. Comfort might not save money, but often people are prepared to pay to improve their levels of comfort. This aspect will be investigated in more detail in the following chapter.

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Chapter 4

RDSM Option: Insulation - Effect on comfort

In this chapter, the effect of Aerolite on indoor comfort in middle-income residential houses was investigated. The chief aim was to provide Owens Corning with scientifically proven information on these aspects. The information is needed to market ceiling insulation with greater confidence to the broader public.

The potential benefits for the home-owner are a reduction in electricity bills in the winter months and improved comfort in the summer months. Owens Corning will benefit financially if they can succeed in marketing these potential advantages. It was found that if only 10% of the middle-income market was reached, more than R400-million could be raised from retail sales alone.

In previous projects conducted by TEMM International, the potential monetary savings of installing ceiling insulation were determined. It was however, found that monetary savings alone do not justify the initial capital outlay. A follow-up project on the comfort benefits of Aerolite was therefore initiated.

Six typical middle-income houses in Pretoria were used as case studies. Temperature measurements were conducted in each house before and after Aerolite was installed. The best case showed an average drop of 4.5 °C in the maximum indoor air temperature.

However, this will not be the same for the whole country. To perform measurements in all regions in South Africa will unfortunately be too costly and time consuming. Simulations were therefore conducted to predict the effect of Aerolite on houses in the other South African regions. The thermal analysis program QUICK II has been proven ideal for this purpose.

Eight simulation models were constructed and verified using measured indoor temperatures and climatic data. The best simulation result obtained was a drop of 4.7°C

in the Palaborwa region. From t[illegible] is found that the drop in indoor temperature would be sufficient to provide a comfortable indoor environment for more than 80% of the South African middle-income population

The most important selling point that was discovered and proven scientifically by TEMM International was: In general Aerolite will increase the percentage of people that are comfortable in their homes from 30% to 90% in most cases.

This means that three times more people will be comfortable after ceiling insulation is installed. Using this important discovery made by TEMM International, Owens Corning will have easy to understand, but scientifically proven material for a marketing campaign.

From an indoor comfort point of view, installing Aerolite seems to be worthwhile. However, although the monetary saving is relatively small, it should not be ignored. In marketing Aerolite, both the increased comfort in summer and the saving in winter should be combined. A pamphlet explaining this idea was designed and included in this report. Proven benefits of Aerolite will ensure a far more successful marketing campaign.

1. Introduction

1.1. Why is this chapter important?

The aim of this chapter was to determine the effect of *Aerolite* insulation on indoor comfort. Six middle-income houses in the Pretoria region were used as case studies. Temperature measurements were conducted in these houses before and after *Aerolite* was installed.

It is important to note that middle income houses were used in this part of the study. This was done because of the benefit such results would have for Owens Corning, but the results would be consistent for low-cost housing too. It was not possible to conduct such a study in low-cost dwellings because these dwellings aren't fitted with ceilings.

Simulations were done for four middle-income houses in Pretoria to predict the possible increase or decrease in comfort after *Aerolite* was installed. The results obtained from these simulations were compared to the measurements from the case study houses. This was done to confirm the accuracy of the *QUICK II* simulation program. Nation-wide simulations were then performed to obtain results in different regions in South Africa.

There are many advantages for the home owner in installing ceiling insulation. One of these is a reduced electricity bill in winter (1). Previous projects have shown that an average household can save up to R260-00 per year on electricity consumption if the ceiling is insulated (2). These savings are summarised in Figure 1 (3).

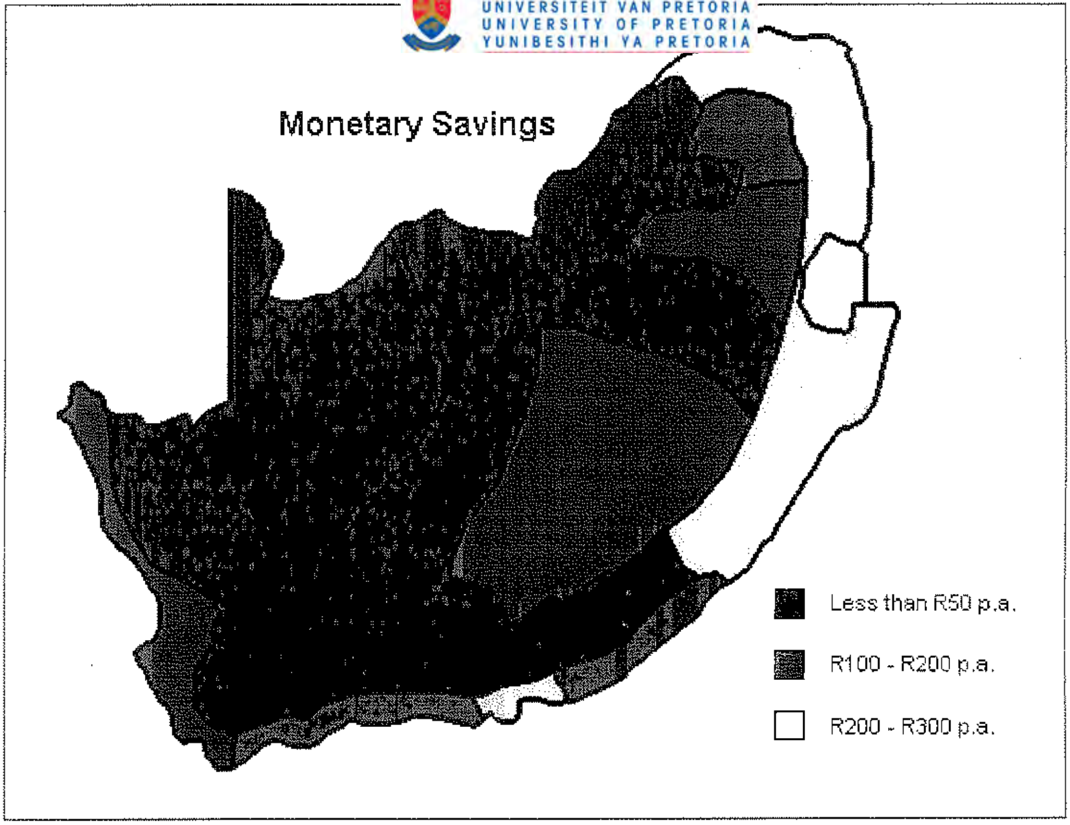


Figure 1: *Predicted monetary savings for* middle-income *households*

The values shown in Figure 1 are based on simulations done in a previous report done for *Owens Corning* (previously AFI) (2). The following assumptions are important to remember when these values are used:

- Only living areas were simulated (i.e. living room, lounge and kitchen). Heaters are not normally used in bedrooms. In the mornings, occupants dress quickly and move to the kitchen or living room.

- It is assumed that heaters are only used when the house is occupied.

- It is also accepted tl only be achieved in the evening. Heaters are likely to be used in the mornings but they are insufficient to ensure thermal comfort during the cold morning hours.

- During the week, heaters may be switched on between 5:00 and 7:00 in the morning and 17:00 until 22:00 in the evening.

- During weekends, heaters may be switched on from 7:00 until 10:00 in the morning and from 16:00 until 24:00 in the evening.

- It is assumed that most developed houses in South Africa have an open-plan design. The stove is taken to contribute 1,5 kW for one hour in the morning and 3 kW for one hour in the evening.

- The minimum number of heaters required to achieve thermal comfort is used at all times. This means that after ceiling insulation is installed, only the time of use will differ and not necessarily the number of heaters.

- There are four winter months per year, with an average of 22 week days and 8 weekend days per month.

- The household consists of two adults, two children and a domestic servant or two adults and three children.

- Oil fin heaters are used and assumed to be 50% convective and 50% radiative.

- While heaters are switched on, the occupants are warmly dressed, relaxed and seated.

- Ceiling insulation c[illegible] wool. It was found that 75mm and 100mm thickness contributed little to the thermal comfort already provided by the 50mm insulation.

According to a brochure published by ESKOM, the total number of middle to high-income houses in South Africa is approximately 3 500 000 (4). Studies have shown that only 22% of these houses have been insulated to date (2). If *Owens Corning* can capture 10% of this market an income of over R400-million could be generated from *Aerolite* sales[1].

This figure only takes into account of the middle to high-income markets. The installation of insulation in low cost dwellings would increase the demand for insulation by millions of square meters, which will result in even more profit for *Owens Corning* and a huge reduction in electricity demand from ESKOM.

To achieve these benefits, marketing information is essential. However, information on monetary savings alone does not seem to be sufficient to convince people to install insulation. This is because an initial capital outlay is involved which can be a problem for the average cash strapped home owner. Furthermore, a payback period of longer than four years can be expected for most cases (see Figure 2) (2).

[1] This was calculated assuming that the cost to insulate a typical middle income house is R1 500.

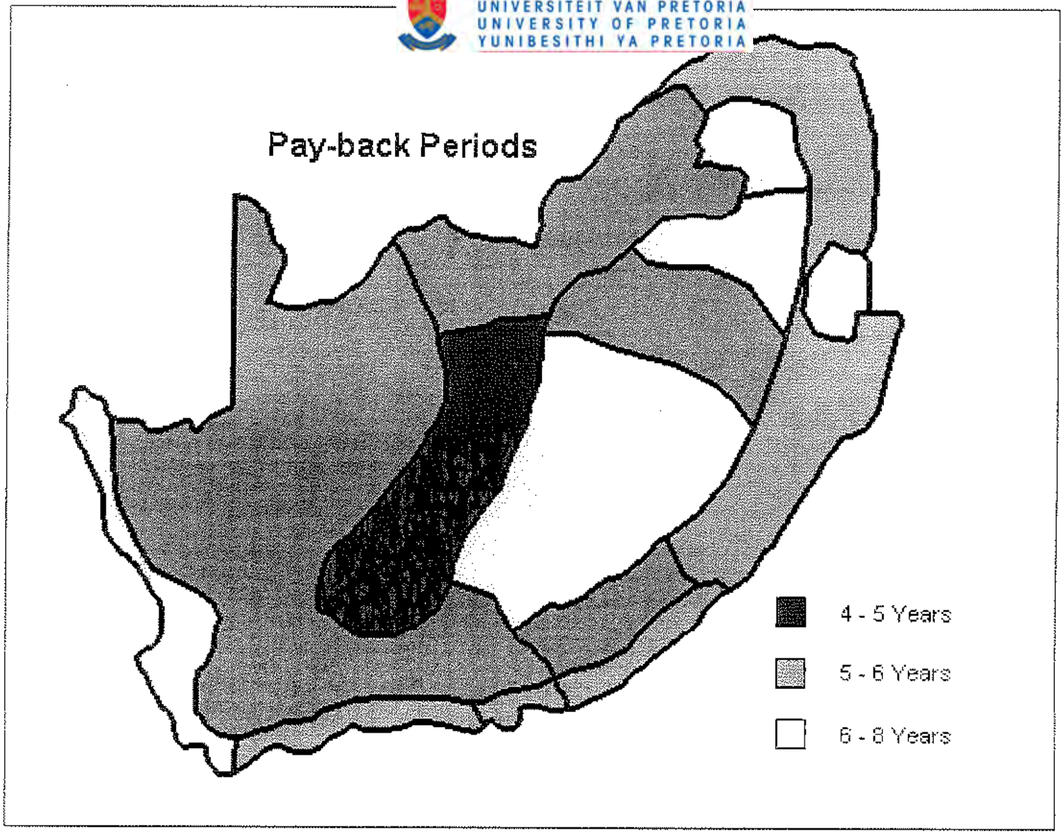


Figure 2: *Expected payback periods for* middle-income *households [2]*

Many of *Owens Corning*'s advertising campaigns have thus stated that *Aerolite* also significantly improves thermal indoor comfort in houses. Preliminary investigations have demonstrated that an insulated house is indeed "cooler" in summer and "warmer" in winter (5).

Because no detail case study quantifying these comfort benefits has been conducted before, this project was initiated. Six case studies were conducted using different houses in the Pretoria region that represented the average middle-income house.

MCI (Pty) Ltd recently launched an energy efficiency campaign for the Department of Minerals and Energy. Surveys done before the campaign as well as feedback received afterwa[...] people are eager to learn about methods to save energy while improving indoor comfort [1].

The people in especially the middle to high-income group, which is this project's target market, showed interest. The findings of this project together with the potential monetary savings would thus ensure that *Owens Corning*'s future marketing initiatives are successful.

1.2. A brief discussion on comfort

The chief objective of this project is to determine whether installing insulation will achieve acceptable levels of comfort. A study done by the project leader has discovered that an indoor temperature of 28.5 °C would be acceptable for 80% of the participants taking part in the survey [6].

This is a significant discovery and can help to enhance the value of this study. The survey consisted of 2 500 participants who were free to wear clothing of their choice. The results from this study are shown in Figure 4.

From these results, it is clear that if the indoor temperature can decrease to 28 °C, more than 80% of the people will feel comfortable. If the indoor temperature is 30.5 °C only 27% of the people who took part in the survey were of the opinion that their indoor comfort was acceptable.

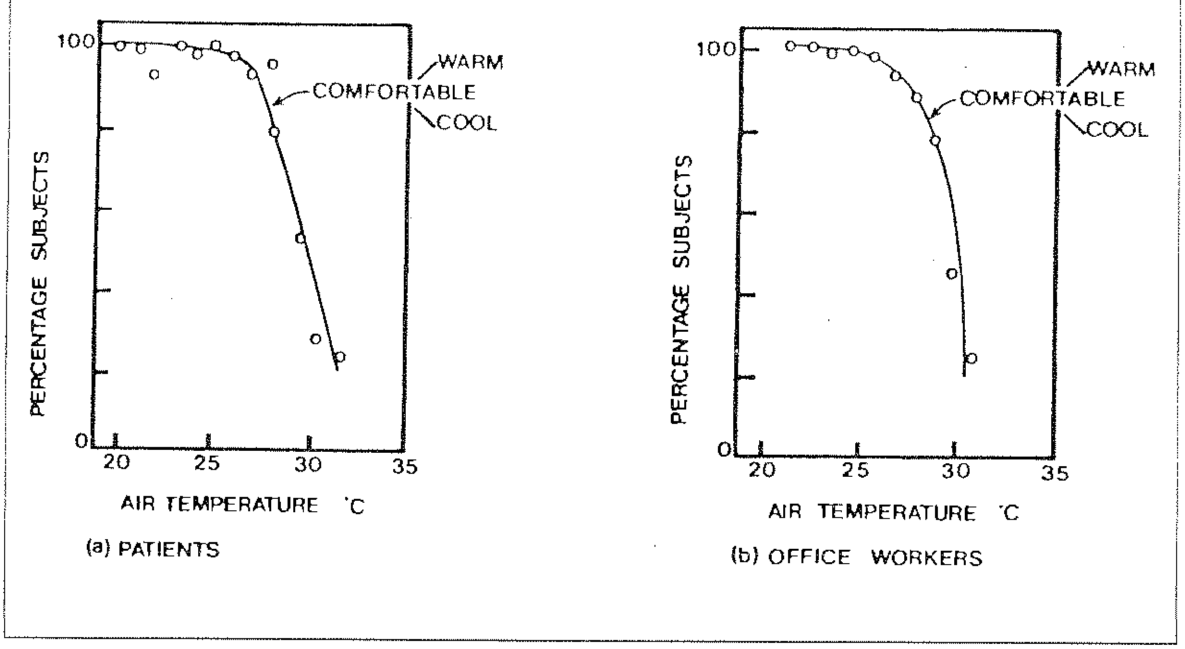


Figure 3: *Subjective reaction of humans to indoor air temperature*

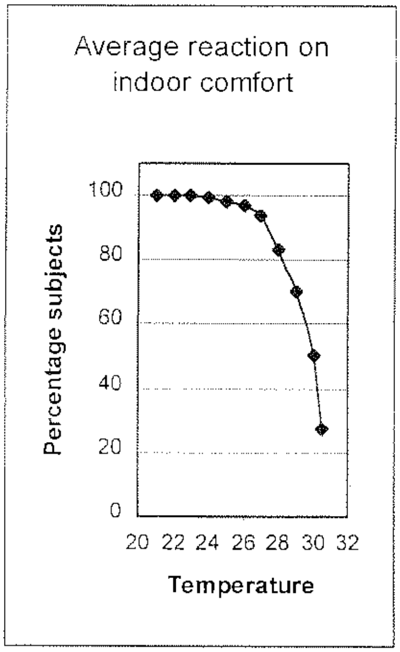


Figure 4: *Average reaction of humans to indoor air temperature*

The results obtained in this st inst the results from this survey. This would give *Owens Corning* a good idea of what part of the market is still open to a marketing campaign promoting increased indoor comfort. This will be discussed in section 3.2.

The importance of this comfort study must not be underestimated. People don't understand the consequence of a drop of 4°C in temperature. However, if Owens Corning can prove to the public that 60% more of them will be comfortable after installing Aerolite, then Owens Corning has a winner.

1.3. Literature survey

Literature surveys were done to investigate monetary savings due to the installation of ceiling insulation. It was found that the monetary savings in general are not enough to convince people to install ceiling insulation.

This prompted a search for information on the improvement in comfort caused by installing ceiling insulation. More than sixty sources were consulted to gain more information on the comfort improvements resulting from ceiling insulation (7-67). These references are given at the back on this report. However, no helpful information pertaining to comfort improvements could yet be found. This emphasises the importance of this study.

1.4. Overview of this chapter

In Section 2 the project methodology is discussed. The participants of the case studies are introduced and the reasons for choosing them are explained. The procedure followed to conduct the measurements and the equipment used in these measurements are discussed.

The processing of the collected data from the eight houses are stepped through in Section 3. This chapter aims to give the reader an overview of the work that has been done to reduce the masses of data to manageable information from which conclusions could be drawn. The results obtained from the data are also given and summarised here.

Section 4 deals with the simulations of increased comfort for the Pretoria region. Explanations of why simulations are needed as well as the results obtained from these simulations are given. The verification of *QUICK II* is also discussed to ensure the findings are scientifically proven..

The improvement in comfort due to the installation of *Aerolite* in all the South African regions is discussed in Section 5. The strategy for simulating comfort in these regions in South Africa is stated and the results obtained from these simulations are summarised.

Section 6 summarises the project and recommendations regarding the strategy to be followed in a marketing campaign are made. The monetary advantages for the winter and the comfort improvements in the summer are combined to give *Owens Corning* scientifically proven information to use in such a campaign.

2. Analysis of this project

2.1. Participants

2.1.1. Description of the houses used for the project

Eight households participated in this project. Six houses were insulated and the comfort situations before and after insulation were compared. Two houses were not insulated to provide a control. This would show if there were any correlation between the outdoor climate and the improvements in comfort shown in the six case study houses.

All the houses used in this project were chosen to fit the profile of an average middle-income household (See Section 5 for more detail on these criteria). In Table 1, the names of all the participants are given as well as the house number. This number will be referred to in this report when a certain house is discussed. The thickness of *Aerolite* installed in each household is also mentioned.

It was decided to insulate the houses with different thicknesses of *Aerolite* to see whether it would make any difference on the indoor comfort. Houses 1, 3 and 4 were specifically insulated with different *Aerolite* thicknesses because they were situated very near to one another (all three are in the same street) and their house designs are very similar.

Table 1 : *Participants of the* UNIVERSITEIT VAN PRETORIA UNIVERSITY OF PRETORIA YUNIBESITHI YA PRETORIA

House number	Participant	*Aerolite* thickness
1	R Brink	50 mm
2	A Kock	Control
3	M Krynaugh	75 mm
4	R Schoeman	100 mm
5	C B Piani	50 mm
6	M Kleingeld	100 mm
7	C S B Piani	Control
8	E van Loggenberg	50 mm

Houses 2 and 7 were not insulated since they would act as the control houses. The data recorded in these houses will be processed exactly as the data collected from the other houses. This will show if there was any effect on the indoor comfort situations due to slight differences in outdoor temperature. The full details of the participants can be found in Appendix F.

2.1.2. Negotiation and contracts

A negotiation period was entered into with the home owners with whom a contract was drawn up. In brief, the contract stated the following:

> The home owner will allow *TEMM International* to place measuring equipment in his home. They will further grant a representative from *TEMM International* access to their house to download the data from such equipment for a period of two years.

TEMM International pr[illegible]ng equipment would be small and would not be an inconvenience to the participant. Further, *TEMM International* undertook to arrange for *Aerolite* to be installed free of charge, to be paid by *Owens Corning*.

2.2. Temperature measurement

Owens Corning must have information on the quality and accuracy of the equipment used to conduct the measurements if they receive any queries regarding their marketing message or on this study.

2.2.1. Measurement equipment

The temperatures were measured using DATATAKER 5 loggers. The loggers were equipped with HUMITTER® 50Y integrated humidity and temperature transmitters. These devices were chosen for their excellent stability properties and their accuracy in the temperature range that was expected. The accuracy in the 30°C range is ± 0.6°C and the repeatability of the measurements is excellent.

Although these devices were expensive (R 5000 each), they were used because they are robust and accurate. Other measurement devises such as thermocouples would have taken too much time and effort to set up properly and recording the measurement data is always a problem because you must have a computer on-site, constantly monitoring the device.

The data recorded by the DATATAKER 5 loggers (DT5) were downloaded using a notebook computer. Specific software was used to read the data and reset the loggers. The recorded data could then be imported to a spreadsheet package

2.2.2. Measurement procedur

It was assumed that comfort is mostly desired in the living areas (i.e. living room, dining room and kitchen). The measurements were therefore conducted in these rooms only. The temperatures in these areas were representative of the general indoor comfort experienced by the occupants. The reason for this is that people spend most of their "awake" time in these areas.

The loggers were calibrated and tested to ensure accurate measurements. After calibration, one logger was placed on a shelf in the living area of each house so that the occupants would not disturb it in their day-to-day life. The loggers were set to record the indoor temperature every 900 seconds (15 minutes). The data recorded by the loggers were downloaded and saved on a notebook computer.

The loggers were placed in February 1996 so that summer and winter temperature measurements could be taken before *Aerolite* was installed. The *Aerolite* was installed in July 1997 and the temperature measurements were continued until January 1998 to get the summer and winter measurements after *Aerolite* was installed.

The difference between the outdoor and indoor temperatures before and after the installation of *Aerolite* were calculated and compared. This comparison will give a good idea of what effect *Aerolite* had on the indoor comfort (See Section 3).

3. Measured results

It is important for Owens Corning to know how the data was processed so that they can back up their marketing message with concrete information on how they got to the results they mention.

3.1. Data processing

3.1.1. Climate data used

The raw data had to be sifted to see which of the data was useful. This meant that the recorded temperature data had to be examined manually to see which periods before and after the installation of *Aerolite* overlapped. The useful data were then compared to the corresponding climatic data.

After the overlap of the measured data had been established, three consecutive days before and after insulation that had more or less the same *climate* had to be found. These climate days were combined to form an average day. The indoor temperatures were compared to the average day to find the comfort improvements in the case study houses.

Three consecutive days were chosen to compensate for any deviations in user patterns for a specific day that would give a misleading result. In Table 1 the chosen days can be seen with their average and maximum temperatures. An example of the climate data is given in Appendix D.

Table 2 : *Climate comparisc … /s in 1996 and 1997*

	December 1996			December 1997			Ave. 96	Ave. 97
Date	**2**	**3**	**4**	**5**	**6**	**7**	**(2,3,4)**	**(5,6,7)**
Maximum Temp.	31.2	30.8	29.3	30.7	31.3	31.1	30.4	30.7
Average Temp.	24.3	24.3	22.2	23.2	23.4	24.6	23.6	23.7

From Table 2 it can be seen that the three days used before insulation (2, 3, 4 December 1996) had very much the same climate as those used after insulation (5, 6, 7 December 1997). The 24th 25th and 26th of December 1996 were also considered because their climates closely resembled those of the three days used from 1996. It was decided not to use these days due to the fact that the user patterns over the Christmas period differ a lot from average day to day life.

A second set of climate days (control days) was used for the houses where the measured indoor temperature data didn't overlap with the first set of climate data. The reason for this was that some of the houses' loggers were reset in that period. The control climate days are shown in Table 3.

Table 3 : *Climate comparison of three consecutive days in 1997 and 1998 (Control)*

	January 1997			January 1998			Ave. 97	Ave. 98
Date	**7**	**8**	**9**	**26**	**27**	**28**	**(6,7,8)**	**(26,27,28)**
Maximum Temp.	31.2	30.8	30.3	30.1	31.4	30.3	30.7	30.6
Average Temp.	23.8	24.6	23.4	23.3	25.5	24.4	23.9	24.4

The results obtained from all the houses are shown and discussed in Section 3. A problem with the logger from House 2 and a battery problem in the logger from house 7 meant that yet another climate period had to be used for these houses (Before insulation: 18, 19 February 1997). After insulation: 6, 7 January 1998). It is interesting to note that although the climate periods used differed, the results stay very much the same (Table 5). The different climate periods used had more or less the same temperature characteristics through the whole day.

Table 4 : Climate periods used for the different houses.

House	Climatic data used before insulation	Climatic data used after insulation
1	2,3,4 Dec. 1996	5,6,7 Dec. 1997
2	18,19 Feb. 1997	26,27,28 Jan. 1998
3	2,3,4 Dec. 1996	5,6,7 Dec. 1997
4	2,3,4 Dec. 1996	5,6,7 Dec. 1997
5	7,8,9 Jan. 1997	26,27,28 Jan. 1998
6	7,8,9 Jan 1997	5,6,7 Dec. 1997
7	7,8,9 Jan. 1997	6,7 Jan 1998
8	7,8,9 Jan. 1997	26,27,28 Jan. 1998

The Weather Bureau provided the climate data from January 1996 to January 1998 in an hourly format (Appendix E). The data from the DT5 loggers were available for every 15 minutes a from House 1 for one month is given in Appendix E.

From this data, the hourly temperatures had to be sampled manually. These temperature measurements were then compared to the climate data (Table 2 and Table 3). The sets of data were then imported into *Microsoft Excel* from where further manipulation was done.

3.1.2. Comparison of climate data to indoor temperatures

The three days' results were evaluated individually. An example using House 4 is shown in Figure 5 to Figure 10. An average of the temperatures was then taken over the three days (Figure 11 and Figure 12). From these figures, the daily trend can be seen. These figures show the average values that represent the general trend for a typical day.

In Figure 5 to Figure 7 the trend for each separate day is shown. These values represent the recorded indoor temperatures before *Aerolite* was installed (December 1996). Figure 8 to Figure 10 represent the recorded indoor temperatures after *Aerolite* was installed (December 1997). The improvements derived from these graphs are discussed in Section 3.2.

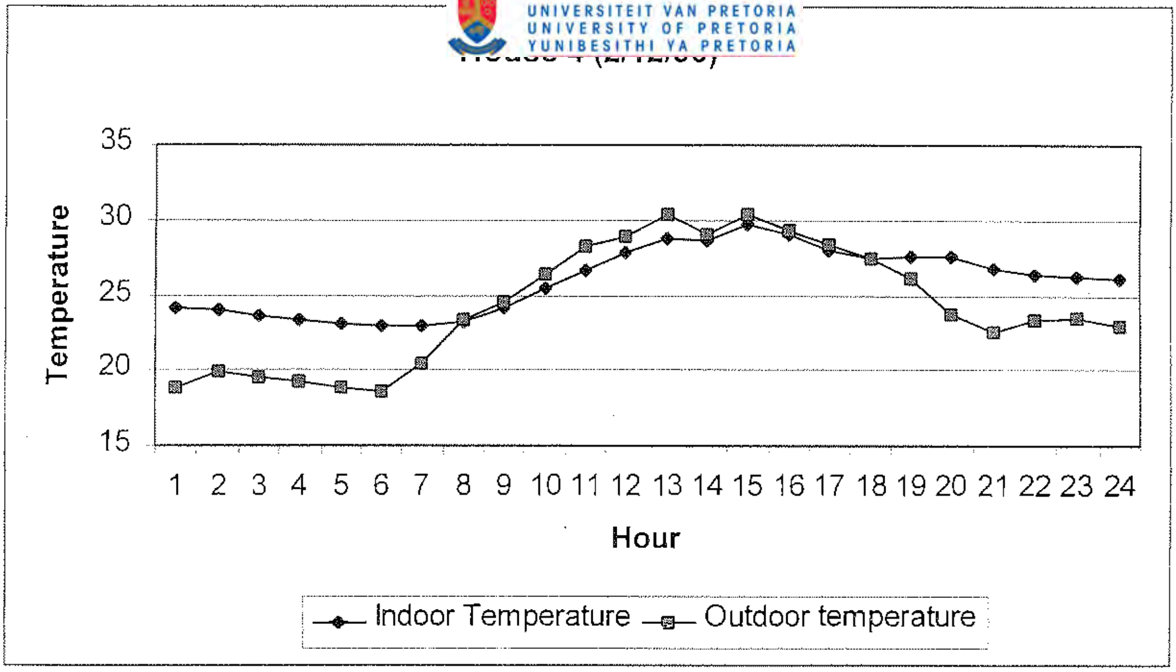


Figure 5: *Temperature comparison of House 4 before insulation (2/12/96)*
Note: Maximum indoor temperature close to outdoor temperature.

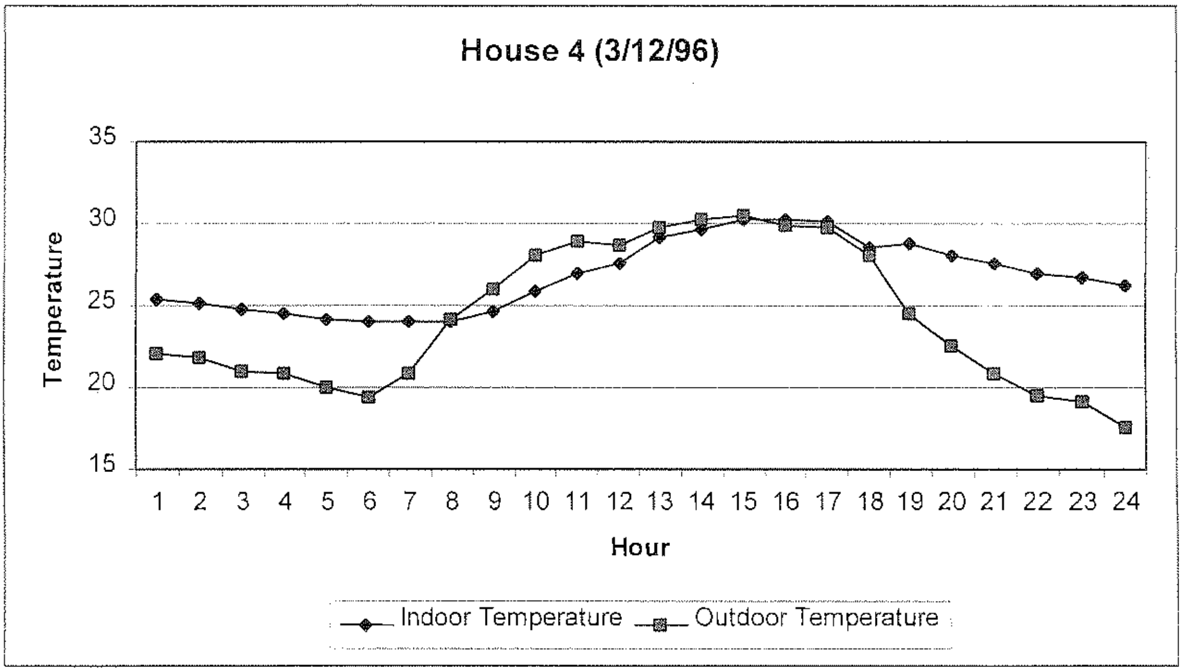


Figure 6: *Temperature comparison of House 4 before insulation (3/12/96)*
Note: Maximum indoor temperature close to outdoor temperature.

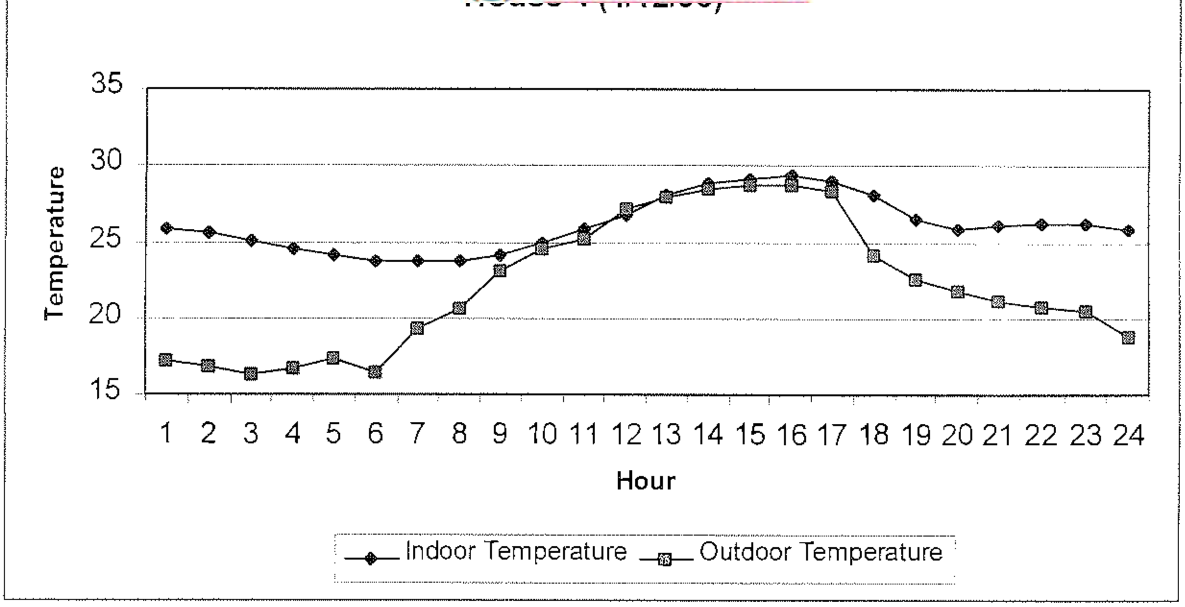


Figure 7: Temperature comparison of House 4 before insulation (4/12/96)
Note: Maximum indoor temperature close to outdoor temperature.

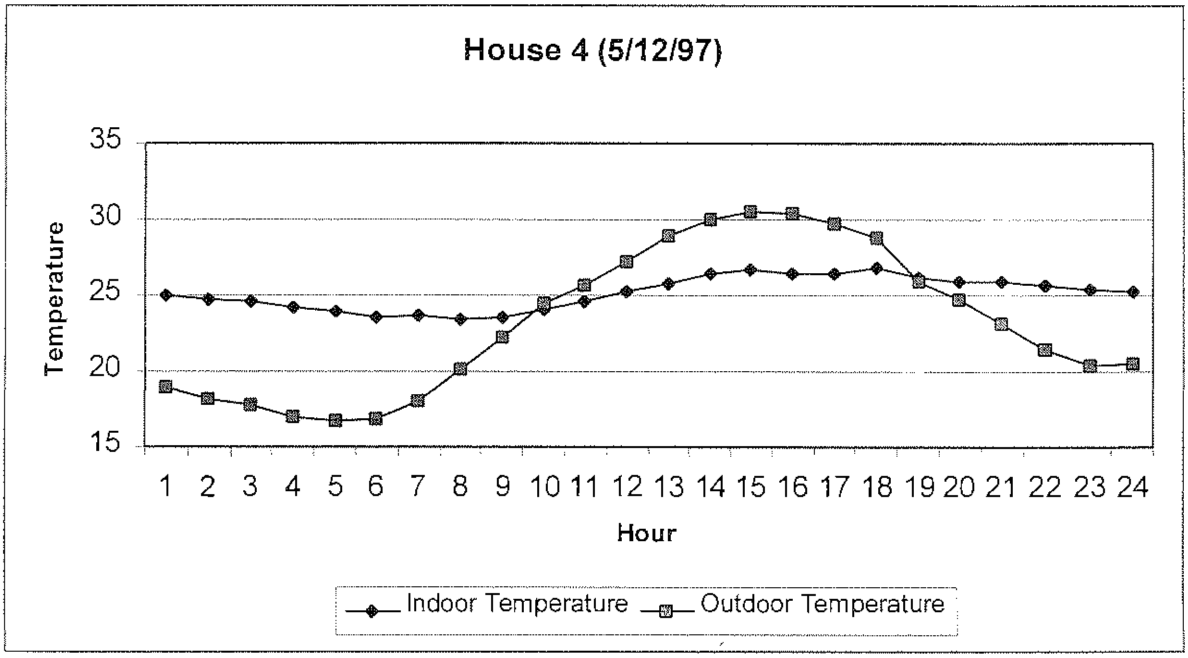


Figure 8: Temperature comparison of House 4 after insulation (5/12/97)
Note: Difference between maximum indoor and outdoor temperature.

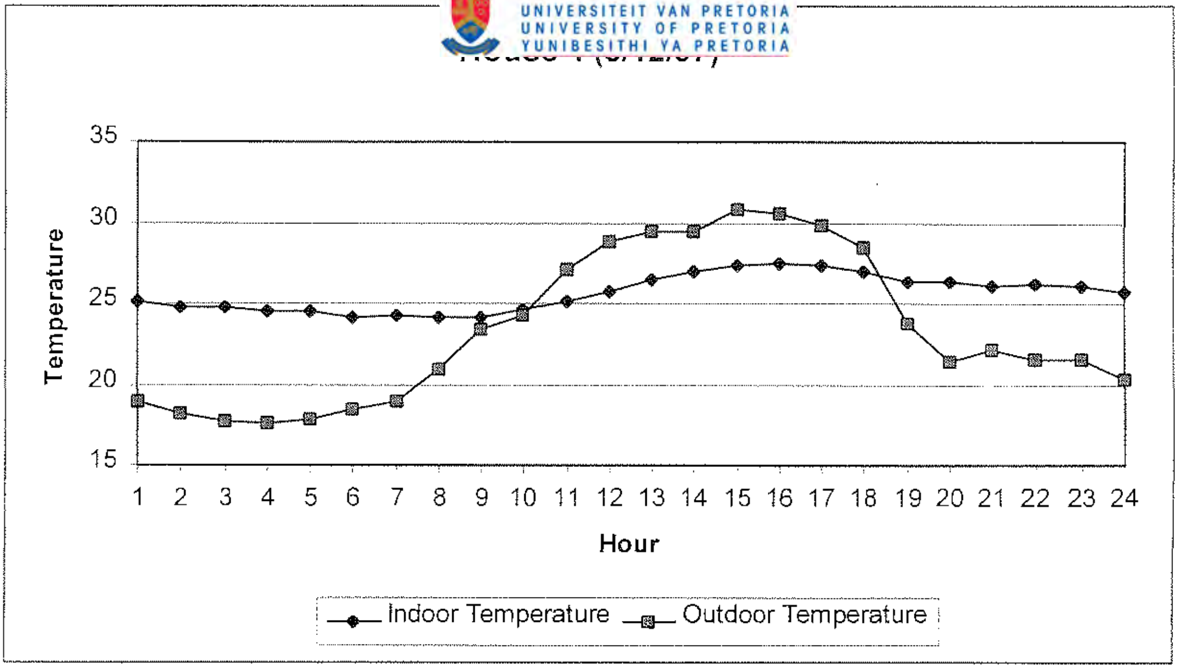


Figure 9: *Temperature comparison of House 4 after insulation (6/12/97)*
Note: Difference between maximum indoor and outdoor temperature.

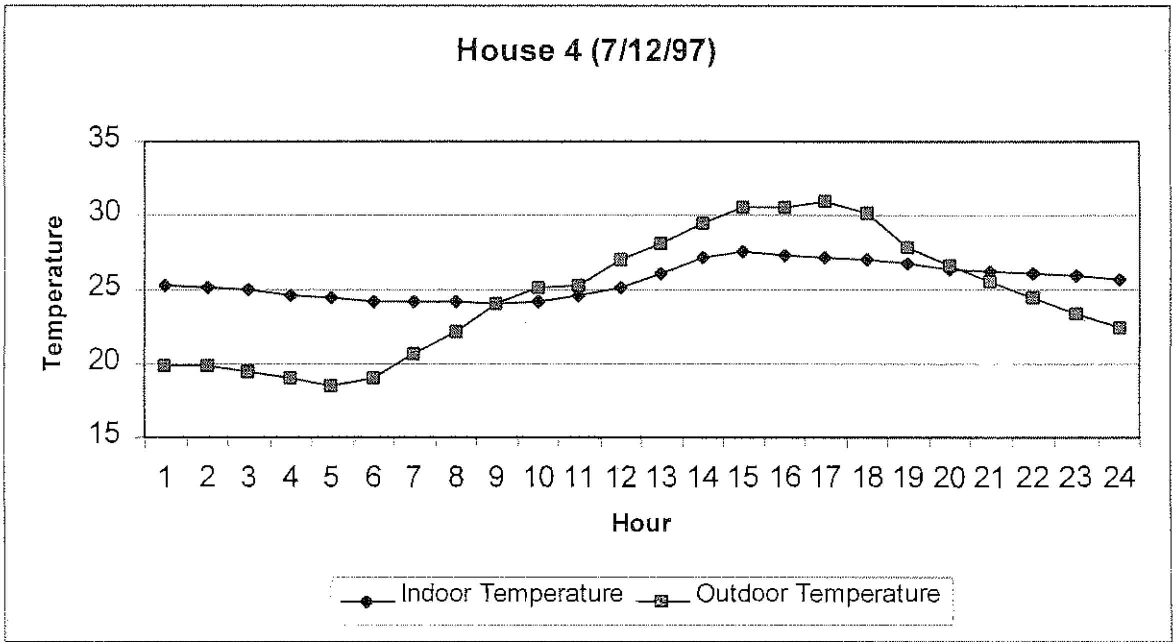


Figure 10: *Temperature comparison of House 4 after insulation (7/12/97)*
Note: Difference between maximum indoor and outdoor temperature.

To form a good idea of a typica[...]ate over the three-day period was used together with the average recorded indoor temperatures (Figure 11 and Figure 12). The corresponding graphs for the other houses are also given in Figure 13 to Figure 22. The results obtained from these graphs are summarised in the following chapter. Note the difference between the indoor temperatures from 11h00 to 18h00 for the before and after insulation cases.

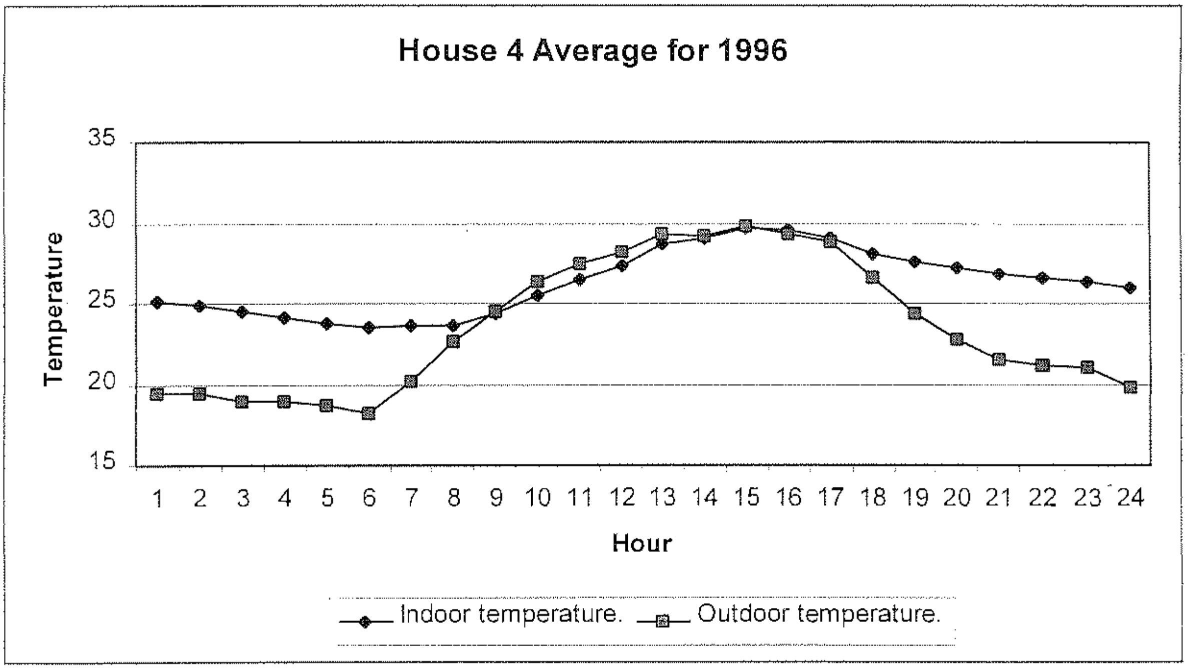


Figure 11: Temperature comparison of House 4 before insulation (1996)
Note: Maximum indoor temperature close to outdoor temperature.

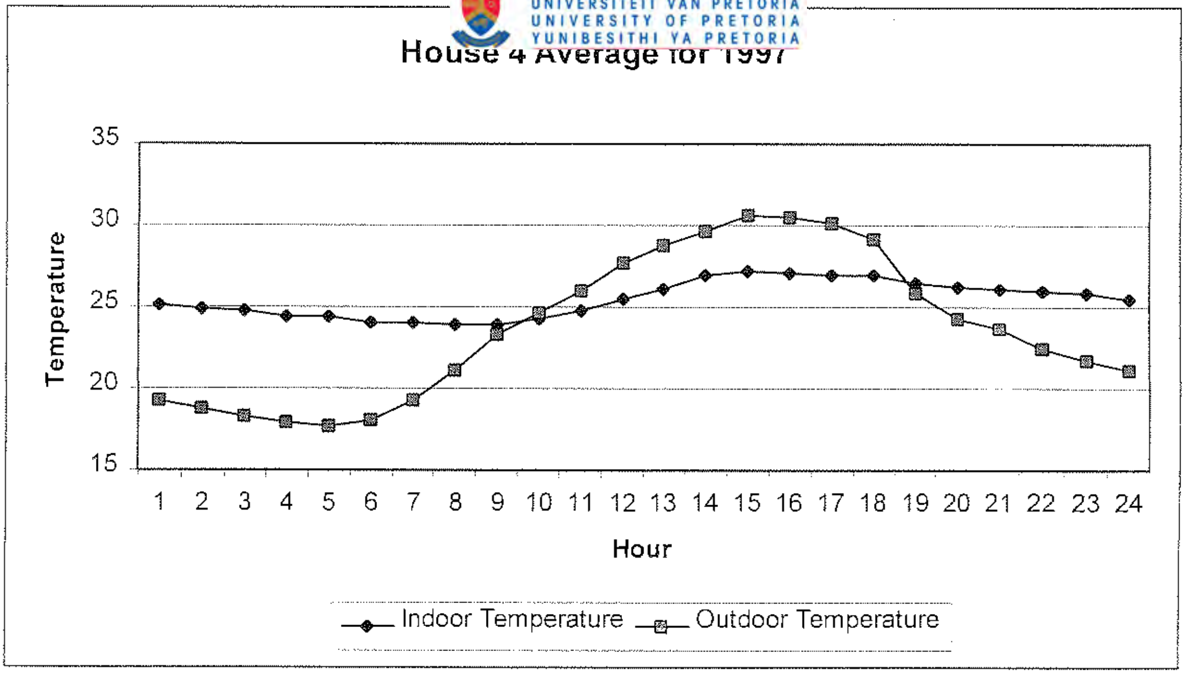


Figure 12: Temperature comparison of House 4 after insulation (1997)
Note: Difference between maximum indoor and outdoor temperature.

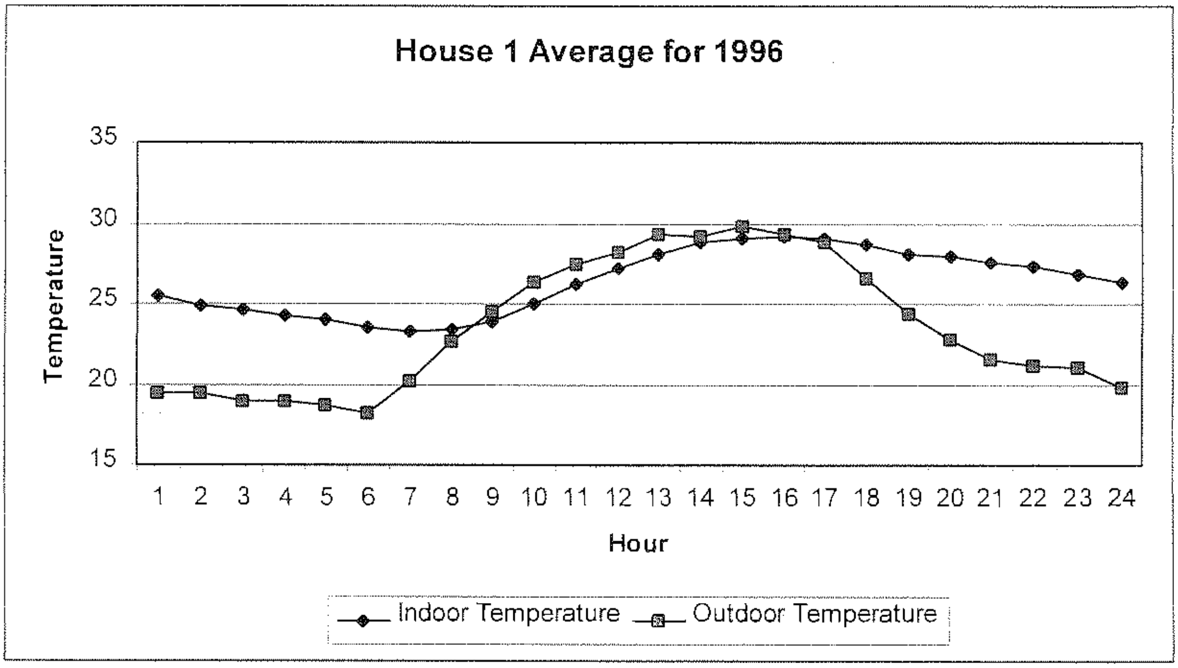


Figure 13: Temperature comparison of House 1 before insulation (1997)
Note: Maximum indoor temperature close to outdoor temperature.

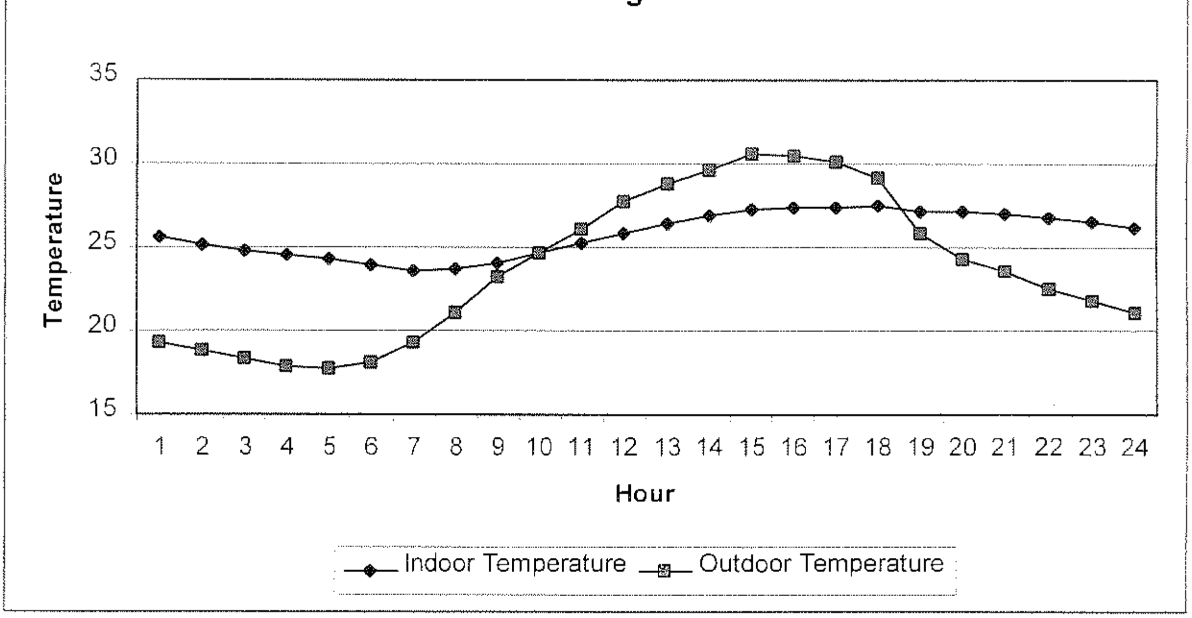


Figure 14: *Temperature comparison of House 1 after insulation (1997)*
Note: Difference between maximum indoor and outdoor temperature.

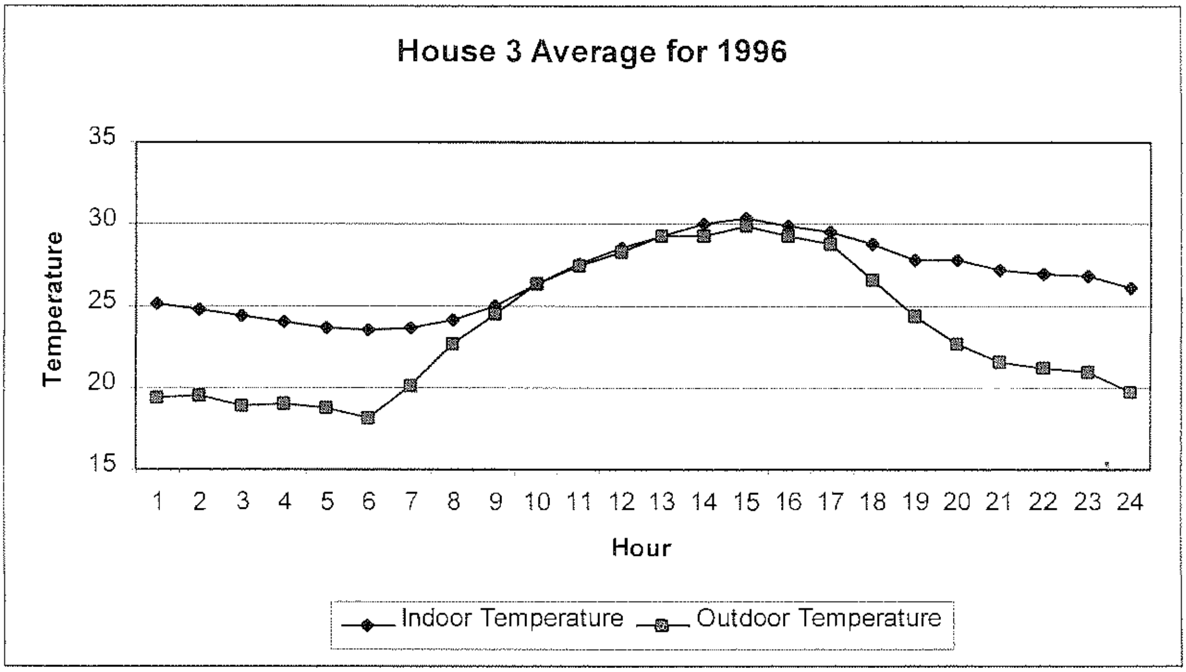


Figure 15: *Temperature comparison of House 3 before insulation (1996)*
Note: Maximum indoor temperature close to outdoor temperature.

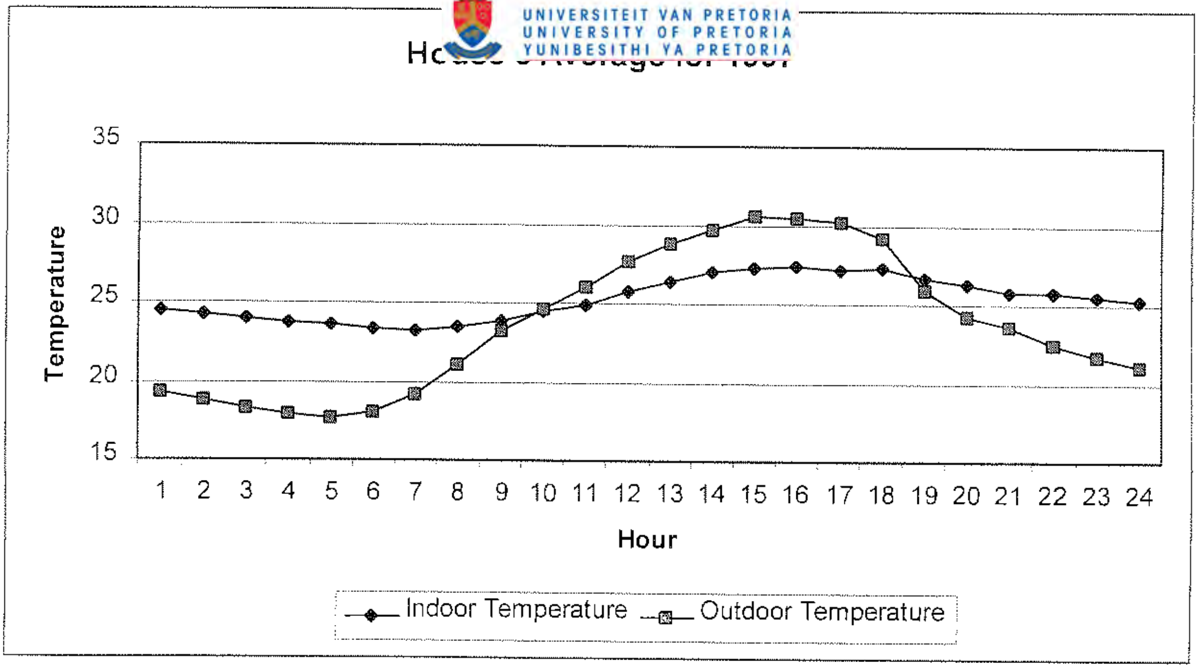


Figure 16: *Temperature comparison of House 3 after insulation (1997)*
Note: Difference between maximum indoor and outdoor temperature.

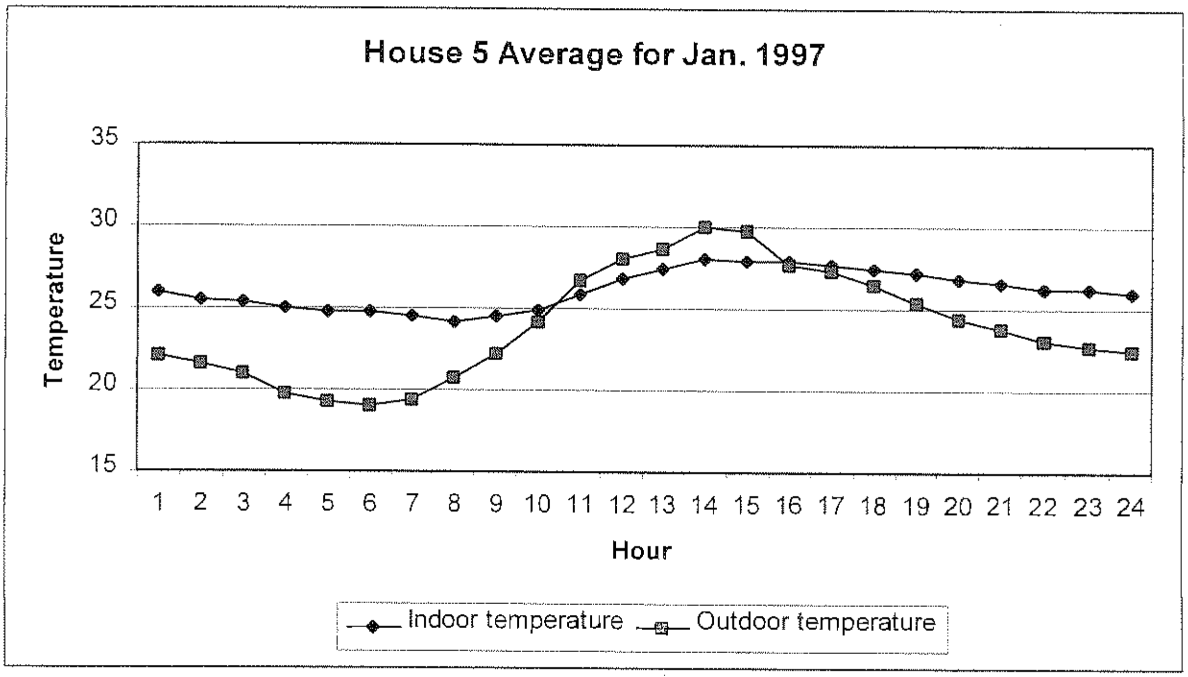


Figure 17: *Temperature comparison of House 5 before insulation (January 1997)*

Note: Maximum indoor temperature close to outdoor temperature.

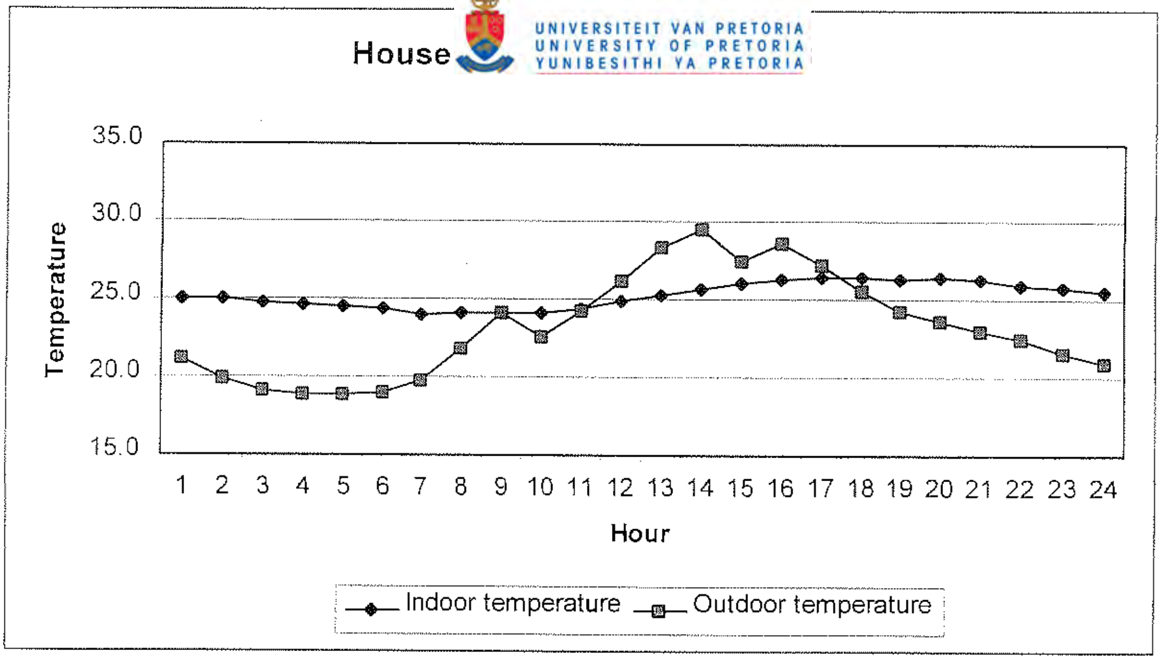


Figure 18: Temperature comparison of House 5 after insulation (January 1998)

Note: Difference between maximum indoor and outdoor temperature.

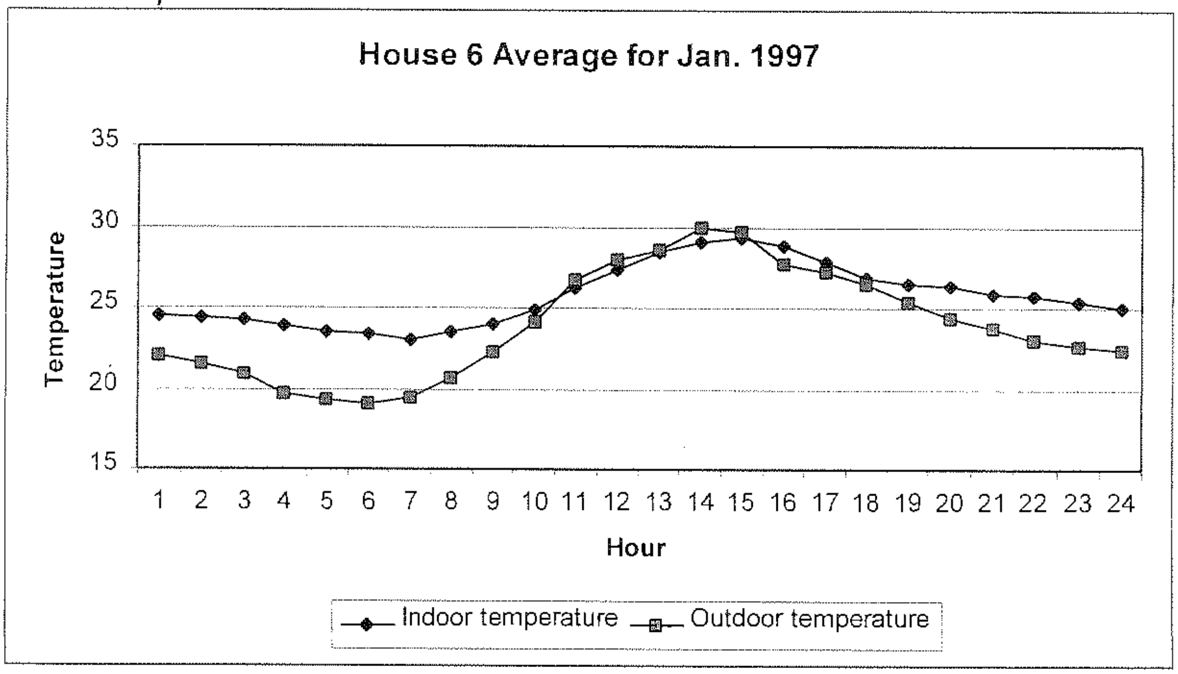


Figure 19: Temperature comparison of House 6 before insulation (1997)

Note: Maximum indoor temperature close to outdoor temperature.

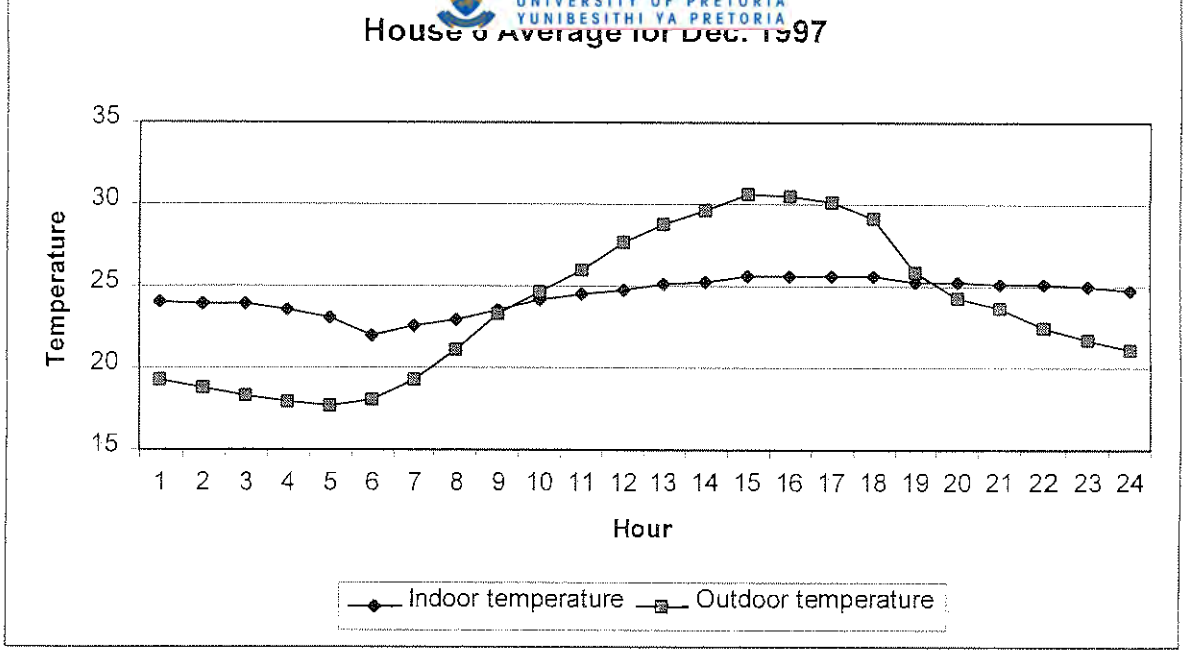


Figure 20: Temperature comparison of House 6 after insulation (1997)
Note: Difference between maximum indoor and outdoor temperature.

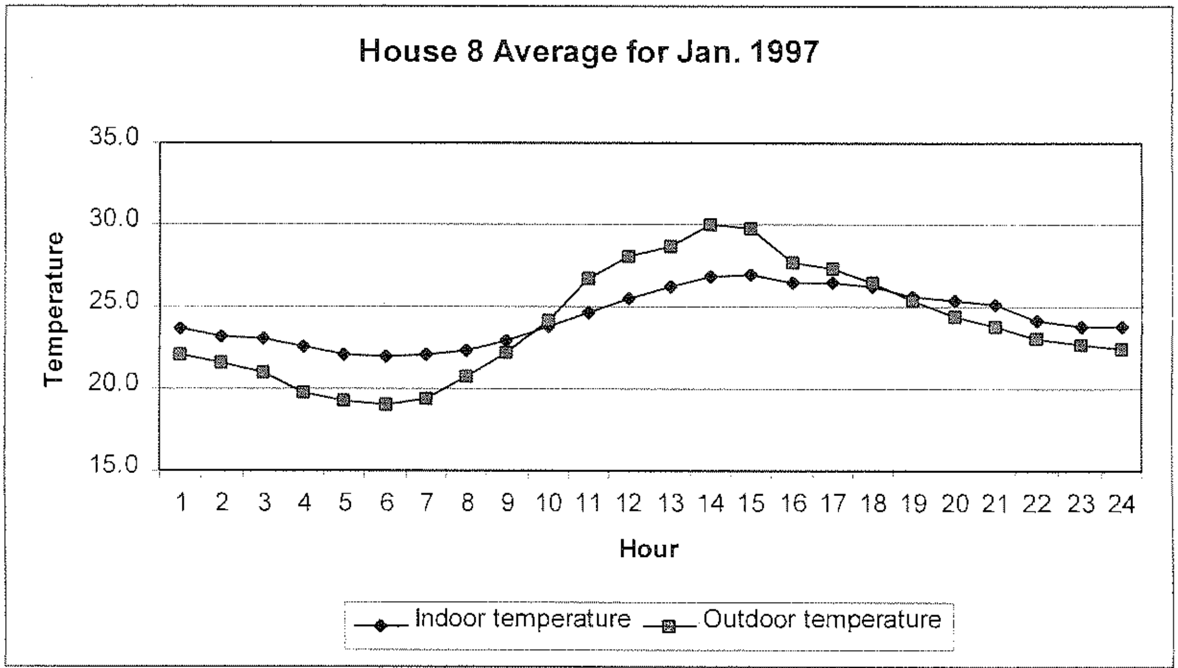


Figure 21: Temperature comparison of House 8 before insulation (1997)

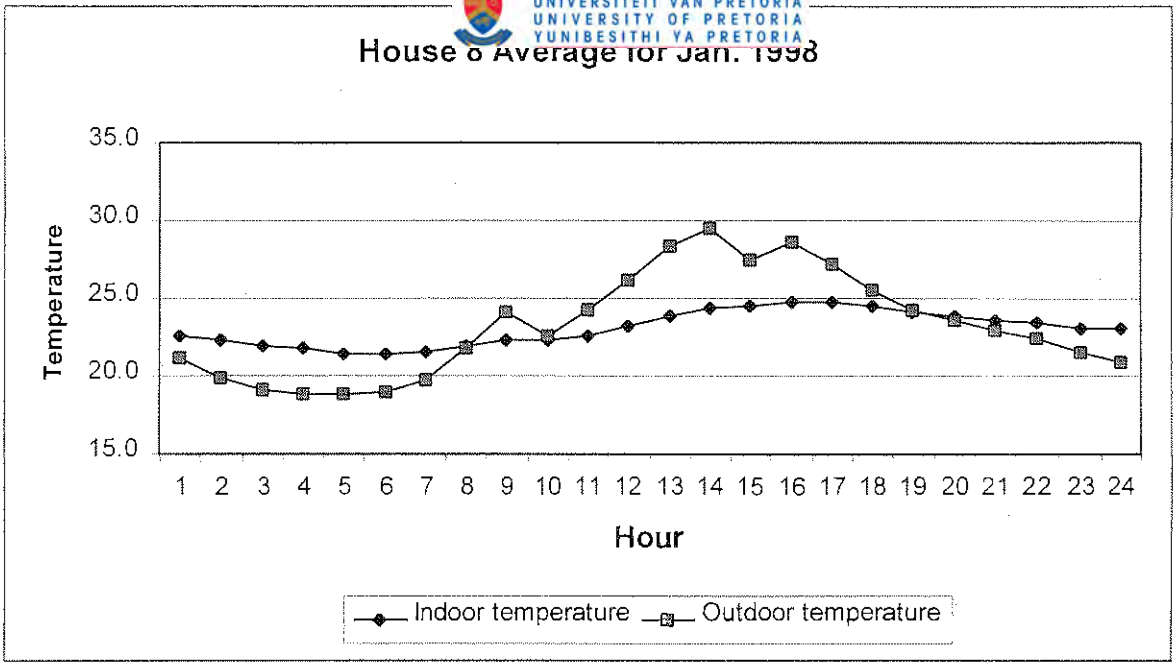


Figure 22: Temperature comparison of House 8 after insulation (1998)

The two control houses' results are also shown (Figure 23 to Figure 26). Note again the indoor temperatures from 11h00 to 18h00. Here it can clearly be seen what little difference (if any) the weather made to the indoor comfort.

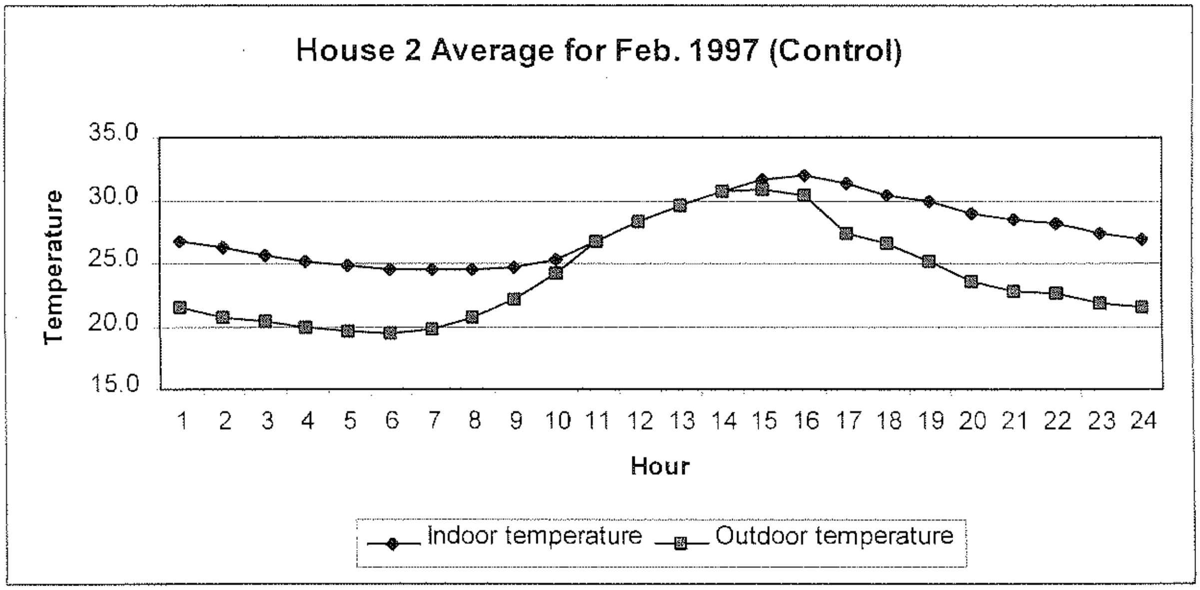


Figure 23: Temperature comparison of House 3 (1997 control)

Note: Maximum i outdoor temperature.

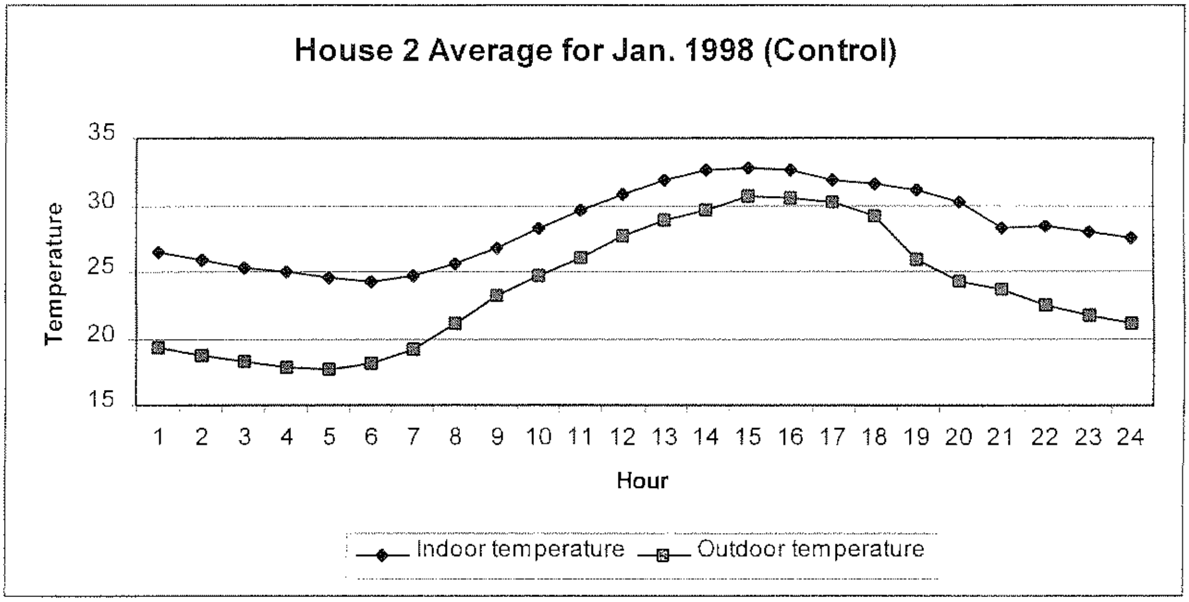


Figure 24: Temperature comparison of House 3 (1998 control)
Note: Maximum indoor temperature above outdoor temperature.

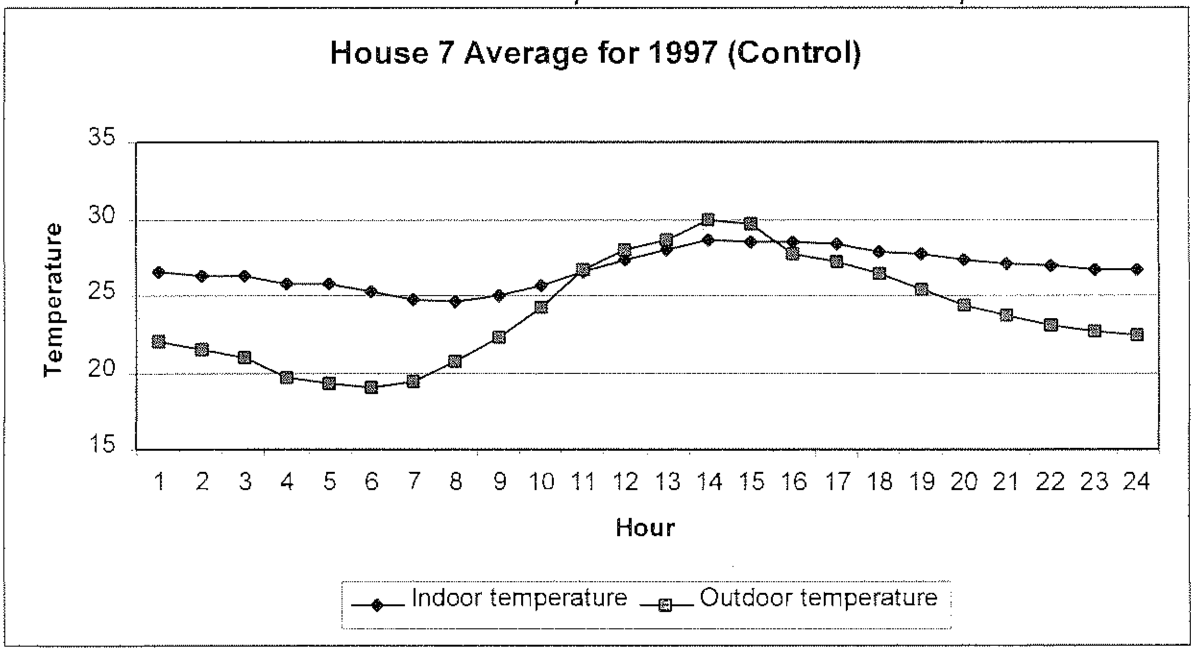


Figure 25: Temperature comparison of House 7 (1997 Control)
Note: Maximum indoor temperature close to outdoor temperature.

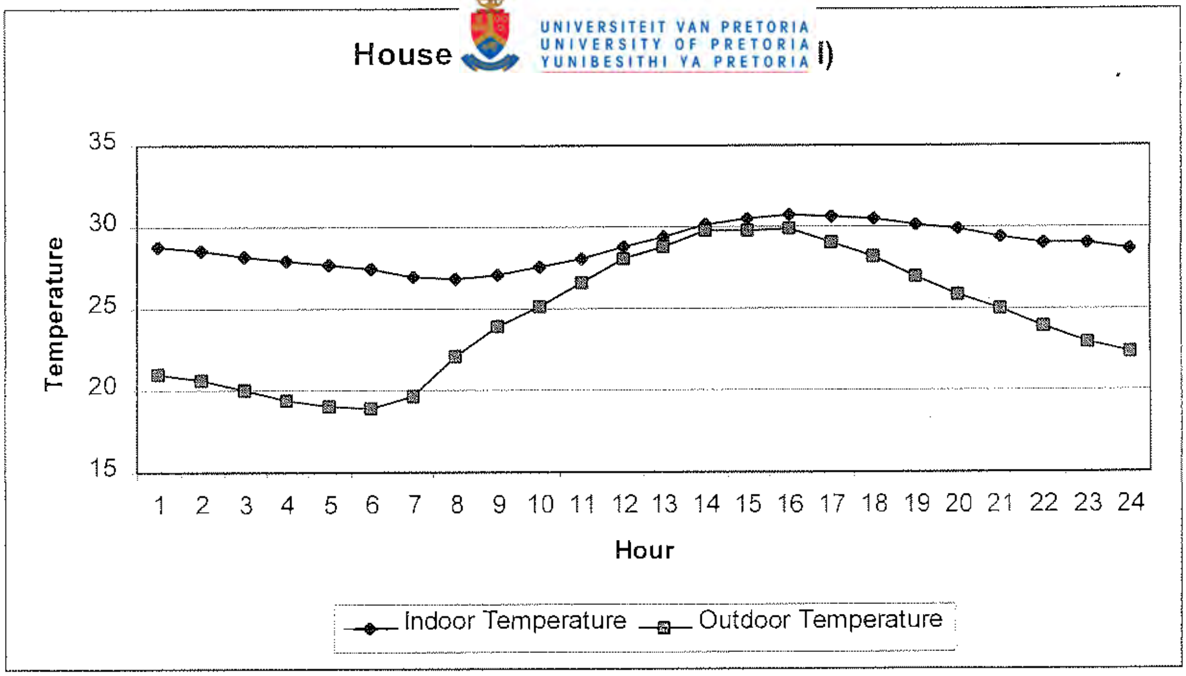


Figure 26: Temperature comparison of House 7 (1998 control)
Note: Maximum indoor temperature above outdoor temperature.

3.2. Results of measuring increased comfort

3.2.1. Comfort improvements

The method of data processing as mentioned above was repeated for each house that took part in the case study. It was found that installing *Aerolite* increased the indoor comfort on hot days from an uncomfortable level to a comfortable one (Section 1.2).

In Figure 11 we can see that the indoor temperature is above 28 °C during the hottest part of the day. This can be considered an uncomfortable situation. Figure 12 shows that after installing *Aerolite* the indoor temperature dropped to a comfortable 26 to 27 °C.

Increased comfort is represen[ted by an increase i]n the difference between the indoor and outdoor temperature. This can be seen in the results from the previous section. Figure 11 shows a difference of 1 °C at 15h00 in the afternoon and Figure 12 shows a temperature difference of 3.8 °C. The improvement mean that the indoor temperature is lower after insulation thus the comfort has improved.

In the previous section, it was clear that the indoor temperature was close to the outdoor temperature before *Aerolite* was installed. After the installation of *Aerolite* the indoor temperature reduced considerably especially during the hottest part of the day (Figure 5 to Figure 22).

The results for the different insulated houses are listed in Table 5. These values are based on the average day (Figure 11 to Figure 22) as explained in the previous section. The average temperature improvement for all the houses was also calculated. These values can be assumed to be the general trend for the Pretoria region. The increased comfort between 14h00 and 15h00 is shown because this is generally the hottest period of the day inside the house.

Table 5 : Measured temperature improvements

	H1	H3	H4	H5	H6	H8	Ave. House
Before Insul.	0.7	-0.5	0.1	1.8	0.4	3.2	0.9
After Insul.	3.4	3.3	3.4	3.9	4.9	5.1	4.0
Improvement	2.7	3.8	3.3	2.1	4.5	1.9	3.1

From the results obtained from the six case study houses around Pretoria, it can clearly be seen that there is a definite improvement in indoor comfort. The houses that were insulated sh[illegible] between 1.9 to 4.5 °C. The average temperature improvement was 3.1 °C. Thus it is cooler inside the house after *Aerolite* was installed.

3.2.2. Thickness of *Aerolite*

From the results obtained from the case studies (H1, H3 and H4), it is evident that the thickness of *Aerolite* doesn't have a significant influence on the indoor temperature. It is however, difficult to see what the influences of *Aerolite* thickness was because the houses do differ in structure. It would be ideal to repeat the measurements for 50, 75 and 100 mm *Aerolite* for a specific house, but this would take at least two more years.

With this problem in mind, the effect of the *Aerolite* was simulated for House 1. The results obtained from these simulations showed that as soon as insulation was inserted into the roof the indoor temperature dropped below the outdoor temperature (See Figure 27). This is an important discovery because now it can be seen that any amount of insulation would improve the indoor comfort situation.

It was thus important to find an optimum point where it didn't make a big difference if the insulation thickness was increased. It was found that the indoor temperature only dropped a further 0.5°C if 100mm *Aerolite* was installed rather than 50mm. Thus it would make sense to motivate people to install the 50 mm version of *Aerolite*, because this will be a cheaper option and would appeal to the middle income household.

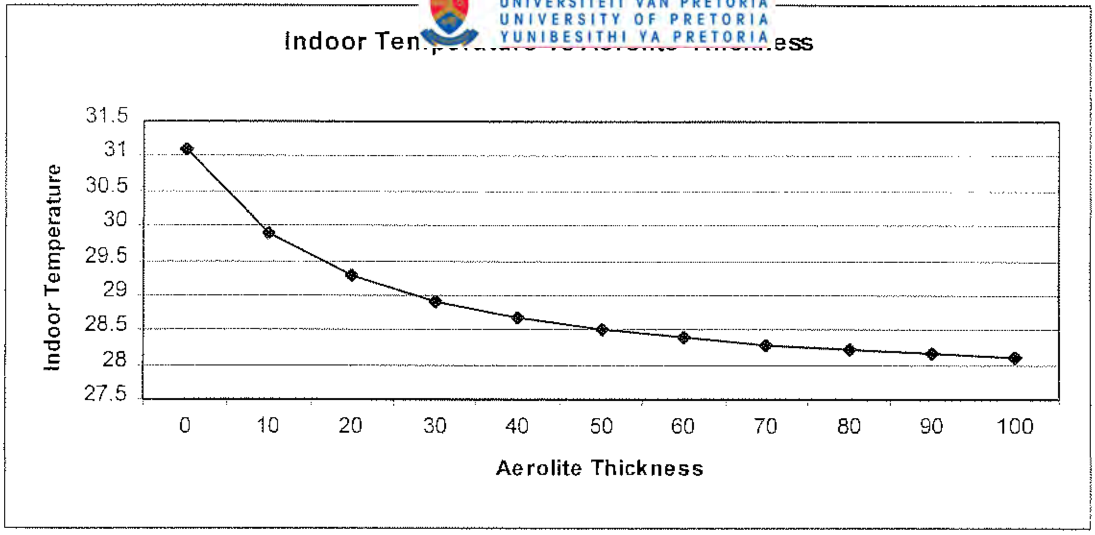


Figure 27 : *Indoor temperature vs Aerolite thickness for House 1 (Outdoor temperature = 30.3°C)*

A similar simulation was done for the improvement in energy efficiency if the thickness of *Aerolite* is varied. It is clear from Figure 28 that the reduction in energy consumption if 100 mm *Aerolite* is installed rather than 50 mm is not much (The difference is 0.19 kW/h). The simulations were done using *QUICK II*. This thermal analysis program is discussed in Section 4.

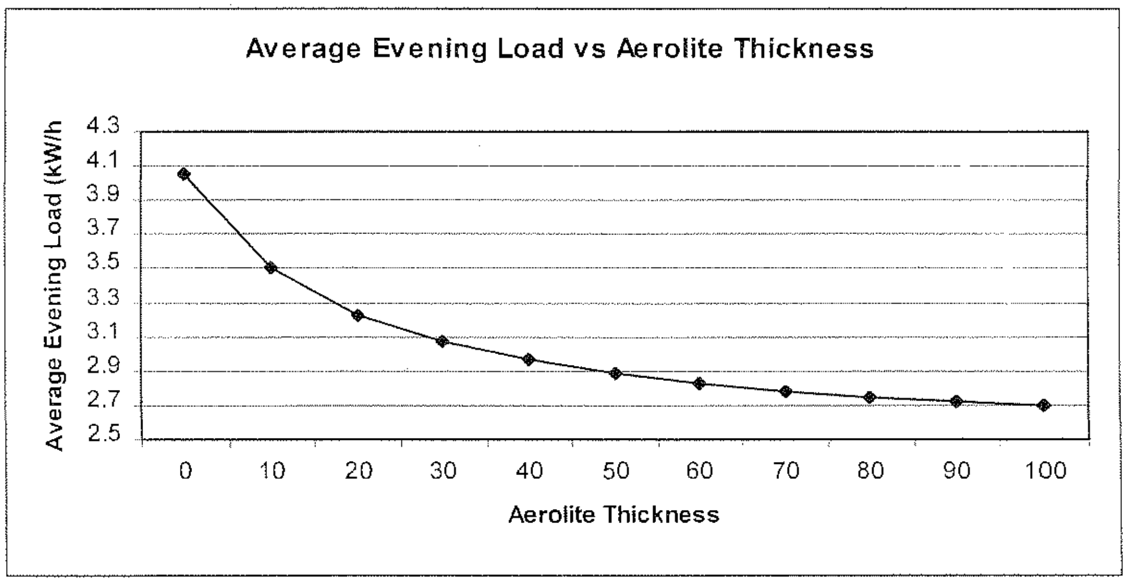


Figure 28 : *Average evening load vs Aerolite thickness for House 1 (In Winter between 17h00 and 22h00 when the desired indoor temperature is 21°C)*

3.2.3. Satisfaction of residents

After implementing the satisfaction criteria discussed in section 1.2, it was found that almost 30% more people were satisfied with their situation after insulation (Table 6). The biggest improvement was 70% for house 3 (See Table 6).

It must be remembered that these values represent the satisfaction of all the people across the country if their *climate* is the same as the one used in the case studies. The average satisfaction improvement in Table 6 would thus be representative for an average day in the Pretoria region only. To form an idea of the satisfaction levels for other regions, one must consider the general climate in that region. This will be shown in Section 5.

Table 6 : Measured satisfaction improvements (Note: Only for measured days. The real value will be seen on the hottest days. The results for the simulations done for the whole country can be seen in Table 12)

Participants	H1	H3	H4	H5	H6	H8	Ave. House
Satis. Before	70%	20%	60%	81%	70%	93%	65%
Satis. After	90%	90%	90%	98%	98%	99%	94%
Improvement	20%	70%	30%	17%	28%	6%	29%

- **Satis. Before/After** – Satisfaction with indoor temperature before and after installation of *Aerolite*

These improvements for Pretoria on an average day can clearly be seen in the following figure:

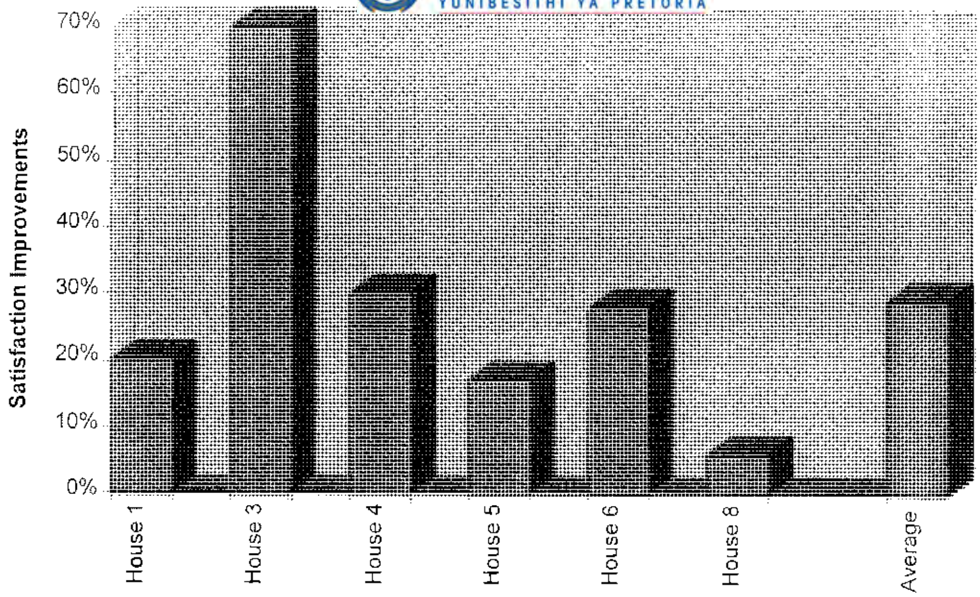


Figure 29 : Satisfaction improvements of residents in the insulated houses (Pretoria)

From the results in the previous section, it can be seen that the indoor temperature for non-insulated houses tends to follow the outdoor temperature closely. Sometimes the indoor temperature is even higher than the outdoor temperature (Table 7). The initial satisfaction level in the warmer climates will therefore be much lower in warmer climates especially for non-insulated houses.

If the maximum outdoor temperature rises to **31.5** °C it can then be assumed that the indoor temperature will be close or even higher. This will result in a satisfaction level of <10 %. When *Aerolite* is installed, a temperature drop of 3.3°C (Table 11) can be expected to **28** °C, which will result in a satisfaction improvement of more than 70% to a level of above 80%. The nation-wide satisfaction results will be discussed in Section 4 (Table 12).

3.2.4. Non-insulated results

To show what the indoor temperature would have been inside the houses, the two control houses' results are shown in Table 7. The climate comparison as mentioned in Table 4 was used to evaluate these houses.

Table 7 : Control houses to show changes in comfort without insulation.

	H2	H7	Ave. House
Control 1997	1.2	1.2	1.2
Control 1998	-2.2	-0.7	-1.5

The negative values in Table 7 indicate a higher indoor temperature than outdoor temperature. This may be due to external factors other than the weather, like heating caused by occupants, kettles, etc. The results obtained from the case studies strongly support the use of *Aerolite* to enhance indoor comfort. The next step is to obtain values for all the regions in South Africa.

It would however be very costly and time consuming to physically measure a number of houses in each region in South Africa as we have done for the eight houses in Pretoria. It therefore makes sense to simulate the conditions in houses from these regions. This procedure is discussed fully in Section 4 and 5.

4. Simulating Increased Summer Comfort

4.1. Why must we simulate increased comfort

To obtain good results from such case studies mentioned in Section 2 can take years. It is thus important to have a reliable way to predict the comfort benefits in different houses in South Africa. The thermal analysis program called *QUICK* was used to simulate the different temperature situations in these houses.

Using a program such as *QUICK* makes it possible to simulate the worst case that could exist in a specific house. The measured data will only give results for a specific climate situation. It is however conceivable that the outdoor temperature could rise to a level above 31°C. This will reduce the satisfaction of the residents considerably. The influence of *Aerolite* on comfort in these cases is thus also important.

The latest and most accurate version of *QUICK*, called *QUICK II* for Windows, was used to simulate the indoor temperatures of the six houses used in the case study. *QUICK II* has been specifically developed for the simulation of houses (section 4.2) in all South African domestic sectors, but is not yet commercially available.

4.2. Short summary of the thermal model used by *QUICK II*

Owens Corning needs perfect proof for the information they use in their marketing campaigns. They need a fair idea of any assumptions that were made for the simulations. Therefore, to show the high level of scientific correctness, this report summarises the *QUICK II* model. This is the latest development:

The occurrence of discrepancies between the results obtained from the first-order model (*QUICK*) and numerical predictions prompted further investigation into an extension to a higher order model (*QUICK II*). A theoretically rigorous procedure was followed to determine the heat flow in a building zone. Firstly, the heat flow through a single wall was considered. The heat flow through several walls was then added to obtain the total heat flow in the zone. At this stage of the procedure, the radiative and convective heat generated in the zone had not yet been included. The use of an electrical analogy for this purpose is introduced in this chapter (See Figure 30).

It can rightfully be asked why an electrical analogy is required, if an analytical solution for the heat flow into a building zone already exists. The only reason for this is that in the analytical solution, it is assumed that the spectra of all the relevant parameters are known beforehand. This is not generally true for example when the calculation of the ventilation rate is dependent on the solution of the inside air temperature, or when the model is applied to the simulation of air conditioning plants.

It is therefore clear that another approach is required if the simulation model is to simulate the building zone with an air-conditioning plant and its controls. The recommended procedure is discussed in the following paragraphs. It must be noted that while the use of an electrical analogy in itself is not novel, the configuration of the electric circuit presented in this paper is.

The air node of the electric circuit is treated as a separate node, and its capacitance (C_i) is simply calculated by

$$C_i = Vol^*\rho^*C_p$$

where *Vol* is the zone volume, ρ is the air density and C_p is the specific heat capacity of the air. The ventilation, infiltration and environmental control are all treated separately and the resistance is given as where *acs* is the air changes per second. These *acs* values for natural ventilation are obtained by the calculation procedure suggested by Rousseau and Mathews [7].

Provision is made for two structural heat flow paths, namely: (1) a low mass path (single node - glass, fenestration and other low mass structures), and (2) a high mass path (triple node). The thermal resistances and capacitances for the high and low mass paths are determined by optimisation. The analytical solution in the frequency domain is determined from the theory derived by Davies [8]. The response of the electric analogy is then matched to the analytical solution by selecting values for R and C. The details of this procedure will form the basis of a separate article.

In other models, the low mass structural heat flow path is often represented by a resistor only [9]. The procedure here is different, thus allowing thermally thicker elements to be included in the low mass path. A thermally thicker element is one for which a large product is obtained when the thermal resistance of the element is multiplied by the thermal capacity of the element. Surface convective resistances are calculated by:

$$R_s = 1/(h_i A_s),$$

and the solar-air temperature is calculated by:

$$T_{sa} = T_o + (\alpha I_s - \varepsilon I_l)/h_o$$

For the ground contact model, the calculation procedure suggested by Richards and Mathews [10] was used. All internal masses are combined and treated as a single capacitor. This internal mass capacitance, C_{im}, accounts for the heat storage effect of the floor and internal masses, and is simply calculated as the sum of all the capacitances. The thermal resistance, R_{im}, is calculated by determining firstly the time constants for each internal mass, and then the effective resistance. The steady state resistance, R_{ss}, accounts for the heat that is lost from the floor to the surr detail discussion of this procedure can be found in [71].

Convective heat gains, Q_c, resulting from internal convective heat sources act directly on the air node. Radiative heat gains, Q_r, resulting from solar penetration and internal radiative heat sources are weighed according to surface area and act directly on the surface.

The governing equations for the complete circuit can be derived by adding the currents at each node. In total, the circuit contains nine nodes. Six of the nodes are associated with capacitors, and the other three with surfaces. The differential equations resulting at the nodes containing capacitors can be discretisized using a forward differencing scheme. The use of heat balances at the surfaces contribute three algebraic equations containing the surface temperature terms.

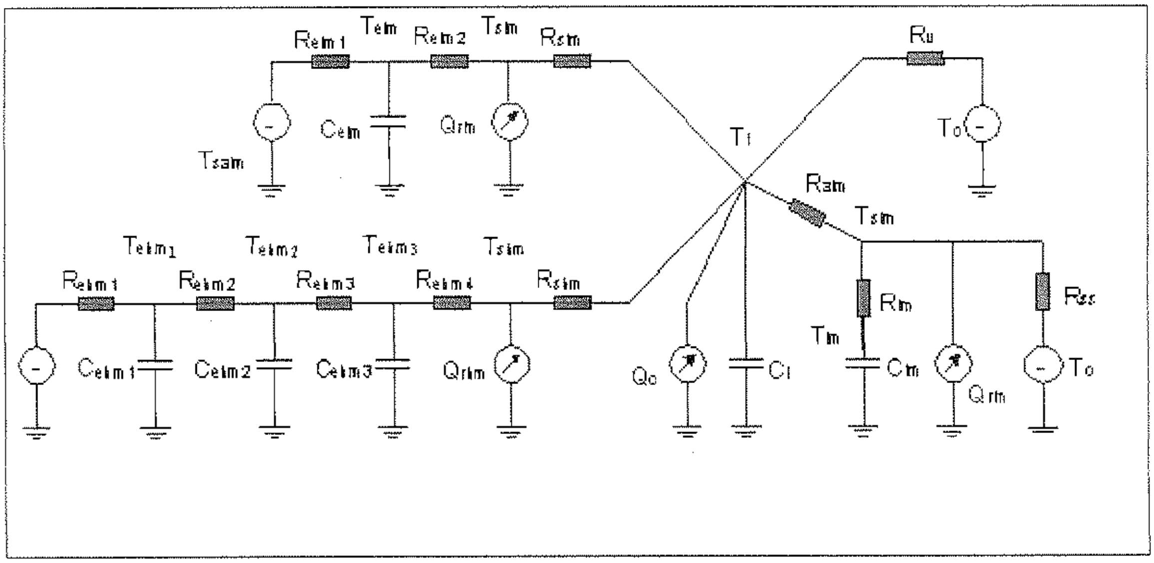


Figure 30: Zone model electrical analogy

The resulting nine equations m[illegible]usly at each time step. Although this is a considerable complication (when considering the original [71, 11] or other low order models such as that proposed by Tindale [70]), the increase in accuracy should justify the effort. While the task might seem formidable, the resulting matrix is sparse with an almost tri-diagonal structure. Most of the coefficients remain constant allowing the matrix to be inverted only once. This data is then stored. Consequently, only the backward substitution needs to be performed at each time step. This can be done very efficiently.

4.3. Assumptions made for *QUICK II*

The following are some of the assumptions that must be remembered when *QUICK II* results are used [12]:

- The heat transfer through any surface is one-dimensional. It therefore doesn't matter how close to a corner in a room you get, the heat transfer through the wall would be the same as in the middle of the wall.
- The heat transfer coefficients for convection and radiation were combined and this meant that in effect the air is assumed opaque.
- It was assumed the air thoroughly mixed. Thus, the temperatures anywhere in the room were equal to the average temperature. The air could thus be reduced to one node in the thermal model.
- The objects of low thermal mass such as glass and partitions were lumped together and the same was done for the objects of high thermal mass such as walls.
- Internal masses were grouped with the floors.
- The convection load and the ventilation influence the air node directly.

Although all simulation models ...tions we believe they were justifiable. These assumptions will be tested by verification of the results obtained from the simulations in the following section.

4.4. Verification of *QUICK II*

People will only believe Owens Corning's marketing initiatives if their material are backed up with scientifically proven information. It is therefore important to ensure that the simulations are representative of results obtained through experimentation (measurements).

The verification of any simulation program is vital to ensure that reliable results are obtained. Seventy verification studies for the new *QUICK II* were performed [13]. They have proven without a doubt that *QUICK II*'s results are accurate.

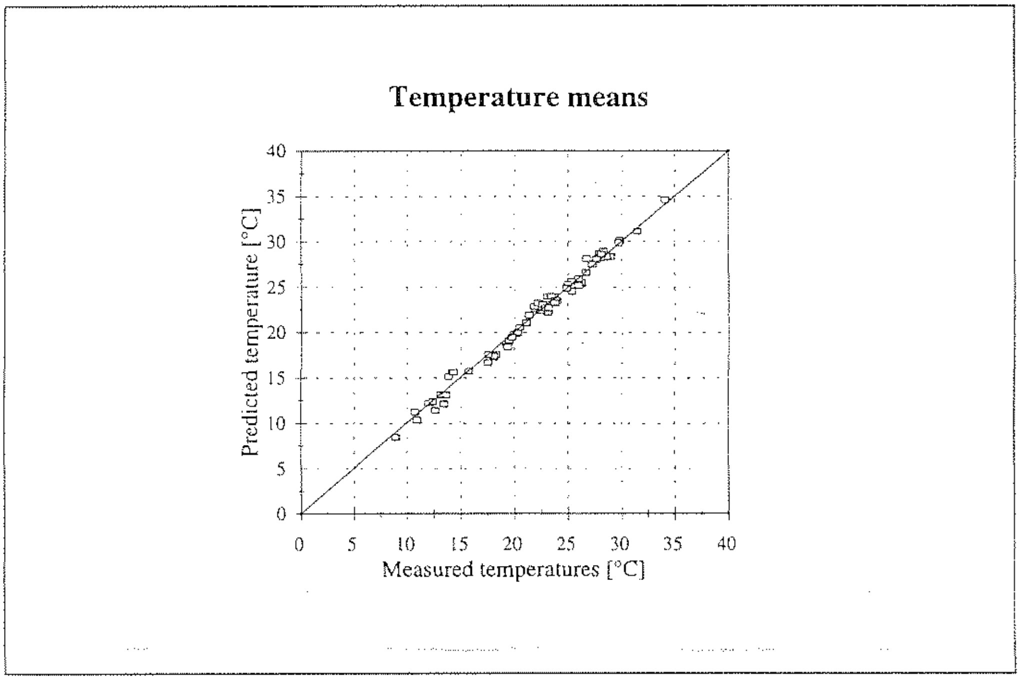


Figure 31: *Measured and predicted indoor air temperature means for the simulation model*

Figure 33 shows a comparison ... and measured indoor air temperature means. The temperature means are calculated by adding the temperatures together and dividing by the number of hours in a day.

Each square represents a single verification study. An accuracy of 100% would result in all squares lying directly on the 45° line. However, the distribution shown using linear regression is within 99% [13].

A comparison between the measured and predicted indoor air temperature swings is given in Figure 32. Temperature swings are the minimum and maximum temperatures occurring during the day. Again, the 45° line represents an accuracy of 100%. The correlation coefficient for *QUICK II*, using linear regression is within 96% [13].

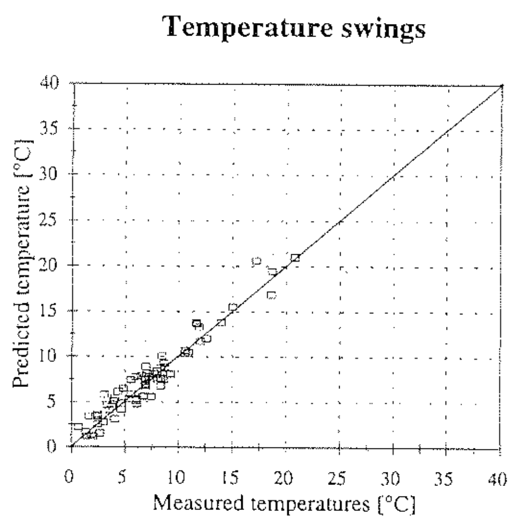


Figure 32: Measured and predicted indoor air temperature swings

QUICK II can thus be used with confidence to simulate the comfort benefits of *Aerolite* in this project. However, the simulation models (i.e. of each house) must also be verified against t ments conducted during the year. This will ensure that the actual input data is correct.

This verification has been done in each of the houses used for the case studies. Figure 33 compares the hourly measured temperatures to the hourly-simulated temperatures. From these results and those obtained from the extensive verification study mentioned above, it can be concluded that the *Quick II* simulations are reliable.

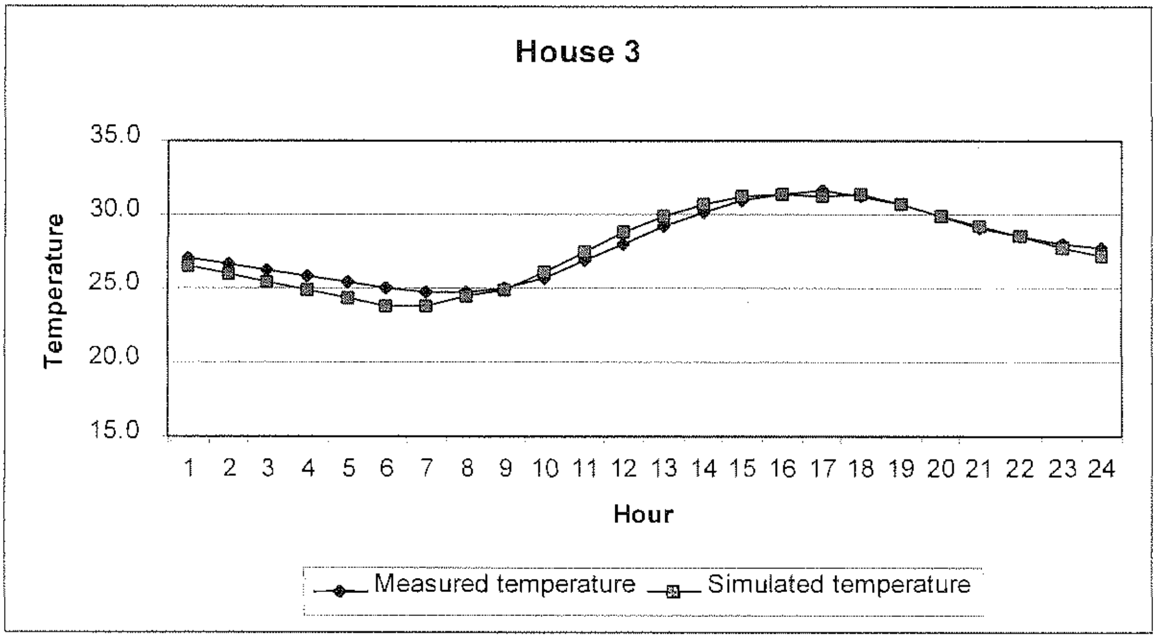


Figure 33 : Simulated vs. Measured temperatures for House 3

4.5. Simulations using *QUICK* for the Pretoria region

The simulation models used for the case study houses mentioned above were used to simulate the increased comfort for these houses. *Aerolite* with a thickness of 50, 75 and 100 mm was added to the ceiling of each of these simulation models. Calculation both the non-insulated and the insulated models. Table 8 lists the thermal properties of the insulation material used for the simulations.

Table 8 : Thermal properties of fibre glass insulation

Property	Value
Thickness [mm]	50
Density [kg/m3]	25
Conductivity [W/m°C]	0.045
Specific heat capacity [kJ/kg°C]	1

Natural ventilation is the flow of air between inside and outside. If there are enough doors or windows open on a windy day, the indoor temperature will approach that of the outside, as a high rate of air flows through the house. If the simulations were conducted in these conditions, ceiling insulation would have little influence on indoor temperature.

This project must find the best comfort improvements due to ceiling insulation. The worst comfort level will be experienced on hot winless days. In these conditions, ceiling insulation will be the most effective. It was therefore decided to use these conditions for the simulations. All eight houses were simulated using the same climate data as provided by the Weather Bureau for 1996.

The best result was obtained for house 4 (Figure 34), with a 4.2°C drop in maximum temperature. House 1 showed the least improvement (Figure 35). The living area of this house is small and a large tree shades its roof for much of the day. Ceiling insulation will thus be less effective for this house. However, it is interesting to note that ceiling insulation was still able to reduce the indoor temperature by almost 2°C.

In Figure 36 the indoor temper[illegible]ed and insulated cases are averaged using all eight houses. All houses except one showed similar improvements of over 3°C as illustrated in Figure 37.

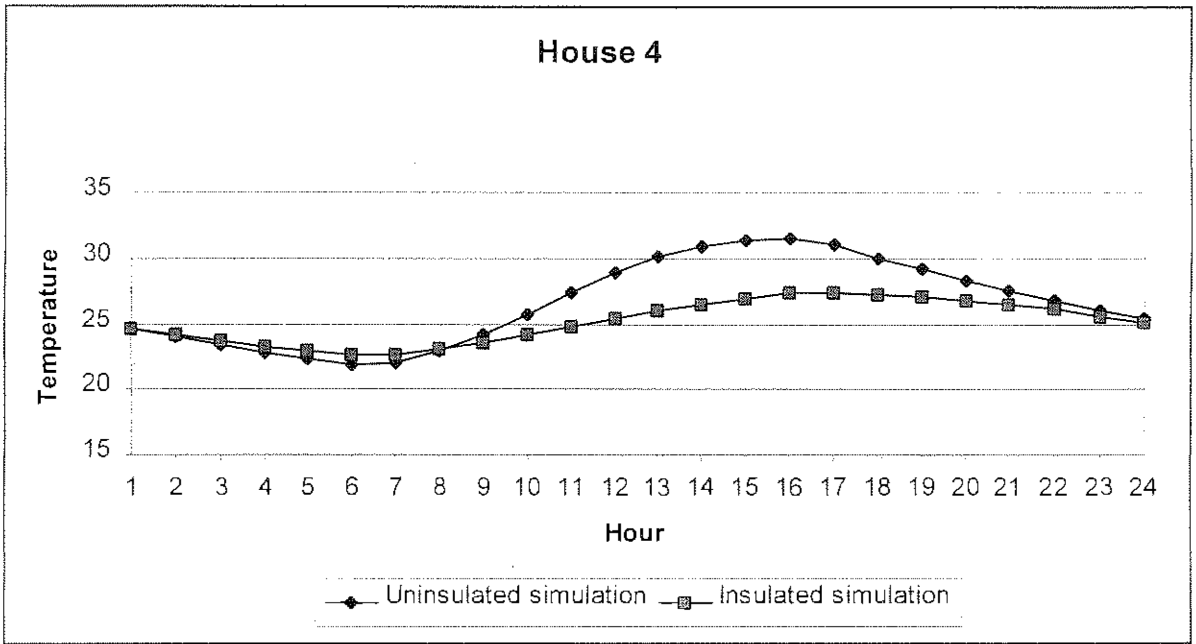


Figure 34 : *Biggest improvements: Indoor temperature with and without ceiling insulation*

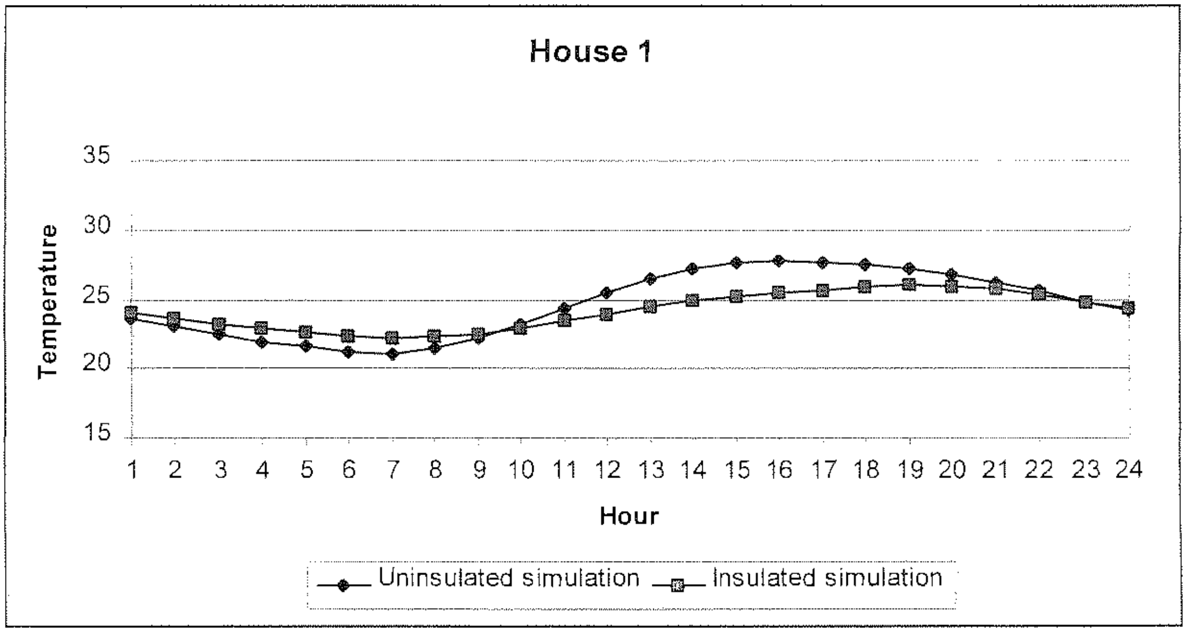


Figure 35 : *Smallest improvements: Indoor temperature with and without ceiling insulation*

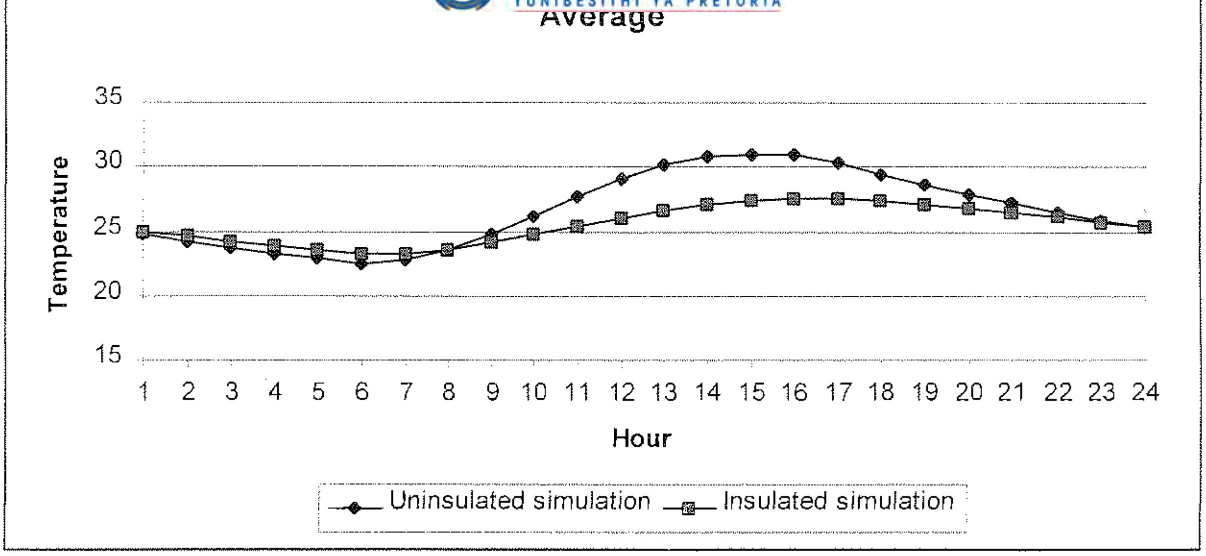


Figure 36 : Simulated indoor temperatures with and without insulation, averaged for eight houses

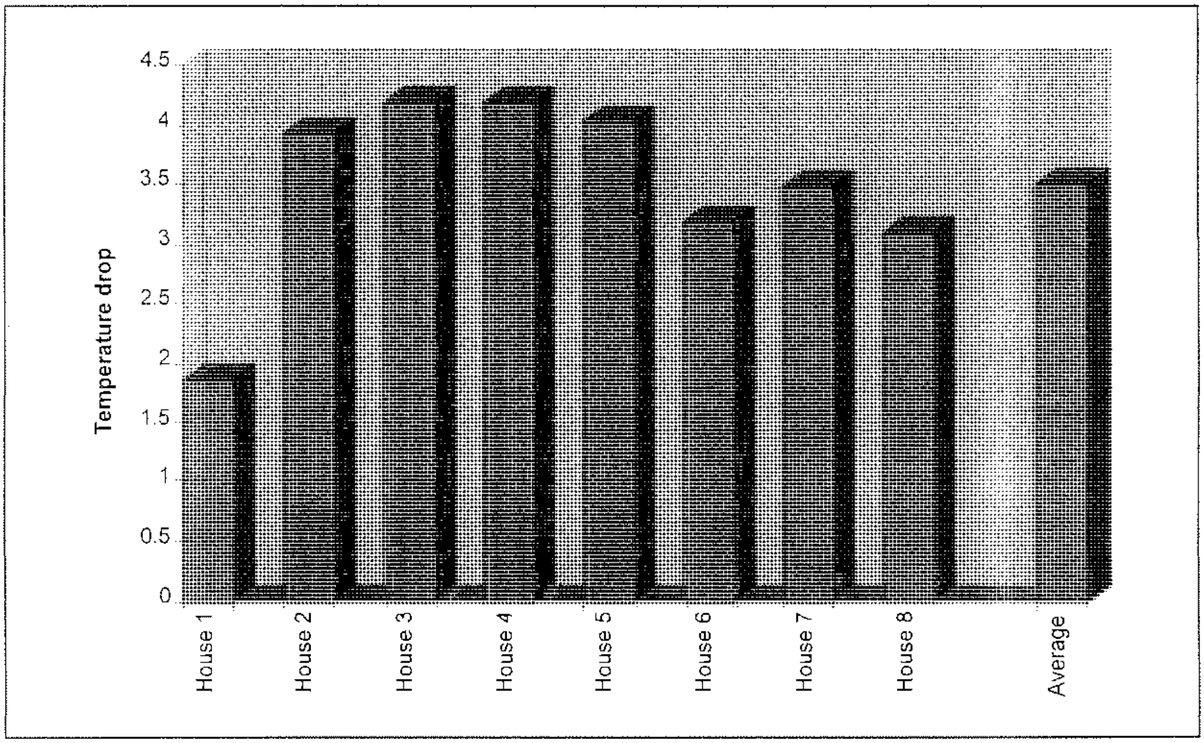


Figure 37 : Decrease in maximum indoor temperature for the houses

From these results it is easy *erolite* to improve indoor thermal comfort. However, the results obtained from the case studies are only valid for Pretoria. In order for *Owens Corning* to launch nation-wide campaigns, results are needed for other South African regions as well.

The most accurate method would be to perform measurements in middle-income houses across the country. A statistical analysis could then be used to predict the comfort benefits of ceiling insulation in the various regions. This is however, a costly and time-consuming task.

It was therefore decided to rather simulate the increased comfort in various regions. This can be done with a tool such as *QUICK II*. This program contains a database of fourteen different climatic regions in South Africa making it possible to simulate the indoor comfort for any building in South Africa. The results from these simulations are discussed in Section 5.

5. Predicting The Nation-Wide Effect of *Aerolite*

5.1. Introduction to simulations

5.1.1. Assumptions for the typical house

Before nation-wide simulations could be done, a typical house to represent the majority of middle-income houses in South Africa had to be found. To decide on a typical construction for middle-income houses however, is a difficult task. This is due to the many variables encountered with middle to high-income houses.

The cost of a house is not only determined by it's size but also by it's condition, the garden, outdoor facilities (e.g. pool and braai-area) and location. Prices of similar houses in different suburbs also vary. This may be because of aspects such as unique designs etc. However, estate agents contacted across the country [14, 15, 16, 17, 18] agreed that a typical house of the higher middle-income group would consist of the following:

- 3 or 4 bedrooms
- 2 bathrooms
- Lounge, kitchen, dining room
- Study or family room
- Double garage with domestic quarters/toilet

It was decided that the most important factor in determining a typical house would be the total floor area. This figure normally includes the garage and outbuildings. It would be virtually impossible to find typical values for finer details such as window sizes, exterior shading, finishing, type of flooring etc.

An estate agent in Pretoria ca... d earning approximately R10 000 per month, could afford a house costing R183 000. The interest rates of January 1996 were used for the calculation. This was done at the beginning of the project when the simulations were planned. Table 9 shows typical floor areas of houses in different suburbs in Pretoria in this price range [75].

Table 9 : Typical floor area for houses in various suburbs in Pretoria

Suburb	Floor area [m^2]
Capital Park	174
Doringpoort	275
Doringkloof	156
Elardus Park	136
Villeria	137
Montana Park	115
Wierda Park	135
Orchards	250
Queenswood	170
Sinoville	157
Sunnyside	185
Rooihuiskraal	195
Rietfontein	170
AVERAGE	**173**

It can be seen that the size of the house is largely dependent on the location. The average floor area of 173 m^2 does however, give a good indication of the typical size of house in Pretoria. Floor areas for houses in other cities were also found. Typical floor areas that can be expected for houses in the major cities in the country are given in Table 10.

Table 10 : Typical flo[illegible]*er cities in South Africa [76-79]*

Major City	Total floor area [m²]
Johannesburg	200
Durban	160
Bloemfontein	180-200
Cape Town	150-180
AVERAGE	**178**

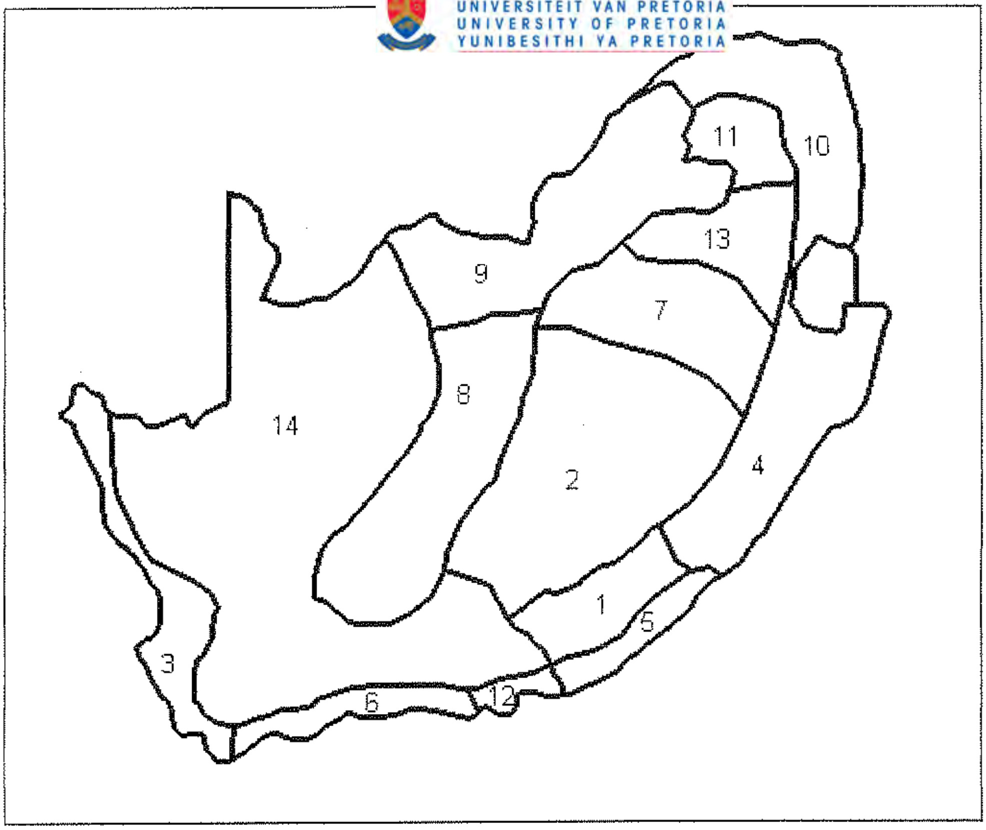
The houses used in for the case studies were chosen to fit in with the above requirements. An exception is House 2 (a town house) chosen to represent it's own portion of the market. Some of the other houses are also slightly larger or smaller than the average floor area given in Table 9. However, they still have all the same elements of a typical house as discussed earlier.

This proves that any one of the eight houses can be chosen to represent a typical South African middle to high-income house. It was therefore decided to use the two houses showing the best and least improvement in indoor comfort in Pretoria for the nation-wide simulations.

5.2. Nation-wide comfort simulations

5.2.1. Simulations using *QUICK II*

For the nation-wide simulations, the fourteen standard climatic regions in *QUICK II* were used. These regions are shown in Figure 38. The assumptions as mentioned above were taken into account when these models were compiled.



1	Bisho	8	Kimberley
2	Bloemfontein	9	Mmabatho
3	Cape Town	10	Phalaborwa
4	Durban	11	Pietersburg
5	East London	12	Port Elizabeth
6	George	13	Pretoria
7	Jan Smuts	14	Upington

Figure 38 : Standard climatic regions in QUICK II

Simulations were conducted for each of the eight houses as if they were situated in every region in South Africa. It was decided to choose the best/worst house based mainly on average temperature drop. This is because a house might not have the best temperature drop in all regions. According to this criteria house 4 showed the best improvements, while house 1 showed the lowest improvements.

5.2.2. Results obtained from

Table 11 : Summary of nation-wide simulations

	Average Improvements			Best Case			Worst Case		
	Unins	Ins	Impr.	Unins	Ins	Impr.	Unins	Ins	Impr.
Bisho	30.7	27.4	3.3	31.1	27.3	3.8	28.0	26.0	1.9
Bloemfontein	32.4	29.2	3.1	33.1	29.3	3.7	30.5	28.5	2.0
Cape Town	29.9	26.5	3.3	30.3	26.3	3.9	27.2	25.3	1.9
Durban	31.5	28.7	2.7	32.1	28.6	3.5	29.6	27.7	1.9
East London	30.3	27.3	2.9	30.6	27.0	3.5	27.3	25.5	1.7
George	29.7	26.0	3.6	29.9	25.6	4.3	26.6	24.3	2.2
Jan Smuts	29.9	26.3	3.6	30.5	26.3	4.2	27.6	25.2	2.4
Kimberley	35.5	32.0	3.5	36.4	33.2	3.2	33.9	31.3	2.5
Mmabatho	34.3	30.7	3.6	35.0	31.0	4.0	32.0	29.7	2.3
Phalaborwa	36.5	33.0	3.5	37.4	32.8	4.6	34.6	32.1	2.5
Pietersburg	31.8	28.3	3.5	32.6	28.4	4.2	29.7	27.3	2.4
Port Elizabeth	28.7	25.6	3.1	29.0	25.3	3.7	25.7	23.8	1.8
Pretoria	31.2	28.2	3.0	31.8	28.2	3.6	29.1	27.0	2.0
Upington	37.6	34.5	3.0	38.4	34.8	3.5	35.9	34.1	1.8
		Maximum improvement	3.6		Maximum improvement	4.6		Maximum improvement	2.5
		Average improvement	3.3		Average improvement	3.9		Average improvement	2.1
		Minimum improvement	2.7		Minimum improvement	3.2		Minimum improvement	1.7

- Unins: - Uninsulated
- Ins: - Insulated
- Impr: - Improvement

House 4 had a maximum drop in temperature of 4.6°C in the Phalaborwa region, and an average drop of 3.9°C in all the other regions. The lowest improvement was for house 1 in the East London region with a drop of only 1.7°C and an average drop for all the regions of 2.1°C. The other houses all showed an average decrease in temperature of between 3 and 4°C, because of ceiling insulation.

After implementing the satisfaction criteria as described in section 1.2 it can be seen that if *Aerolite* is installed more than 90% of the people will regard their indoor comfort as acceptable. e 12 are based on the simulation values given in Table 11 for **average** improvements in indoor temperature.

Table 12 : Average satisfaction improvements for whole country (Simulated)

Region	Satisfaction before insulation	Satisfaction after insulation	Satisfaction improvement
Bisho	20%	90%	70%
Bloemfontein	<10%	68%	>58%
Cape Town	52%	95%	43%
Durban	<10%	75%	>65%
East London	30%	90%	60%
George	53%	98%	45%
Jan Smuts	52%	96%	44%
Pietersburg	<10%	80%	>70%
Port Elizabeth	73%	98%	25%
Pretoria	<10%	81%	>71%
Average	**<32%**	**87%**	**>55%**

To give a better idea of the improvements a bar chart is given showing the satisfaction improvements (Figure 39).

indoor comfort as acceptable. ble 12 are based on the simulation values given in Table 11 for **average** improvements in indoor temperature.

Table 12 : Average satisfaction improvements for whole country (Simulated)

Region	Satisfaction before insulation	Satisfaction after insulation	Satisfaction improvement
Bisho	20%	90%	70%
Bloemfontein	<10%	68%	>58%
Cape Town	52%	95%	43%
Durban	<10%	75%	>65%
East London	30%	90%	60%
George	53%	98%	45%
Jan Smuts	52%	96%	44%
Pietersburg	<10%	80%	>70%
Port Elizabeth	73%	98%	25%
Pretoria	<10%	81%	>71%
Average	**<32%**	**87%**	**>55%**

To give a better idea of the improvements a bar chart is given showing the satisfaction improvements (Figure 39).

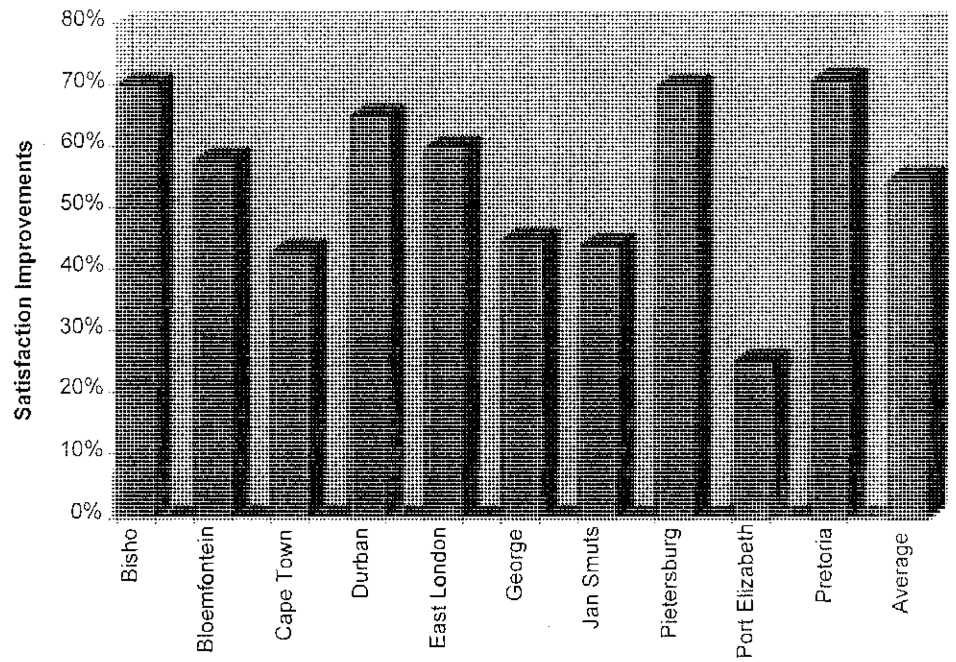


Figure 39 : Average satisfaction improvements derived from the simulations for insulated houses

Table 13 : Best satisfaction improvements for whole country (Simulated)

Region	Satisfaction before insulation	Satisfaction after insulation	Satisfaction improvement
Bisho	<10%	90%	>80%
Bloemfontein	<10%	68%	>58%
Cape Town	30%	96%	66%
Durban	<10%	75%	>65%
East London	30%	92%	62%
George	52%	98%	46%
Jan Smuts	19%	96%	77%
Pietersburg	<10%	80%	>70%
Port Elizabeth	70%	98%	28%
Pretoria	<10%	81%	>71%
Average	**<25%**	**87%**	**>62%**

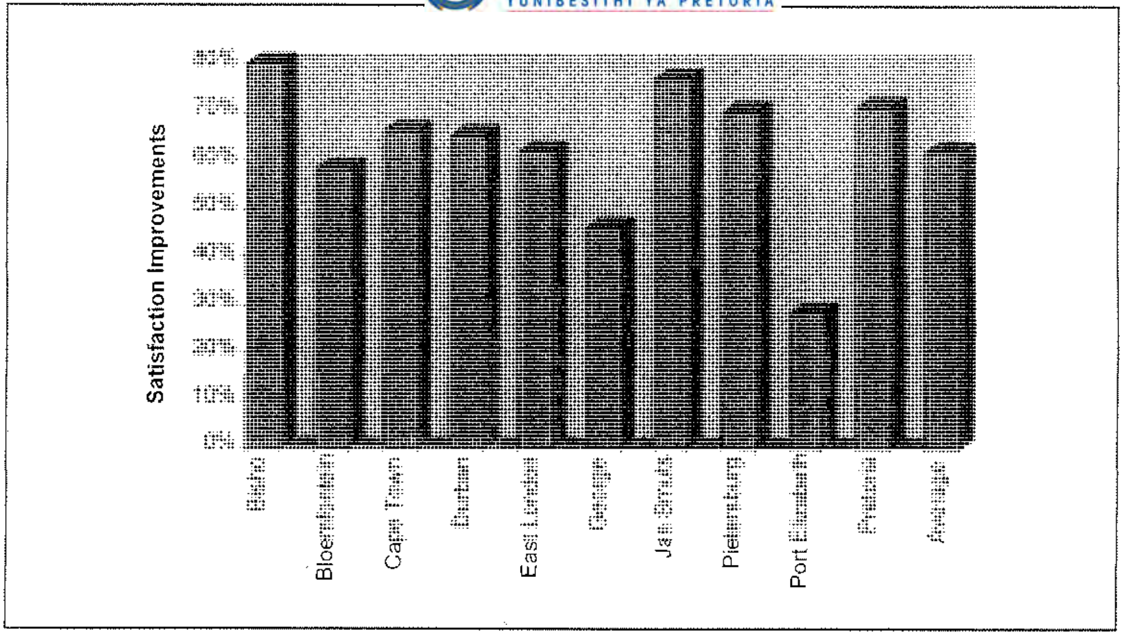


Figure 40 : *Best satisfaction improvements derived from the simulations for insulated houses*

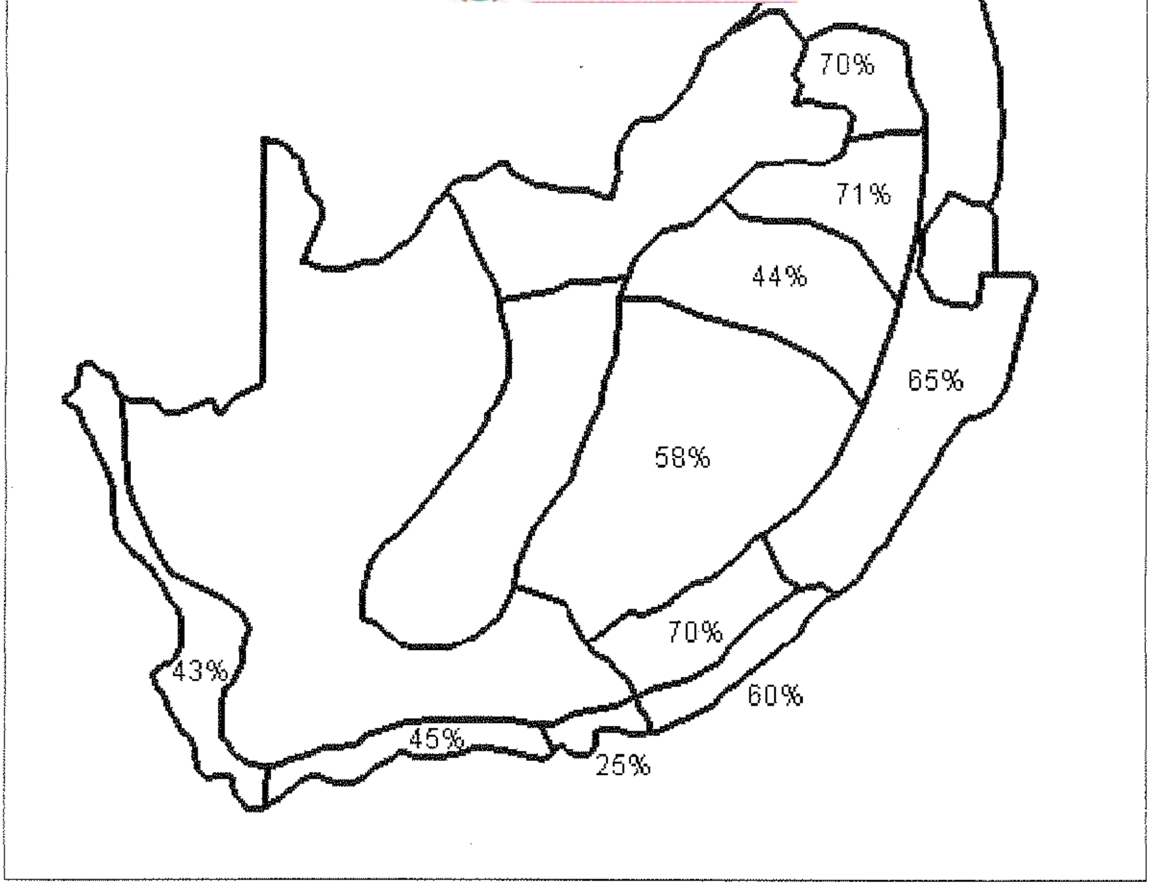


Figure 41 : Best satisfaction improvements

For a better visual representation of the differences in indoor comfort, the temperatures obtained with and without ceiling insulation are shown on maps of South Africa. Figure 42 shows the best case, Figure 43 the worst case and Figure 44 shows the average for all eight houses.

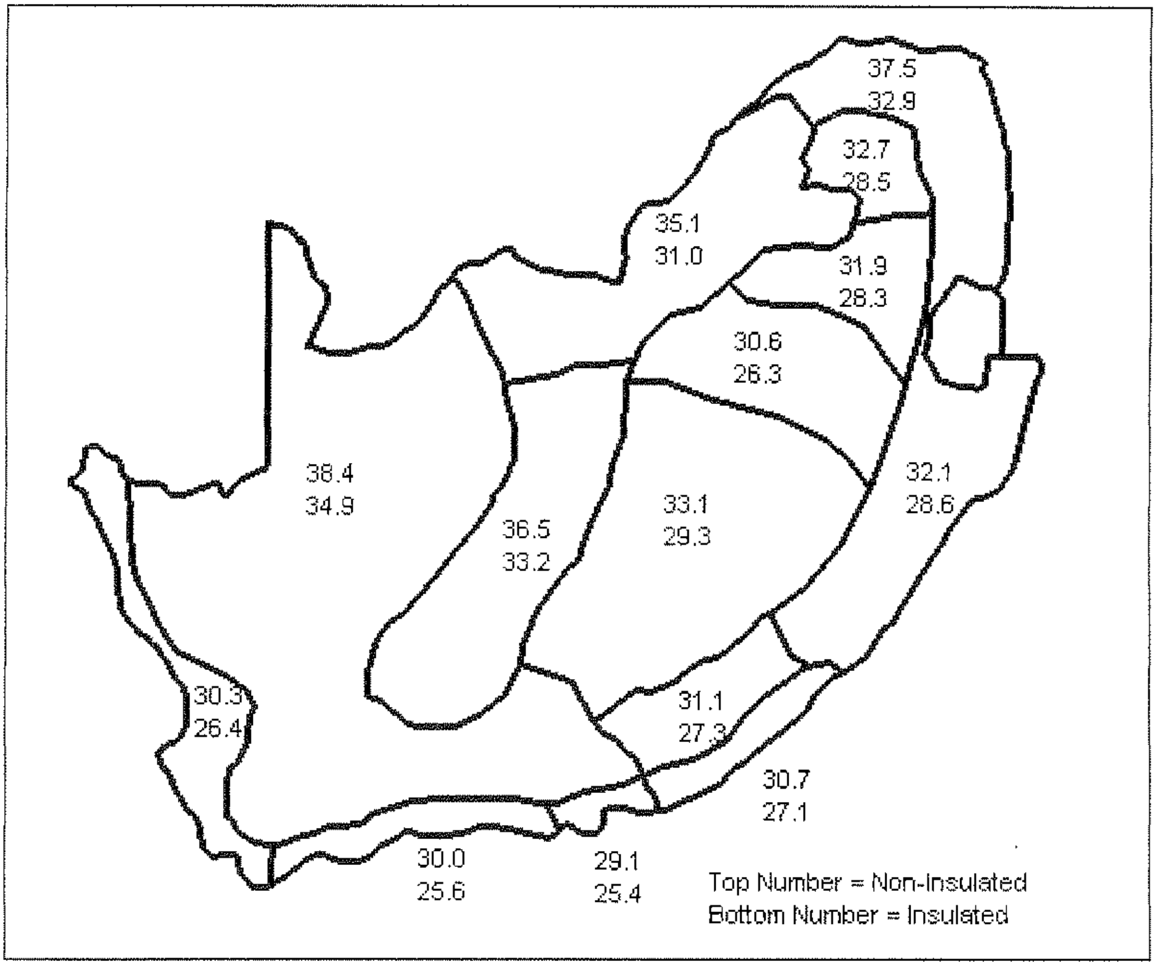


Figure 42 : Best Case - Nation-wide improvements in maximum indoor temperature

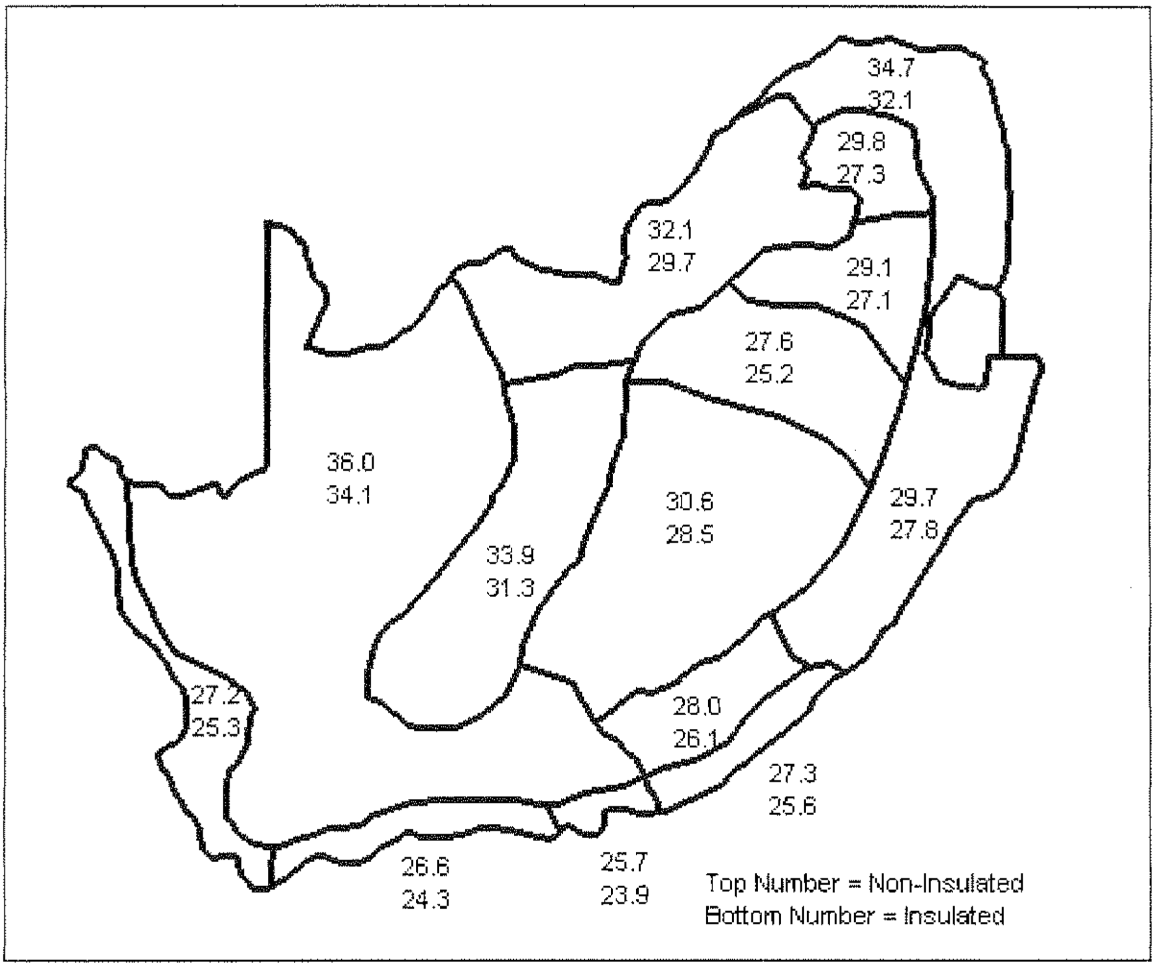


Figure 43 : Worst Case - Nation-wide improvements in maximum indoor temperature

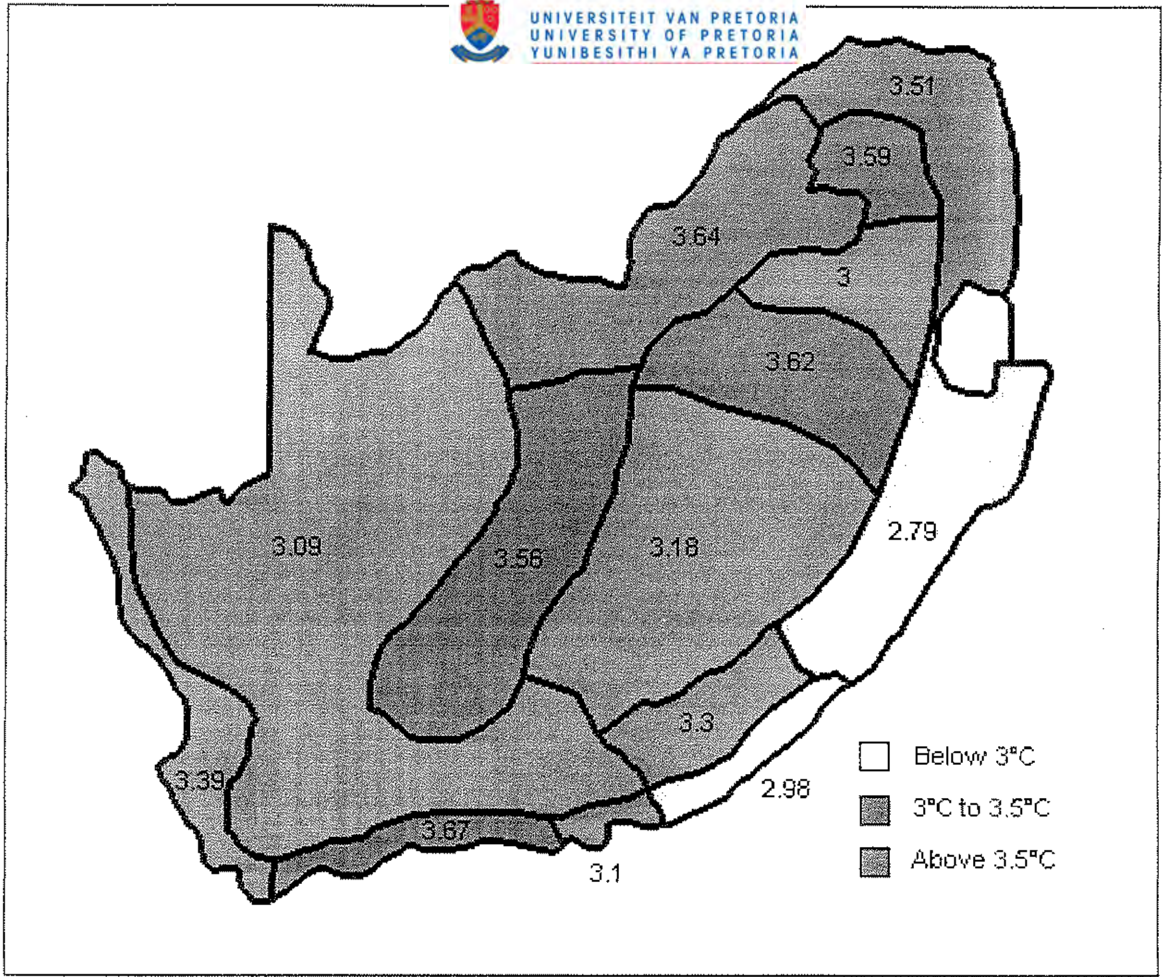


Figure 44 : Average Nation-wide improvements in maximum indoor temperature

The most favorable results were obtained in the hottest climatic regions in the country. These results show a great improvement in the reduction of the maximum indoor temperature. These are the areas where such improvements are most needed. Some other areas also show good improvements, although the maximum outdoor temperatures in these regions are not as high.

The results prove that ceiling insulation can decrease indoor temperatures in typical South African houses by at least 3°C in most areas and by almost 4°C in the warm regions.

6. Summary and Strategy

6.1. Summary

The aim of this chapter was to investigate the effects *Aerolite* would have on domestic households. These effects were researched in two specific areas. They were the monetary savings due to reduced electricity bills in winter and the comfort improvements inside a house due to the reduction of indoor temperature in the summer.

It was found that the average household could save R 260.00 per year, which resulted in a payback period of between four and six years. The monetary savings were achieved mainly during the winter months when electrical heaters were used.

A further advantage of *Aerolite* is the improved comfort felt in the summer months. From the results of the case studies undertaken it was found that houses insulated with *Aerolite* showed an average improvement of 3.1 °C in indoor comfort. The best result obtained was a decrease of 4.5 °C in House 6.

The simulations done for the nation-wide comfort improvements showed an average improvement of 3.3 °C. The best improvement in indoor comfort was obtained in the Phalaborwa region. The improvement was 4.6 °C.

A further estimate was that 32 % of the population would find the indoor comfort acceptable before *Aerolite* is installed. After *Aerolite* is installed, the number of people who will find the indoor temperature acceptable will grow to 87%. This means that almost three times more people would be satisfied with their indoor temperature if *Aerolite* is installed.

These results are useful to bo[illegible] ESKOM. Owens Corning will use these results to improve their sales of insulation due to the scientific results that can back their claims, while ESKOM will benefit from the resulting drop in electricity demand. This is a major and attainable part of RDSM as discussed in Chapter 1 to Chapter 2: The installation of *insulation* and *ceilings*.

6.2. Recommendations

From the results it is important to notice that the indoor comfort improvements will only be felt if people are at home during the hottest part of the day. It makes sense to aim your marketing campaign mainly at people who are at home from 11h00 to 18h00.

People will want increased comfort over the weekends and in holidays that are spent at home. People like housewives are always at home and thus they should be the target group when comfort is considered. The working people will find the reduction in electricity bills in winter months more appealing because they are at home during the evenings when heaters are often used.

A sensible slogan should be considered like :

1) "Changes your indoor situation from *uncomfortable to comfortable*". or

2) "2 ½ times more people are comfortable with *Owens Corning* insulation installed"

An article using one of the participants of the case study should be published in a magazine like "HUISGENOOT" or "YOU". These magazines are read by the people who should be considered as a target market.

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12 van Heerden, E., *Integrated simulation of building thermal performance. HVAC system and control*., June 1997, University of Pretoria, Mechanical Engineering, Phd

13 van Heerden, E., *Preliminary report for doctoral thesis under Prof. E.H. Mathews*, January 1996, University of Pretoria, Mechanical and Aeronautical Engineering,

14, Personal communication with Mrs Jean Klein, *ADENIA Properties*, Pretoria, (012) 46 6990

15 Personal communication with Ms Angela Heyns., *Eskel Jawitz Properties* (JHIsaacs Group) (011) 880-3550.

16 Personal communication with estate agent from *Chellin Estates*, Durban, (031) 469 1044.

17 Personal communication with Ms Karin Oosthuizen, *Dan Pienaar Eiendomme*, Bloemfontein (051) 447 8999.

18 Persomal communication with Ms Herculene Visser, SEEF Properties, Cape Town (021) 797 8879.

Appendix A-F

APPENDIX A

QUESTIONNAIRES FOR SOCIO ECONOMIC STUDY

(Please answer all questions and mark your choices with an X next to the correct option)

Question 1

What is your age: ____________

Male	
Female	

Question 2

Where do you currently live? (Township.) ________________________________

Question 3

How far do you live from your nearest business center (hardware store)?

____________km

Question 4

What type of transport do you use to do shopping with?

Bicycle	
Bus	
Taxi	
Train	
A friend's car	
My own car	

Question 5

Do you have your own car?

Yes	
No	

If **No**, does one of your close friends or family who live close to you have a car?

Yes	
No	

Question 6

What type of house do you live in?

Informal structure	
Brick walls, flat roof	
Brick walls, standing roof	
Hostel or flat	

Question 7

Who is the owner of the house you live in?

Yourself or husband/wife	
Someone else	

Question 8

Does your house have a ceiling?

Yes	
No	

If **yes** answer the following:

Do you feel comfortable in your house? Did the ceiling improve the indoor comfort in your house?

Yes, Definite improvement	
No, Don't feel any difference	

Question 9

Do you like the appearance of the ceiling you have just seen?

Yes	
No	

What did you like most about the ceiling?______________________________

____

Question 10

Does the ceiling make your house look better on the inside ?

Yes	
No, there is no change	

Question 11

Does the ceiling increase the indoor brightness?

Yes, it seems brighter	
There is no change	

Question 12

Do you think this product will last for a long time?

Yes	
No	

Question 13

Would you want to change the ceiling's appearance the installation method?

No, I'm happy with the appearance and the installation	
Yes, I want to change …	

If **Yes**, please mention:____

____

____

Question 14

Do you think you can install this product yourself?

Yes	
No	

Question 15

Do you think someone can run a successful business by installing these ceilings on a permanent basis.

Yes	
No	

Question 16

Would you buy this ceiling?

Yes	
No	

Why? ____

Question 17

How much would you be prepared to **pay** for this ceiling material and to have it installed in a room the same size as this one?

R 50 – R100	
R100 – R150	
R150 – R200	
R200 – R250	
R250 – R300	
R300 – R350	
R350 – R400	
More than R400	

Question 18

If the instructions and material were freely available would you pay to have the ceiling installed or would you install it yourself?

Do it myself	
Pay someone else	

Question 19

If you can't afford to pay cash to buy this ceiling, how much would you be able to pay **per month**?

Less than R20	
R20-R50	
R50-R70	
R70-R100	
R100 – R120	
More than R120	

Question 20

Do you think this type of ceiling must be included in all new low cost houses?

Yes	
No	

Question 21

Why do you think it is important to have a ceiling in your house?

____

____

____

____

____

____

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

(Beantwoord al die vrae en merk die toepaslike antwoorde met 'n X)

Vraag 1

Wat is jou ouderdom: ____________

Man	
Vrou	

Vraag 2

In watter omgewing bly jy? ("Township") ________________________________

Vraag 3

Hoe ver bly jy van jou naaste hardeware winkel af?

____________km

Vraag 4

Watter tipe vervoer gebruik jy tipies as jy gaan inkopies doen?

Fiets	
Bus	
Taxi	
Trein	
'n Vriend se motor	
My eie motor	

Vraag 5

Besit jy jou eie motor?

Ja	
Nee	

As Nee, besit een van jou nabye vriende of famililede wat by jou bly 'n motor?

Ja	
Nee	

Vraag 6

In watter tipe huis bly jy?

Informele struktuur	
Baksteen mure, plat dak	
Baksteen mure, staan dak	
"Hostel" of woonstel	

Vraag 7

Wie is die eienaar van die huis waarin jy tans bly?

Jyself of jou man/vrou	
Iemand anders	

Vraag 8

Besit jou huis 'n plafon?

Ja	
Nee	

Vraag 9

Hou jy van hoe die plafon lyk (wat jy nou net gesien het)?

Ja	
Nee	

Waarvan hou jy die meeste?____

____

Vraag 10

Lyk die huis beter met die plafon of is daar nie eintlik 'n verskil nie ?

Ja, lyk beter	
Nee, geen verskil	

Vraag 11

Lyk dit asof daar 'n verandering in die beligting van die huis is met die plafon?

Ja, binnekant lyk ligter	
Nee, sien geen verandering nie	

Vraag 12

Dink jy die plafon sal oor 'n paar jaar nog mooi lyk?

Ja	
Nee	

Vraag 13

Sal jy die plafonmateriaal en die installasiemetode wil verander ?

Nee, ek is gelukkig met die materiaal en die installasie metode	
Ja ek sal die volgende wil verander…	

As Ja, noem asseblief:____

____

____

Vraag 14

Sal jy die plafon self kan installeer?

Ja	
Nee	

Vraag 15

Sal iemand 'n suksesvolle besigheid kan begin deur die plafonne op 'n permanente basis te installeer.

Ja	
Nee	

Vraag 16

Sal jy die plafon koop?

Ja	
Nee	

Hoekom?____

Vraag 17

Hoeveel sal jy bereid wees om iemand te betaal om vir jou die plafon te kom installeer (prys sluit plafonmateriaal in) ?

R 50 – R100	
R100 – R150	
R150 – R200	
R200 – R250	
R250 – R300	
R300 – R350	
R350 – R400	
Meer as R400	

Vraag 18

As die instruksies en die materiaal verkrygbaar is sal jy die plafon self installeer of sal jy iemand betaal om dit vir jou te doen?

Doen dit self	
Betaal iemand anders	

Vraag 19

As jy nie kontant kan betaal nie, hoeveel sal jy per maand kan betaal om die plafon te koop?

Minder as R20	
R20-R50	
R50-R70	
R70-R100	
R100 – R120	
Meer as R120	

Vraag 20

Dink jy alle nuwe lae koste huise moet met so 'n plafon toegerus word?

Ja	
Nee	

Vraag 21

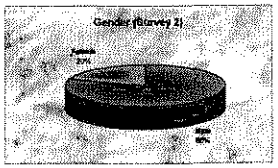
Hoekom is dit belangrik om 'n plafon in jou huis te hê?

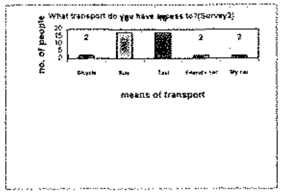
____
____
____
____
____
____

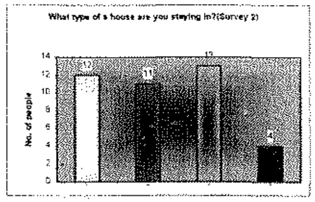
APPENDIX B

OTHER RESULTS FROM MARKET SURVEY

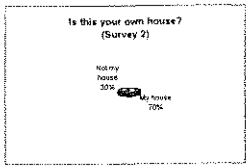
Question 1		Question 2	Question 3	Question 4					Question 5			
			How far is the nearest hardware store	What type of transport do you use					What type of house do you live in?			
Male	Female	Township		Bicycle	Bus	Taxi	Friend's car	My car	Temp Str	Brick/flat	Brick/standi	Hostel/flat
1	0	Eersterust	25km	0	0	1	0	0	1	0	0	0
1	0	Hammanskraal	25km	0	1	0	0	0	0	1	0	0
1	0	Hammanskraal	40km	0	1	0	0	0	1	0	0	0
1	0	Soshanguve	2km	0	0	1	0	0	0	1	0	0
1	0	Mamelodi	2km	0	0	1	0	0	0	0	1	0
0	1	Soshanguve	55km	0	1	0	0	0	0	0	1	0
1	0	Hammanskraal	25km	0	1	0	0	0	0	0	1	0
0	1	Kwa-Mhlanga	2km	0	1	0	0	0	0	1	0	0
1	0	Makapanstad	75km	0	1	0	0	0	0	1	0	0
1	0	Lynnwood	2km	0	0	1	0	0	0	0	0	1
1	0	Atteridgeville	15km	0	1	0	0	0	0	1	0	0
0	1	Mamelodi	25km	0	0	1	0	0	0	0	1	0
1	0	Temba	1km	0	0	1	0	0	1	0	0	0
1	0	Mabopane	20km	0	1	0	0	0	0	1	0	0
1	0	Ookasie(Brits)	30km	0	1	0	0	0	0	0	1	0
1	0	Arcadia	3km	0	0	1	0	0	0	0	0	1
1	0	Mpumalanga	3km	0	1	0	0	0	0	1	0	0
0	1	Pretoria	5km	0	1	0	0	0	0	0	0	1
1	0	Mamelodi	7km	0	0	1	0	0	1	0	0	0
0	1	Soshanguve	30km	0	0	0	0	1	0	0	1	0
1	0	Marapyane	10km	0	1	1	0	0	0	0	1	0
1	0	Mamelodi	5km	0	0	0	0	1	0	1	0	0
1	0	Mamelodi	50km	0	0	1	0	0	0	1	0	0
1	0	Eersterust	15km	0	1	1	0	0	0	0	1	0
1	0	Mabopane	500km	1	0	0	0	0	1	0	0	0
0	1	Pretoria	10km	0	0	1	0	0	1	0	0	0
0	1	Kwa-Mhlanga	3km	0	1	0	0	0	0	1	0	0
1	0	winterveldt	7km	0	0	1	0	0	1	0	0	0
1	0	cullinan	5km	0	0	1	0	0	0	0	1	0
1	0	Soshanguve	3km	0	0	0	1	0	0	0	0	1
1	0	Mabopane	500km	0	1	0	0	0	1	0	0	0
1	0	Mamelodi	10km	0	0	0	1	0	1	0	0	0
1	0	kwarielagte	10km	0	0	1	0	0	1	0	0	0
1	0	Vaalbank	0.5km	1	0	0	0	0	0	1	0	0
1	0	Hammanskraal	20km	0	1	0	0	0	1	0	0	0
0	1	Mamelodi	12km	0	1	0	0	0	0	0	1	0
1	0	Eersterust	100km	0	0	1	0	0	0	0	1	0
1	0	Mamelodi	12km	0	1	0	0	0	1	0	0	0
1	0	Soshanguve	20km	0	0	1	0	0	0	0	1	0
1	0	Soshanguve		0	0	1	0	0	0	0	1	0
32	8	Average		2	18	18	2	2	12	11	13	4

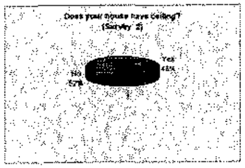


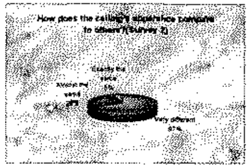


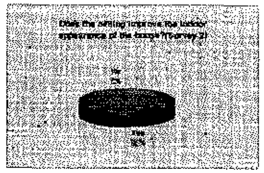


Question 6 Is this your house/Family/friend My house	 Not my house	Question 7 Does your house have ceiling? Yes	 No	Question 8 Do you like the appearance of the ceiling ? Yes	 No	Question 9 How does the ceiling's appearance compare to others? Very differ	 Almost th	 Exactly the same	Question 10 Does the ceiling improve the indoor appearance? Yes	 No
0	1	1	0	1	0	1			1	
1	0	1	0	1	0			1	1	
0	1	0	1	1	0		1			1
1	0	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
1	0	1	0	1	0	1			1	
1	0	1	0	1	0	1			1	
0	1	1	0	1	0	1			1	
1	0	1	0	1	0		1		1	
0	1	0	1	1	0	1			1	
1	0	1	0	1	0		1		1	
0	1	1	0	0	1	1			1	
1	0	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
0	1	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
1	0	1	0	1	0		1		1	
0	1	0	1	1	0	1				1
1	0	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
1	0	0	1	1	0	1			1	
1	0	0	1	0	1	0	1	0	1	0
0	1	1	0	1	0	1	0	0	1	0
1	0	1	0	1	0	0	1	0	1	0
0	1	0	1	1	0	1	0	0	1	0
0	1	1	0	1	0	1	0	0	1	0
1	0	0	1	1	0	0	0	1	1	0
1	0	0	1	1	0	0	1	0	1	0
1	0	1	0	1	0	1	0	0	1	0
1	0	1	0	1	0	0	1	0	1	0
1	0	0	1	1	0	1	0	0	1	0
1	0	1	0	1	0	0	1	0	1	0
1	0	0	1	1	0	1	0	0	1	0
0	1	0	1	0	1	0	1	0	1	0
1	0	1	0	0	1	1	0	0	1	0
1	0	1	0	1	0	1	0	0	1	0
0	1	0	1	1	0	1	0	0	1	0
1	0	1	0	1	0	1	0	0	1	0
1	0	1	0	1	0	0	1	0	1	0
28	12	19	21	36	4	27	11	2	38	2

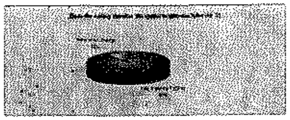


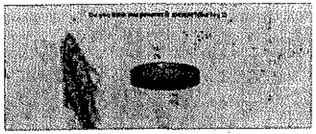


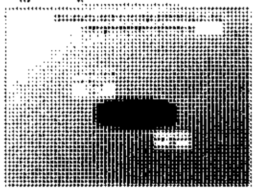


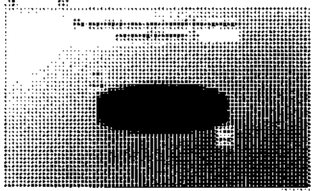


Question 11		Question 12		Question 13		Question 14	
Does the ceiling increase the indoor brightness?		Do you think this product is durable?		Would you want to change something on the ceiling/installa		Dou think you can install this product yourself?	
Yes, it see	There is no change	Yes	No	No,I am hap	Yes,I want to change to change somethin	Yes	No
1		1		1		1	
1		1			1	1	
1		1		1		1	
1		1		1		1	
1		1		1			1
1		1		1		1	
1		1		1		1	
1		1			1	1	
1		1		1		1	
1		1		1			1
0	1	1		1		1	
1		1		1		1	
1		1		1		1	
1		1		1			1
0	1	1		1		1	
1		1			1	1	
1		1		1			1
1		1		1		1	
1		1		1			1
1		1		1			1
1		1		1		1	
1		1		1		1	
1		1		1	0	1	0
1	1	1		1		1	0
1	0	1		1	0	1	0
1	0	1		0	1	0	1
1	0	1			1	1	0
1	0	1		1	0	0	1
1	0	1		1	0	1	0
1	0	1		1	0	0	1
1	0	1		1	0	1	0
1	0	1		1	0	1	0
1	0	1		1	0	1	0
1	0	0		1	0	1	0
1	0	1		1	0	0	1
1	0	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	1	0	1	0
1	0	1	0	1	0	0	1
1	0	1	0	[illegible]	[illegible]	[illegible]	[illegible]
37	4	37	2	###	###	###	###





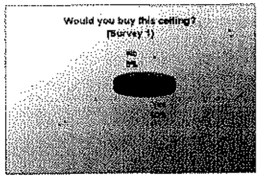




Question 15
Do you think some one can run a successful business by installing these ceilings on permanent basis?

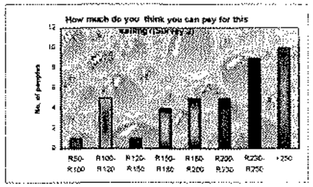
Question 16
Would you buy this ceiling ?

Q15 Yes	Q15 No	Q16 Yes	Q16 No
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
1		1	
	1	1	
1		1	
1			1
1		1	
1		1	
	1	1	
	1	1	
1		1	
1		1	
1		1	
1		1	
1		1	0
1		1	
1	0	1	0
1	0	1	0
1	0	0	1
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
0	1	0	1
1	0	1	0
1	0	1	0
1	0	1	0
1	0	1	0
36	4	37	3



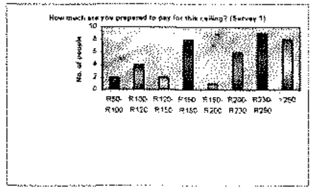
Question 17
How much do you think this ceiling cost?

R50-R100	R100-R12	R120-R15	R150-R18	R180-R20	R200-R23	R230-R250	>250	
						1		
			1					
	1							
						1		
							1	
							1	
			1					
						1		
	1							
							1	
			1					
	1							
					1			
						1		
1								
				1				
					1			
					1			
				1				
							1	
				1				
				1				
						1		
0						1		
0			1					
		1						
							1	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	0	1	
0	0	0	0	0	1	0	0	
0	0	0	0	0	1	0	0	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	1	0	
0	1	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	
0	0	0	0	0	0	1	0	
0	0	0	0	1	0	0	0	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	1	0	
1	5	1	4	5	5	9	10	0



Question 18
how much are you prepare to pay for this ceiling?

R50-R100	R100-R120	R120-R150	R150-R180	R180-R200	R200-R230	R230-R25	>250	
						1		
					1			
	1							
			1					
							1	
							1	
					1			
						1		
	1							
							1	
			1					
	1							
			1					
						1		
1								
							1	
					1			
					1			
			1					
						1		
						1		
				1				
			1					
						1		
			1					
			1				0	
							1	
0	0		0	0	0	0	1	
0	0		0	0	0	0	1	
0	0		0	0	0	1	0	
0	0	0	0	0	1	0	0	
0	0	0	0	0	0	1	0	
0	0	1	0	0	0	0	0	
0	0	0	0	0	0	0	1	
1	0	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	
0	0	1	0	0	0	0	0	
0	0	0	0		0	1	0	
0	0	0	0	0	1	0	0	
0	0	0	1	0	0	0	0	
2	4	2	8	1	6	9	8	0



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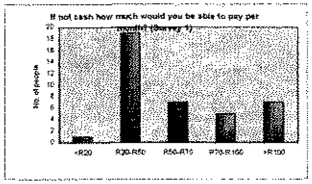
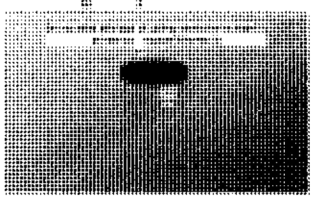
Question 19
If the instructions were freely available would you pay to have the ceiling installed/install it yourself?

Question 20
If not cash how much would you be able to pay per month?

Question 21
Do you think this type of ceiling should be included in all new low cost houses?

Do it myself	Pay someone else	<R20	R20-R50	R50-R70	R70-R100	>R100	Yes	No
1						1		1
1				1			1	
1			1				1	
1					1			1
	1					1	1	
	1					1	1	
1			1				1	
	1		1				1	
1			1				1	
	1				1		1	
1			1				1	
1			1				1	
1		1					1	
	1			1			1	
1			1				1	
1				1			1	
1			1				1	
	1		1				1	
1						1	1	
	1		1				1	
1				1			1	
1				1			1	
	1			1			1	
1						1	1	
1			1				1	
0	1		1				0	1
1	0	0	0	0	0	1	1	
0	1	0	0	0	1	0	1	0
1	0	0	0	0	1	0	1	0
1	0	0	1	0	0	0	1	0
1	0	0	1	0	0	0	1	0
1	0	0	0	0	0	1	1	0
1	0	0	0	0	1	0	1	0
1	0							
1	0	0	1	0	0	0	1	0
1	0	0	1	0	0	0	1	0
1	0	0	1	0	0	0	1	0
1	0	0	1	0	0	0	1	0
0	1	0	0	1	0	0	1	0
1	0	0	1	0	0	0	1	0
26	11	1	19	7	5	7	[illegible]	[illegible]





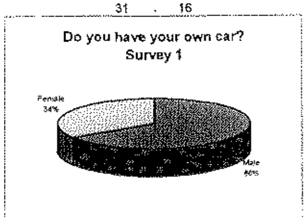
Question 22
Why do you think it is important to have a ceiling in your house?

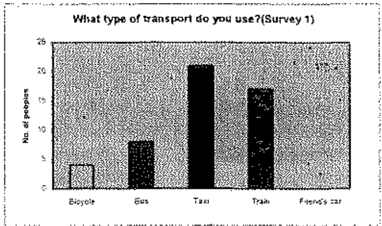
This ceiling is bright and good
It is very important to have a ceiling in my house,it modify the house, it gives the house beautiful shape

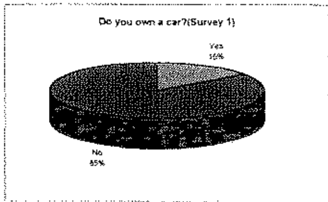
To keep warmth in you house during winter and to keep it cool in summer also to give your house a nicer view
Brightness/and warming winter
Because when the rain is falling, the ceiling protect my house
You cant hear the rain and the wind
Because my winter is cold my summer is hot
As warm is,dan dit hou die huis warm toe
To prevent noise normally caused by the noise and to stabilize the temperature
Because it keeps my house bright and nice and warm in winter
Because is so cheap not heavy and easy to install

Bright and warm
This is not a better ceiling because it if it is raining there is much noise,secondly the ceiling is light
cool and heat it looks m odern and more saver
To decrease temperature and put more bright into the house
To decrease temperature and put more bright into the house
hitte oordrag

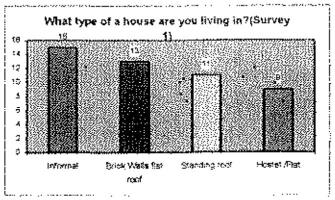
Age	Male	Female	Township	Nearest Hardware store	Transport Type: Bicycle	Bus	Taxi	Train	Friend's car	Own Car? Yes	No	If No, Friend or family Yes	No
42	1		Hammanskraal	15km		1					1	1	
25	1		Mamelodi	13km			1			1			
25	1		Mamelodi	24km			1				1		1
28		1	Mamelodi	10km				1			1	1	
27		1	Saulsville	3km			1				1		1
22		1	Atteridgeville	10km			1				1	1	
23	1		Vaalbak	24km		1				1		1	
21	1		Mamelodi	1km			1				1	1	
35	1		Mabopane	30km				1			1	1	
29	1		Hatfield	4km	1					1			
23	1		Plaas	30km		1					1	1	
37	1		KwaNdebele	3km		1					1	1	
38	1		Garankuwa	40km				1			1	1	
48		1	Eersterust	15km				1			1	1	
26		1	Hammanskraal	30km		1	1				1	1	
48	1		Mabopane	18km				1			1	1	
36	1		Mamelodi	18km				1		1		1	
30	1		Hammanskraal	50km		1				1			
28	1		Eersterust	4km	1						1		1
26		1	Eersterust	4km			1				1	1	
25	1		Mamelodi	13km				1			1	1	
31	1		Sunnyside	5km			1				1		1
30	1		Tembisa	30km			1				1	1	
47		1	Hammanskraal	50km		1				1			
31		1	Atteridgeville	15km			1	1			1	1	
26	1		Pretoria	5km			1				1	1	
36	1		Mamelodi	5km				1			1	1	
26		1	Saulsville	15km				1			1	1	
31	1		Mamelodi	15km				1			1	1	
60	1		Atteridgeville	15km			1				1	1	
40	1		Mamelodi	20km	1					1			
42	1		Mamelodi	15km				1			1	1	
45	1		Siyabuswa	30km			1				1		1
40		1	Mamelodi	30km			1				1	1	
25		1	Mamelodi	20km			1				1		1
44	1		Mamelodi	25km	1						1	1	
34		1	Atteridgeville	15km			1				1	1	
27		1	Atteridgeville	15km			1				1	1	
32		1	Mamelodi	27km				1			1		1
27	1		Eersterust	15km				1			1	1	
32		1	Brits	40km			1				1		1
27	1		Diepsloot	7km			1				1	1	
43	1		Diepsloot	7km				1			1	1	
23	1		Parkview Hotel	3km			1				1		1
42	1		Mamelodi	10km				1			1		1
37		1	Mamelodi	17km			1				1	1	
35	1		Brits	40km		1		1			1		1
	31	16			4	8	21	17	0	7	40	31	11

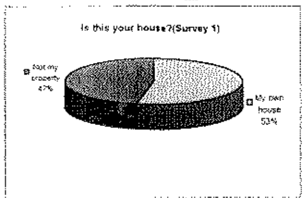


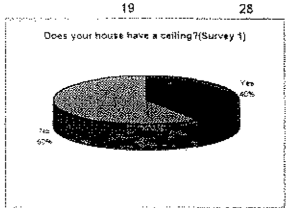


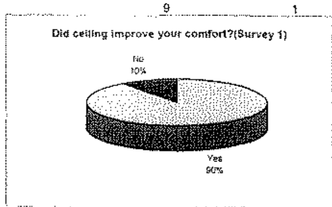


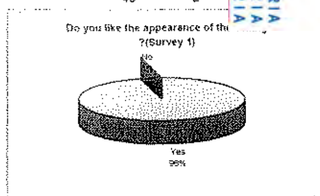
House Type				Is this your house?		Does your house have a ceiling?		If Yes(Did ceiling improve comfort)		Like Ceiling Appearance just seen	
Informal	Brick Walls,flat roof	Standing roof	Hostel /Flat	My own house	Not my property	Yes	No	Yes	No	Yes	No
		1		1			1			1	
			1		1	1		1		1	
	1			1		1		1		1	
		1			1		1			1	
		1		1			1			1	
		1			1		1			1	
	1			1		1				1	
	1				1	1				1	
1				1		1				1	
	1				1	1				1	
	1				1	1				1	
	1			1			1			1	
1				1		1				1	
	1			1		1				1	
		1			1		1			1	
		1		1			1			1	
1				1		1		1		1	
1				1			1			1	
1					1		1			1	
			1		1		1			1	
1					1	1				1	
			1		1	1		1		1	
	1			1			1			1	
			1	1		1			1	1	
		1			1	1		1		1	
			1		1		1			1	
			1		1		1			1	
		1			1		1			1	
			1		1		1			1	
		1		1			1			1	
1				1		1				1	
1	1			1			1			1	
1				1			1			1	
		1		1		1		1		1	
		1			1		1			1	
			1	1			1			1	
1				1			1			1	
1				1			1			1	
	1				1		1			1	
	1				1	1		1		1	
1				1			1			1	
1					1		1				1
1					1		1			1	
			1		1	1		1		1	
	1			1		1		1			1
	1			1			1			1	
1				1			1			1	
15	13	11	9	25	22	19	28	9	1	45	2



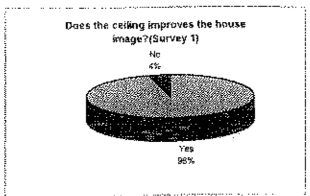


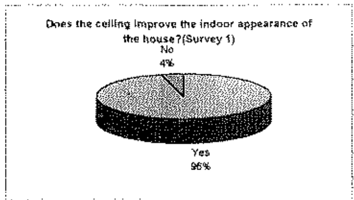


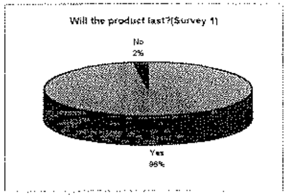


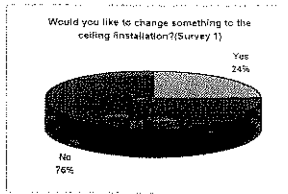


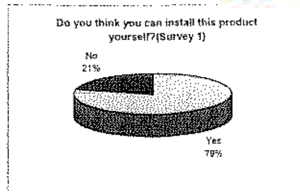
Like most about the ceiling	Does ceiling improves house image Yes	No	Increase Indoor Brightness Yes	No	Will the product last Yes	No	Change the ceiling's appearance If Yes Yes	No	Install Product Yourself Yes	No
	1		1		1		1			1
It works	1		1		1		1		1	
the colour	1		1		1			1	1	
Simple,beautiful and shining	1		1		1			1	1	
It's strong and shiny	1		1		1			1		1
Simple,comfortable,easy to clean	1		1		1			1		1
the colour	1		1		1			1	1	
good and unique	1		1		1			1	1	
It looks beautiful and light	1		1		1			1	1	
the colour must be green	1		1		1		1		1	
	1			1	1			1	1	
	1		1		1			1		1
Keeps the house cooler	1		1		1			1	1	
It looks good	1		1		1			1	1	
It saves time,it's comfortable	1		1		1			1		1
It keeps the house warmer	1		1		1		1			1
It's cheap	1		1		1			1	1	
It cools the house and keep it warm	1		1			1		1		1
It looks cool and not difficult to install	1		1		1			1	1	
It looks cool and pretty	1		1		1			1	1	
The house is more brighter	1		1		1		1		1	
The design is good	1		1		1			1		1
Good and nice	1		1		1			1	1	
	1		1		1		1		1	
Keeps the house warm	1		1		1		1			1
Bright and shining	1		1		1			1	1	
Brightness and shining	1		1		1			1	1	
It is bright		1	1		1			1	1	
Keeps the house cool and warm	1		1		1			1	1	
very strong and shiny	1		1		1			1	1	
	1		1		1		1		1	
Easily fitted in the house	1		1		1			1	1	
nice and shining	1		1		1		1		1	
It is white and beautiful	1		1		1			1	1	
Keeps the house warm	1		1		1			1	1	
	1		1		1				1	
It's nice and shiny	1		1		1			1	1	
Strong and shiny	1		1		1			1	1	
easy to install and cheap		1		1	1			1	1	
The quality and the colour is good	1		1		1			1	1	
It's nice	1		1		1			1	1	
Nice and comfortable	1		1		1			1	1	
It looks good	1		1		1			1	1	
Easy to install	1		1		1		1		1	
Not bad	1		1		1					1
It's okay	1		1		1			1	1	
It is smart and wonderful	1		1		1		1		1	
0	45	2	45	2	46	1	11	34	37	10



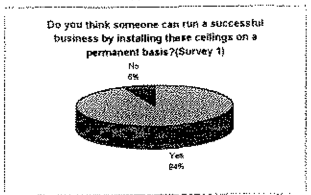


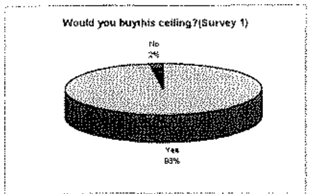


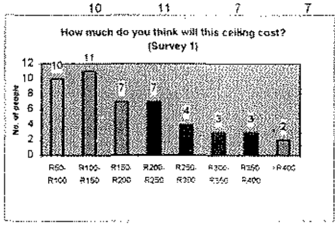




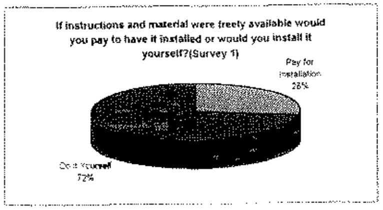
Can a business emerge from ceiling's: Yes	No	Would you buy the ceiling?: Yes	No	Why?	Pay for the ceiling and installation: R50-R100	R100-R150	R150-R200	R200-R250	R250-R300	R300-R350	R350-R400	>R400
1		1										1
1		1			1							
1		1					1					
1		1		It is beautiful		1						
1		1		It will improve my house	1							
1		1					1					
1		1					1					
1		1				1						
1		1		It makes the house cooler	1							
1		1				1						
1		1						1				
1		1		It is beautiful and cheap		1						
1		1		It is light and cheap	1							
1		1			1							
1		1		It is nice,safe and easy		1						
	1	1		It's beautiful						1		
1		1		cheaper		1						
1		1		Because it is nice		1						
1		1		It looks nice				1				
1		1		It looks very nice				1				
1		1					1					
1			1			1						
1		1					1					
1		1						1				
1		1		It's cheaper		1						
	1	1		It's nice and shining								1
1		1		It looks bright				1				
1		1		It's easy to install		1						
1		1		It looks good	1							
1		1								1		
1		1							1			
1		1		It is cheaper	1							
1		1							1			
1		1		It is cheap						1		
	1	1		Easy to install		1						
1		1					1					
1		1		Looks so nice and bright							1	
1		1									1	
1		1			1							
1		1		For cooling the house							1	
1		1		It looks bright and nice	1							
1		1							1			
1		1		It has quality and it's easy to install				1				
1		1		It's cheap			1					
1		1			1							
1		1							1			
1		1						1				
44	3	46	1		10	11	7	7	4	3	3	2

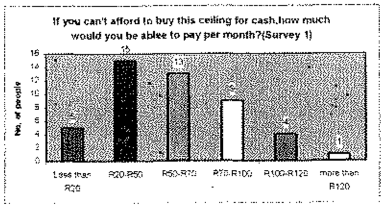


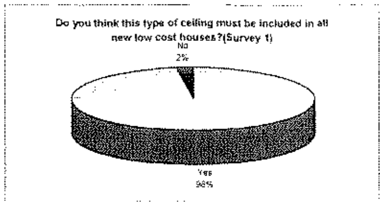




Pay for Installation	Do it Yourself	If you can't pay cash,then how much per month						Must this ceiling be inclu		Why do you think it is important to have a ceiling in your house
		Less than R20	R20-R50	R50-R70	R70-R100	R100-R120	more than R120	Yes	No	
	1				1			1		Because it is bright and nice
	1					1		1		Because it looks nice
	1							1		
	1			1				1		To make my house beautiful,brighter and shining
	1		1					1		It will protect my family from hotness and coldness
1					1			1		If there is a ceiling in the house it is always warm and cool
	1		1					1		It is a good thing
1			1					1		Gives a house a very good look from inside
	1		1					1		It is beautiful and it keeps the house warm
1				1				1		The ceiling is good
1				1				1		Ceilings are a good thing
	1		1					1		It makes the house look bright and it is also cheap
	1	1						1		It is light and it makes the house to be cooler
	1	1						1		Because it's nice and beautiful
	1			1				1		
1					1			1		Because it keeps the house warm
	1		1					1		look clean and bright
1			1					1		To keep the house warm and cool
1						1		1		There is no ceiling in my house
1			1					1		Because it brightens the house and keep it warm
1		1						1		Because the ceiling brightens the house
	1		1					1		
	1			1				1		
1				1				1		
1				1				1		
	1		1					1		
	1			1				1		
	1			1				1		
	1	1						1		
	1				1			1		
1						1		1		
	1		1					1		
	1				1			1		
1					1			1		
	1		1					1		
	1					1		1		
	1				1			1		
	1				1			1		
	1				1			1		
	1						1	1		
	1		1					1		
	1		1					1		
	1			1				1		
	1			1				1		
	1	1	1						1	
	1			1				1		
	1			1				1		
13	34	5	15	13	9	4	1	46	1	







APPENDIX C

BUSINESS PEOPLE EXPOSED TO CEILING

Discussions with various stakehol[illegible]otential industrial partners were held regarding the low cost ceiling. These people were all exposed to the low cost ceiling and all of them showed interest in the potential of this product. All were informed of the confidentiality of the product.

1)	Developer	Deon van den Berg
2)	Insulation Manufacturer (Owens Corning)	Mike Meyers
		Derek Reardon
		Michael Effing
		Chuck Stein
		Karel Helling
		Chuck Dyna
		Hennie Steyn
3)	Rand Water	Willem le Roux
4)	Peer Africa	Douglas Guy
5)	IIEC	Michael Scholand
6)	LOXAF	Michael Niewoudt
7)	DME	Sunti Tjobejane & Miss Lisa
8)	GTZ	Mr. Marinfeld
9)	Nampak	André Smit
		(Previous President)
10)	Sinergie	Johan Basson
11)	University of Pretoria	Zenda Ofir
12)	Materials Engineer	Usi Ofir & Pine Pienaar
13)	The Bussiness Bank	Tjaart van der Walt
14)	FRD	Ms. Moypone
15)	Spoormaker & Partners	Henk Spoormaker
16)	Boutek (CSIR)	Mark Napier

APPENDIX D

EXAMPLE OF CLIMATE DATA

NOTE

avg = Average temperature
mx = Maximum temperature
mxt = Time of max temperature (eg 12 15 = 12h15)
mn = Minimum temperature
mnt = Time of min temperature (eg 0255 = 2h 55)
Temp = temperature in degrees Celsius

HOURLY DATA - TEMPERATURE

51 3314C 9 PRETORIA WO 1996/1

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	20.2	19.6	18.2	18.5	18.4	16.3	20.1	22.8	25.2	26.0	26.7	28.7	29.5	28.6	27.8	26.7	25.7	22.3	21.0	20.8	20.8	22.3	21.6	21.6	553.1	23.0	29.7	1341	16.4	540
2	20.8	20.2	20.0	20.0	19.3	19.6	26.3	23.3	23.8	25.7	30.7	28.6	29.2	29.7	29.5	29.5	26.8	29.4	26.9	25.4	25.0	23.4	22.6	23.2	546.2	24.5	29.7	1416	18.0	502
3	22.8	22.6	21.0	20.4	20.7	20.7	22.1	25.2	27.5	29.1	30.6	31.1	31.8	32.9	33.0	29.6	29.1	27.4	24.1	23.6	20.6	21.3	21.9	21.4	[illegible]	25.2	33.1	1417	20.2	346
4	21.6	21.1	20.3	19.4	18.6	18.4	20.6	23.7	26.7	28.7	28.0	28.6	30.1	30.9	30.2	31.2	30.9	30.6	28.8	26.2	24.3	22.7	21.7	21.2	[illegible]	24.1	31.8	1620	18.0	557
5	21.4	21.2	20.3	19.3	19.2	18.4	20.2	23.3	26.6	27.6	29.1	29.3	30.4	30.5	31.3	25.9	26.3	24.0	23.5	22.6	24.8	24.5	23.6	21.3	563.6	24.3	31.7	1444	18.3	608
6	18.4	19.3	19.4	18.7	19.3	18.7	20.3	22.9	24.7	25.8	21.3	27.9	26.5	29.0	30.0	28.1	26.0	19.3	19.3	18.8	18.1	19.1	16.0	18.8	523.4	22.2	30.0	1441	16.1	555
7	19.5	18.4	19.1	19.0	18.1	19.0	18.4	21.2	23.8	25.6	26.8	27.5	27.5	28.0	26.9	29.8	26.6	28.5	27.6	26.6	25.5	23.2	22.2	21.8	575.6	24.0	29.0	1606	18.8	1700
8	25.9	21.0	21.0	20.8	20.5	19.7	21.5	25.6	26.8	28.3	29.2	29.7	30.4	31.6	26.5	24.1	23.3	23.7	23.6	21.4	21.6	21.6	23.0	24.1	[illegible]	23.8	31.0	1405	19.5	[illegible]
9	20.1	20.1	20.3	19.7	19.0	18.8	18.6	21.1	22.4	23.7	25.2	25.4	28.4	27.3	27.6	26.5	26.5	26.5	24.8	26.0	22.2	22.8	22.3	22.0	562.1	23.4	28.6	1504	16.7	544
10	21.4	20.2	18.8	19.4	16.7	18.4	21.5	25.4	24.2	25.7	27.0	26.3	29.6	29.1	30.4	29.6	25.4	27.0	26.2	24.6	20.5	20.1	18.7	20.7	558.2	23.2	29.8	1517	18.6	558
11	21.5	20.2	20.5	19.9	18.8	18.9	20.3	22.2	20.5	23.8	24.7	25.8	26.3	27.7	28.5	27.2	23.2	22.0	21.5	24.7	22.0	21.8	21.4	21.0	542.5	22.6	29.5	1517	18.?	550
12	20.4	20.6	20.4	20.2	20.3	20.4	25.6	22.1	22.8	23.6	24.7	25.8	24.6	27.5	27.8	27.5	22.5	23.6	20.3	19.5	19.5	19.8	20.5	25.6	550.?	23.0	24.7	1573	20.1	605
13	20.6	20.7	20.8	20.4	20.2	19.9	20.1	20.9	23.6	23.8	24.7	26.4	26.6	27.6	28.1	28.4	26.0	22.3	26.4	22.7	23.2	22.0	21.5	20.7	564.6	21.6	28.4	1575	16.4	2105
14	20.1	19.5	19.0	18.6	18.2	18.0	18.7	21.6	22.6	24.1	25.0	26.0	27.4	26.4	29.0	28.5	29.6	29.2	26.9	25.3	24.7	24.3	22.6	21.8	559.1	23.7	29.6	1604	18.2	503
15	21.6	21.3	20.2	19.9	18.0	16.5	20.0	23.3	25.2	27.0	27.2	28.4	29.3	29.5	30.1	30.1	30.0	28.4	28.6	27.2	26.4	26.4	23.9	22.5	[illegible]	27.2	30.4	1415	18.?	530
16	21.6	20.1	18.8	20.0	20.0	20.3	21.1	29.2	25.2	27.6	27.5	29.4	28.4	29.2	30.6	30.5	29.6	29.5	24.7	24.1	23.7	23.6	21.2	21.4	594.8	24.8	30.8	1605	18.7	250
17	20.9	29.3	16.0	18.6	18.3	16.4	18.2	21.6	23.2	23.5	24.5	26.5	27.3	27.6	28.0	20.8	20.8	20.6	21.2	20.5	20.2	19.6	19.1	19.6	515.0	21.5	28.9	1407	18.1	540
18	18.1	17.8	17.9	17.2	17.2	17.8	18.4	19.7	21.0	23.4	23.2	24.4	24.4	24.8	25.6	26.5	26.9	26.6	26.3	24.1	23.9	25.5	23.3	21.7	530.8	22.0	27.5	1620	17.0	426
19	18.2	17.4	17.4	18.6	17.6	17.3	17.4	17.6	17.9	19.3	18.8	19.5	19.5	20.6	20.8	23.4	24.4	25.8	27.2	21.3	20.7	20.3	19.9	19.8	414.3	19.6	24.6	1720	16.6	226
20	19.6	19.7	19.4	19.5	19.3	18.9	19.4	18.9	19.6	19.2	18.7	19.1	19.9	21.6	22.2	23.8	23.9	30.2	18.9	18.9	18.9	18.5	18.6	18.6	472.5	19.1	22.2	1613	18.6	1067
21	18.4	18.4	17.6	16.5	18.2	18.1	18.?	18.4	19.1	18.8	20.1	21.4	22.0	22.7	23.1	23.0	22.8	30.1	18.8	19.2	18.4	16.2	15.5	18.0	476.9	19.8	23.?	1506	18.0	631
22	18.6	17.8	17.4	17.6	17.6	17.7	16.2	19.7	20.7	22.8	23.8	24.2	24.0	24.8	26.4	24.8	24.5	24.2	23.8	22.7	21.5	20.0	20.0	19.6	510.?	21.3	26.7	1442	17.3	390
23	18.6	18.5	19.2	19.2	16.8	18.6	16.8	22.1	23.2	24.1	25.2	25.6	26.5	27.3	27.3	27.1	27.5	26.7	25.7	24.3	23.8	23.9	23.5	22.0	556.?	23.3	27.7	1536	18.1	226
24	22.2	22.2	21.8	21.1	20.8	20.7	20.9	21.7	23.1	24.4	25.2	26.1	26.4	27.0	27.6	27.3	26.2	25.4	24.7	23.9	23.1	20.7	20.5	20.1	567.5	23.4	29.2	1536	20.7	554
25	19.4	19.0	19.0	19.4	19.0	19.5	20.2	19.6	19.2	19.2	19.7	22.1	20.0	18.6	29.6	20.6	19.7	19.7	19.9	19.7	19.6	20.2	26.2	20.0	476.4	19.9	22.9	1246	16.8	221
26	19.1	18.0	18.1	18.7	18.2	18.2	19.1	20.1	20.2	21.8	22.1	24.5	20.2	25.0	25.2	21.0	22.1	20.3	22.6	22.0	22.2	23.1	20.6	19.5	509.2	21.2	26.4	1427	18.0	300
27	19.7	19.8	19.8	19.7	18.7	19.7	20.1	20.3	19.6	19.1	19.6	21.3	20.3	19.9	20.3	20.1	16.7	17.9	17.0	15.8	15.7	16.0	15.9	15.2	451.3	18.8	21.9	1336	15.3	1366
28	14.7	14.3	14.2	14.0	14.1	14.2	14.2	14.2	15.0	16.0	17.5	18.2	18.1	18.6	18.7	19.1	18.6	16.2	17.5	18.7	15.6	16.2	15.1	14.7	387.1	16.1	19.5	1558	14.0	335
29	14.2	13.0	13.1	13.0	12.8	12.8	13.5	15.5	17.8	19.2	20.9	22.6	23.9	24.6	25.3	25.3	25.5	24.7	23.2	22.0	20.9	20.0	18.8	18.8	467.4	19.3	25.8	1617	12.5	615
30	17.2	18.2	15.6	14.6	14.1	14.0	15.3	18.6	20.7	23.3	24.3	25.3	26.6	26.6	26.7	26.3	25.9	24.0	22.6	21.0	20.6	19.7	18.9	15.4	484.2	20.7	27.9	1621	13.8	550
31	18.0	17.4	16.2	18.0	16.6	16.9	17.0	20.5	22.9	25.3	26.5	28.0	28.4	28.6	28.4	26.4	26.0	27.2	25.9	24.3	22.5	21.5	20.5	21.8	556.9	23.0	29.2	1408	16.4	505
tot	610	3 597	7 586	6 590.	6 572.	4 569	3 568	0 654	7 692.	6 729	9 780	3 795	2 811	8 827	7 834.	1 805	3 793.	5 759.	0 729	3 692.	3 672.	0 657	5 639	8 629.5	16591		6 963	7	558	8
avg	19.7	19.3	18.0	16.7	18.5	18.4	19.3	21.1	22.3	23.5	24.5	25.7	26.2	26.7	26.0	26.0	25.5	24.6	23.5	22.3	21.7	21.2	20.6	20.3		22.3	27.6		18.0	

HOURLY DATA TEMPERATURE 1 - (CONTINUED)

51 3314C 9 PRETORIA WO 1996/2

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	20.8	19.5	19.0	19.0	19.7	19.6	20.1	21.5	23.2	23.4	24.6	26.1	26.5	26.7	26.0	26.2	18.6	18.6	17.5	17.5	17.4	17.6	17.9	18.0	[illegible]	20.0	27.1	1310	19.4	540
2	17.8	18.6	18.9	16.2	15.6	16.4	18.1	18.7	20.6	22.4	23.4	24.5	25.6	25.9	26.7	26.2	25.5	24.4	23.1	21.4	20.5	18.5	19.1	19.4	501.8	20.9	27.0	1645	15.3	558
3	19.2	19.1	19.1	18.4	17.6	18.6	18.6	19.3	21.7	23.1	24.4	25.5	26.7	27.6	27.8	28.4	27.3	26.0	20.3	20.8	20.1	19.8	19.7	19.4	[illegible]	21.8	26.5	1634	17.9	568
4	19.9	19.0	19.0	19.1	18.6	18.8	18.5	20.2	21.4	21.7	22.6	21.6	22.5	23.6	24.5	24.3	24.6	24.6	22.8	20.5	21.5	21.4	20.6	20.2	511.5	21.3	24.8	1647	18.1	546
5	19.7	19.7	19.5	19.0	18.6	18.2	18.9	20.5	21.6	22.6	24.6	24.8	25.2	25.7	26.7	26.8	26.2	25.3	24.3	21.9	17.8	18.0	18.6	18.4	522.?	21.8	27.2	1647	18.1	554
6	18.8	18.6	18.0	18.5	17.4	18.0	18.5	18.0	20.2	21.7	22.5	24.2	24.5	26.0	26.2	26.4	26.2	26.0	24.8	23.9	22.2	21.3	21.1	19.8	524.6	21.8	26.7	1537	17.4	452
7	16.9	16.3	17.6	17.4	17.0	16.6	17.3	18.6	21.5	21.6	24.2	25.5	26.7	27.6	27.7	27.1	27.3	26.3	24.7	23.2	21.8	20.4	19.6	18.6	516.6	21.9	28.1	1620	16.4	617
8	17.1	17.5	16.1	15.9	16.3	17.3	18.2	20.0	24.1	25.8	27.1	27.7	27.6	27.9	27.9	29.5	28.9	28.3	26.8	23.9	23.6	21.4	21.9	22.1	543.?	22.4	29.3	1602	17.1	630
9	22.5	22.2	21.2	21.0	20.8	20.8	21.2	23.1	24.1	25.9	26.3	27.6	28.6	29.2	29.7	30.1	29.6	29.4	26.0	24.3	23.4	23.0	22.4	22.1	585.?	24.8	30.1	1521	20.7	549
10	22.2	22.0	21.5	21.5	21.2	21.1	21.5	23.4	24.5	25.2	24.1	21.8	23.0	23.6	24.1	24.4	24.0	23.1	21.2	21.8	21.2	20.6	20.5	20.7	[illegible]	22.3	25.4	1512	21.2	616
11	20.4	20.6	20.3	20.4	19.1	18.6	18.7	18.8	19.6	19.2	19.3	18.6	20.1	20.8	20.1	19.8	20.2	19.8	19.1	18.8	18.6	18.9	18.5	18.9	[illegible]	19.5	20.9	1344	18.6	562
12	18.8	18.6	18.4	18.2	18.7	18.1	18.0	18.2	18.5	18.8	18.9	19.9	19.9	19.8	19.1	19.4	19.8	19.8	19.6	19.6	19.7	18.9	18.9	19.0	455.6	19.0	20.0	1726	17.8	637
13	18.1	18.2	18.6	18.6	18.5	18.5	18.2	18.4	18.7	19.3	21.1	22.0	20.5	23.6	21.7	23.0	20.9	21.4	21.5	20.7	20.2	19.9	18.7	20.0	[illegible]	20.1	23.6	1415	18.2	754
14	18.2	18.8	17.2	15.9	16.3	16.4	17.0	17.8	17.8	18.3	21.1	22.3	23.7	24.4	25.4	24.5	25.2	24.5	23.3	21.8	20.5	19.7	19.1	18.1	[illegible]	19.4	25.5	1624	15.8	455
15	18.2	18.5	18.2	17.7	17.4	15.6	15.4	15.6	14.8	14.8	19.1	15.5	16.6	18.6	18.0	17.1	16.8	17.0	18.7	16.6	16.5	15.6	15.5	16.2	[illegible]	16.4	[illegible]	[illegible]	[illegible]	[illegible]
16	15.6	15.1	14.9	14.8	14.8	15.7	15.5	17.6	19.6	19.7	20.4	21.4	23.4	24.3	24.6	24.9	24.2	24.3	22.7	21.7	21.5	19.3	18.5	18.5	465.8	19.4	25.4	1526	14.7	317
17	16.3	17.6	16.1	16.5	16.3	16.7	18.5	18.8	20.1	21.5	23.6	24.2	24.4	25.1	24.4	24.8	23.8	24.7	18.9	19.6	18.5	16.3	17.6	17.3	[illegible]	20.3	[illegible]	1530	[illegible]	149
18	16.9	16.6	16.5	16.4	16.5	16.4	16.7	16.4	21.2	22.4	23.4	23.7	25.1	25.5	22.5	22.6	22.9	22.8	20.9	17.0	17.3	18.5	18.1	17.6	[illegible]	19.6	[illegible]	1409	16.3	350
19	18.3	18.5	18.6	18.2	18.2	18.1	18.5	19.9	21.0	22.6	22.5	23.9	24.4	25.6	25.8	26.0	25.5	22.0	21.3	22.6	19.8	18.3	18.7	[illegible]	[illegible]	[illegible]	[illegible]	1601	[illegible]	[illegible]
20	17.4	18.2	18.5	16.1	15.8	15.6	16.6	19.2	21.4	23.6	24.3	25.7	26.4	26.6	26.7	26.0	25.6	24.6	23.3	22.0	21.1	20.8	20.7	20.3	[illegible]	21.4	27.2	1531	15.6	[illegible]
21	19.9	19.2	16.9	18.1	18.2	17.5	18.2	20.5	21.6	23.2	26.0	27.8	27.7	28.2	28.2	28.3	27.5	26.6	25.4	23.6	23.1	21.5	21.0	20.3	[illegible]	[illegible]	[illegible]	1420	17.5	[illegible]
22	19.8	19.9	19.6	18.9	19.7	19.3	19.7	21.6	22.1	24.7	26.0	26.4	27.2	28.3	28.5	27.9	27.8	26.6	21.6	21.1	20.7	19.2	19.2	[illegible]	[illegible]	22.5	28.5	1545	18.4	357
23	19.6	19.3	18.9	18.9	18.8	18.5	19.0	19.7	21.3	23.4	24.0	25.1	25.4	26.2	26.6	26.6	26.5	26.7	24.7	24.0	23.6	20.9	23.4	21.4	[illegible]	22.8	26.8	1541	18.4	532
24	21.0	20.7	20.2	19.6	19.6	19.5	19.5	21.5	22.8	23.8	24.0	25.5	26.3	22.6	24.5	24.2	22.9	22.3	21.4	21.0	20.5	22.1	21.6	21.3	[illegible]	22.4	[illegible]	1501	19.5	640
25	20.5	20.0	20.1	19.7	18.7	18.6	19.8	20.2	21.7	22.8	23.0	23.6	25.4	25.4	26.6	26.2	26.2	24.1	24.1	22.7	22.6	18.9	18.6	18.5	[illegible]	22.0	26.6	1412	18.5	612
26	16.3	16.3	18.3	18.4	18.3	18.3	18.3	[illegible]	20.0	21.2	21.5	23.8	24.8	26.1	26.1	25.0	24.0	23.0	19.3	18.6	18.5	18.6	18.7	18.8	[illegible]	20.7	26.5	1505	[illegible]	[illegible]
27	18.3	18.4	18.2	18.3	17.6	17.7	17.9	18.9	19.2	19.5	19.4	21.1	21.8	21.6	22.1	22.5	21.8	21.2	20.7	20.7	20.1	19.5	19.0	18.8	[illegible]	19.8	22.6	1546	[illegible]	[illegible]
28	18.4	17.1	17.5	16.3	15.8	15.0	16.4	17.6	17.4	18.3	18.7	18.5	20.2	22.5	22.5	23.0	22.4	21.8	20.6	18.8	18.2	17.4	16.8	16.2	445.8	18.6	23.4	1600	15.0	500
29	15.7	15.4	15.1	14.8	14.6	14.6	15.2	18.5	21.3	22.6	23.0	25.0	25.2	26.3	25.7	26.2	25.8	25.0	23.4	21.1	20.4	19.6	18.7	18.0	[illegible]	[illegible]	[illegible]	1401	14.4	537
tot	650	3 542.	7 536	6 527.	1 520	2 514.	9 526	3 565	5 603	1 633.	7 680	1 681.	1 702.	5 716	2 725.	2 735.	1 704.	8 671	0 640.	7 612.	2 547.	8 577	0 582.	3 553.9	14652.		8 740		0 506.	5
avg	19.0	18.7	18.6	18.2	17.9	17.8	18.1	19.5	20.8	21.8	22.0	23.5	24.2	24.7	25.0	24.9	24.3	23.1	22.1	21.1	20.3	19.7	19.4	19.1		21.0	25.6		17.5	

HOURLY DATA TEMPERATURE 2 - (CONTINUED)

51 3314C 9 PRETORIA WO 1996/3

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	19.0	18.8	18.4	18.3	17.5	17.2	17.9	21.2	22.2	23.2	24.3	26.0	26.7	26.9	27.5	27.5	26.0	25.4	23.9	23.6	22.3	21.6	20.7	21.1	552.0	22.4	27.6	1442	17.1	557
2	19.7	19.3	18.9	18.8	19.0	18.9	18.8	19.7	22.3	22.7	23.1	23.9	25.8	26.3	26.7	26.6	26.5	25.4	24.5	23.1	22.7	21.6	21.9	20.4	535.8	22.3	27.1	1528	18.2	607
3	20.2	19.7	19.5	18.8	18.7	18.1	18.5	20.5	22.6	24.4	24.5	24.7	25.7	26.4	27.2	27.3	26.0	25.0	24.4	23.8	23.5	22.6	16.7	15.5	534.6	22.3	27.6	1607	18.0	651
4	16.3	16.0	15.6	16.7	15.6	15.7	15.6	15.5	16.6	17.4	16.2	17.5	20.1	19.9	20.5	20.6	19.6	15.0	16.8	15.8	15.4	15.2	14.9	14.2	408.8	17.0	20.7	1514	15.3	2342
5	13.7	13.8	15.3	13.4	13.5	13.7	14.0	14.9	16.2	17.5	18.0	18.5	20.6	20.4	20.6	22.0	21.1	20.?	18.9	17.6	16.1	17.5	16.3	16.3	409.?	17.1	22.0	1600	13.0	244
6	14.5	12.9	13.5	13.2	13.1	13.7	15.2	16.2	17.2	19.7	21.3	21.9	23.4	23.8	23.7	24.2	23.7	23.0	20.9	19.8	16.2	17.1	16.3	15.9	459.9	18.9	24.4	1557	12.7	551
7	15.1	14.6	14.2	13.8	13.5	13.2	14.3	17.2	21.0	23.5	24.9	25.0	25.0	25.1	24.6	25.6	25.4	24.1	22.4	20.8	19.6	18.5	17.3	16.8	475.?	19.8	25.8	1545	13.0	600
8	16.1	15.5	15.0	16.0	14.6	13.5	15.4	18.3	21.9	24.6	25.1	26.7	21.2	27.7	27.2	27.0	26.6	25.6	25.7	23.1	20.6	19.6	16.6	17.9	504.?	21.0	27.6	1416	13.6	610
9	17.0	16.6	16.0	15.3	16.0	15.5	16.8	20.5	22.0	23.6	25.4	26.8	27.3	27.9	27.5	26.1	27.7	26.7	25.1	23.3	21.5	20.3	20.3	18.5	534.?	21.9	28.1	1556	15.0	627
10	18.0	17.3	16.0	16.6	16.0	17.9	18.7	20.7	23.1	24.0	24.8	27.0	28.1	29.0	29.3	29.0	27.8	26.5	25.6	24.2	22.7	21.7	21.0	21.8	547.?	22.8	29.4	1557	15.9	601
11	20.5	18.6	17.8	16.9	17.0	17.8	18.8	21.3	23.7	24.3	25.9	26.7	27.7	28.5	28.4	28.2	27.6	26.7	25.0	23.5	21.6	20.4	19.6	19.7	548.0	22.7	29.6	1557	16.4	470
12	17.9	17.1	16.9	16.6	16.0	15.6	16.8	20.3	22.7	25.2	26.1	27.2	26.0	26.7	26.5	26.4	26.8	26.8	24.5	22.0	22.?	21.4	21.9	20.7	540.0	22.6	26.7	1545	15.6	611
13	15.8	16.0	18.6	17.7	17.0	17.3	17.1	17.2	17.7	15.0	14.0	15.5	15.0	19.4	20.3	20.4	20.7	17.4	16.2	16.6	16.3	15.9	15.2	14.8	416.0	17.4	21.0	1634	13.9	1117
14	18.2	15.0	15.0	15.0	15.0	14.9	15.1	16.0	16.3	18.4	20.1	21.4	23.2	23.1	23.2	27.5	23.3	21.3	17.7	17.6	18.0	15.3	14.6	15.6	425.0	17.9	23.8	1528	14.0	222
15	15.1	15.2	14.4	14.1	14.4	14.4	14.7	16.6	17.3	18.5	18.8	20.5	21.2	20.5	22.7	23.2	22.7	21.7	20.0	18.6	17.8	17.0	16.0	15.4	427.0	18.0	23.2	1546	13.9	430
16	14.5	13.9	13.5	15.3	13.1	12.9	13.6	17.3	19.7	20.1	22.1	23.8	24.0	25.6	25.6	25.7	25.4	24.6	23.2	22.2	19.9	19.1	17.7	16.7	465.2	19.5	26.2	1632	12.8	547
17	16.2	15.2	14.4	16.3	15.6	14.7	19.2	18.1	21.1	22.5	23.7	24.5	24.8	26.0	25.7	25.3	25.7	24.6	22.6	22.2	21.5	20.2	16.9	17.9	493.1	20.5	26.6	1436	14.0	316
18	16.7	16.7	15.8	15.3	14.7	14.3	15.1	17.9	18.8	18.8	21.3	22.2	23.0	20.9	24.2	24.3	24.1	22.6	20.9	19.7	19.0	18.4	16.7	16.0	463.6	19.2	24.5	1636	14.5	612
19	16.2	15.6	15.1	14.6	14.7	14.5	15.4	16.8	18.2	19.9	21.2	23.7	24.5	25.6	24.5	25.1	24.2	23.3	21.9	20.6	19.5	16.4	17.7	16.6	465.1	19.4	25.3	1606	14.2	605
20	18.0	15.5	14.9	14.5	14.4	13.9	15.3	18.2	21.1	20.7	26.7	26.7	27.4	28.1	27.8	27.1	26.0	24.7	23.0	21.9	20.4	19.6	18.2	17.6	501.1	20.9	28.1	1359	13.9	603
21	18.6	15.6	14.7	15.3	14.8	14.1	14.7	16.0	18.4	20.2	21.3	21.8	22.2	23.5	24.0	24.5	24.2	23.4	21.8	20.5	19.7	19.3	18.3	17.6	465.0	19.4	24.6	1554	13.9	643
22	17.2	16.6	16.3	15.9	15.8	15.7	16.2	17.0	19.7	20.9	22.0	22.8	24.4	25.6	26.1	25.7	24.4	23.4	21.9	21.2	20.3	19.2	18.1	17.4	486.6	20.2	26.3	1440	15.6	603
23	16.9	18.1	17.4	17.2	16.5	16.5	17.2	19.6	21.5	22.5	25.7	29.3	25.4	28.5	25.1	24.2	25.7	24.1	22.5	20.8	19.1	18.1	17.0	16.4	495.3	20.6	28.7	1409	16.2	543
24	16.1	15.4	15.0	14.9	14.2	13.9	14.6	17.6	21.0	24.6	27.4	28.8	29.4	29.2	25.7	25.4	24.4	23.8	22.8	21.1	20.1	18.9	18.0	17.4	499.6	20.8	29.7	1351	13.6	636
25	18.1	17.3	17.1	17.6	17.1	16.6	17.0	18.3	18.4	21.1	23.2	26.0	26.0	26.1	26.9	26.9	26.0	25.3	23.1	21.5	21.1	20.2	19.6	18.7	509.7	21.2	27.2	1546	18.5	630

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	max		min	
26	13,5	17,9	17,6	17,3	17,1	16,8	17,3	18,7	20,9	22,9	24,3	26,1										22,1	21,8	21,1	531,2	22,1	27,8	1510	16,5	546
27	20,4	20,2	18,8	17,6	17,3	16,9	16,8	20,3	21,9	24,4	26,0	25,4										20,4	19,7	19,4	530,0	22,5	28,0	1308	16,9	550
28	20,0	19,7	18,3	18,1	19,0	18,8	18,7	19,4	21,2	22,0	23,7	24,5										19,7	19,0	18,0	513,8	21,4	25,3	1246	18,4	633
29	17,5	16,9	17,0	16,8	16,0	15,3	15,9	17,7	18,9	20,7	21,8	23,0										18,0	17,6	16,5	471,7	19,7	24,9	1240	15,2	632
30	16,3	15,5	15,8	15,4	14,9	13,0	13,5	16,8	18,8	20,8	21,9	22,6										16,6	16,7	14,6	451,4	18,8	24,4	1510	13,5	641
31	13,8	13,3	12,9	12,0	12,0	11,8	12,8	16,2	19,6	22,3	23,2	26,1										19,7	17,8	16,5	466,6	19,5	26,3	1537	11,5	639
tot	629,	3 514	3 489	1 492	3 484	0 474,	7 495,	7 562	1 023	1 870	9 709,	9 758,										1 593,	3 563	9 541,0	15099		8 806		6 402	8
avg	17,1	16,6	16,1	16,9	15,7	16,3	16,0	16,1	20,1	21,6	22,9	23,8	24,9	25,4	25,3	25,6	25,0	23,8	22,1	21,0	20,1	19,1	18,2	17,5		25,2	28,1		14,8	

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DAY	51 3314C h01	h02	9 PRETOR h03	IA WO h04	h05	h06	h07	h08	h09	h10	H h11	OURLY 1996/ h12	DATA h13	TEMP 4 h14	ERATUR h15	E h16	h17	h18	(CO h19	NTINUE) h20	h21	h22	h23	h24	tot	S avg	TATION max	HEIGH meters	T 1326 min	m metres
1	15,8	17,0	16,8	16,4	16,2	15,8	16,1	17,6	15,4	20,9	23,1	23,0	24,5	24,8	24,8	24,9	24,5	23,0	21,9	19,2	18,1	16,6	16,4	16,4	427,6	19,7	25,5	1521	15,5	67
2	15,8	16,9	17,8	18,1	16,6	16,3	17,5	16,5	16,7	19,0	22,7	23,7	24,4	25,2	25,2	24,0	22,3	21,6	19,7	19,2	18,7	17,6	17,4	17,0	456,0	18,4	25,4	1420	15,8	103
3	16,6	16,4	15,9	15,5	15,5	14,8	14,0	16,1	16,4	17,6	17,9	16,8	19,3	18,3	15,7	18,1	17,6	16,6	15,4	15,3	14,8	14,6	13,7	14,1	390,4	16,4	19,6	1507	14,7	635
4	14,3	14,4	14,4	14,4	14,3	14,4	14,4	14,9	15,2	15,5	16,2	15,5	16,2	14,9	15,2	15,2	16,3	15,5	15,3	15,3	16,2	16,3	14,8	14,1	357,7	14,8	16,6	946	13,5	2246
5	13,6	13,8	14,1	13,7	13,9	15,5	15,8	14,4	15,2	15,7	16,5	16,8	17,9	18,3	18,9	19,1	19,7	18,9	16,9	16,5	16,3	15,6	15,1	13,9	384,2	16,0	20,2	1057	13,4	649
6	15,2	15,2	14,5	14,0	12,8	13,7	13,6	14,9	15,6	17,6	19,6	18,9	21,0	21,5	21,3	21,4	21,0	19,7	17,4	16,7	14,8	14,0	13,2	12,6	411,1	16,7	21,5	1606	13,4	646
7	12,1	11,2	10,8	10,7	10,5	9,8	10,5	14,6	17,0	19,4	20,8	21,4	23,1	22,4	22,6	23,1	22,6	20,9	18,6	17,1	15,0	14,9	14,1	13,6	398,2	16,6	23,2	1553	9,7	637
8	13,0	12,5	12,6	11,5	11,1	11,0	11,6	14,5	18,4	20,7	23,5	23,2	23,4	23,0	24,6	25,7	25,1	23,6	19,6	17,1	16,3	15,2	14,4	14,1	414,1	17,3	24,6	1430	10,7	637
9	13,6	12,6	12,3	11,9	11,5	11,7	12,6	16,3	19,6	20,8	23,4	24,0	24,2	25,7	25,5	25,7	25,2	23,5	21,0	19,5	18,1	17,0	16,0	15,3	450,2	18,8	25,9	1611	11,5	352
10	14,4	14,2	14,3	13,5	12,0	12,7	14,3	16,6	21,2	24,4	25,5	27,5	27,8	28,2	27,8	27,5	26,8	24,8	21,7	20,8	18,7	17,2	16,5	15,5	467,9	20,2	28,4	1402	12,6	636
11	14,0	14,0	14,1	13,0	12,0	12,6	15,0	13,5	13,9	14,6	15,0	16,0	18,4	16,9	19,2	19,1	19,0	18,4	17,6	16,8	16,6	16,0	14,8	14,6	362,2	15,8	19,4	1645	13,1	430
12	14,6	14,6	13,7	13,2	15,0	12,2	12,4	13,7	14,7	15,8	17,2	17,6	18,5	19,2	19,2	20,0	19,5	18,4	17,0	16,5	14,6	14,0	14,2	13,8	377,2	15,7	20,1	1005	12,2	672
13	13,5	13,2	12,6	12,9	12,5	12,3	13,1	14,5	15,5	17,5	18,3	20,4	21,0	21,4	21,4	18,5	19,0	19,2	18,1	17,0	17,5	17,0	16,7	16,4	394	16,6	22,0	1402	12,7	554
14	16,9	15,6	15,3	14,4	14,2	14,5	13,9	16,5	18,6	19,2	22,4	20,6	23,2	22,3	23,4	22,6	18,6	14,5	17,0	16,6	16,8	15,2	14,4	14,5	[illegible]	17,1	23,3	1535	13,8	707
15	13,8	13,0	12,8	12,6	12,5	12,9	13,5	15,5	18,4	19,6	21,2	22,7	23,8	24,3	24,1	21,6	17,5	17,0	16,8	16,3	16,3	16,4	16,4	15,0	[illegible]	17,2	24,6	1647	12,6	665
16	15,2	14,7	13,6	13,0	12,7	12,3	13,0	15,8	19,6	20,1	23,4	24,9	26,3	25,3	24,8	25,6	23,3	21,4	20,0	19,3	18,0	18,1	17,0	16,6	[illegible]	18,9	26,4	1326	12,3	555
17	16,4	15,8	15,5	15,1	15,1	15,3	15,2	16,2	16,6	17,3	18,4	18,6	19,1	20,6	20,6	21,2	20,8	19,3	18,1	17,4	17,0	11,9	12,4	12,6	360,1	16,5	21,2	1557	15,1	418
18	12,5	12,3	11,8	11,8	11,7	12,4	11,5	12,6	14,9	17,3	14,5	20,6	22,4	23,8	22,2	22,3	22,0	20,5	18,7	18,5	17,5	17,0	17,0	16,4	404,1	16,8	22,9	1509	11,3	546
19	17,2	15,6	15,0	16,2	13,6	15,3	13,2	14,3	16,5	17,5	19,0	20,5	21,6	21,5	20,9	20,7	20,0	18,2	16,9	15,9	14,7	13,8	13,4	12,4	401,1	16,7	21,5	1515	13,0	624
20	11,7	10,1	10,5	9,3	8,3	9,6	9,4	12,3	16,7	17,8	18,5	20,4	21,7	21,8	21,9	23,3	21,8	18,7	17,5	15,3	15,6	15,6	14,8	14,0	379,9	15,7	22,4	1551	8,3	504
21	13,6	12,6	12,0	11,5	10,5	9,5	9,8	13,0	15,1	16,1	17,2	18,3	20,7	20,9	21,6	21,5	21,0	19,2	17,3	16,2	14,9	14,0	13,0	12,5	372,1	15,6	21,7	1500	9,5	640
22	11,7	11,6	11,0	10,1	10,0	9,8	10,6	13,8	16,8	19,2	21,6	23,1	23,4	25,6	23,5	24,0	22,8	20,5	17,8	16,2	14,6	13,6	12,8	11,9	362,1	16,4	24,0	1600	9,6	549
23	11,1	10,5	9,8	9,3	8,6	8,7	9,6	15,1	16,8	20,6	22,3	23,5	24,5	24,7	24,7	24,5	23,4	20,7	18,6	16,8	15,4	13,9	12,8	12,1	395,8	16,5	25,0	1430	8,5	545
24	11,6	10,0	10,8	10,7	9,6	9,3	10,5	15,2	17,7	19,9	22,3	22,9	23,0	23,3	23,4	23,2	22,1	20,5	17,8	16,3	15,3	14,5	14,5	15,1	397,1	16,5	23,6	1530	9,2	618
25	12,2	11,6	11,2	10,2	9,8	9,4	9,8	14,1	17,6	20,1	22,4	23,7	24,0	24,6	24,4	23,7	22,3	21,9	20,6	19,0	17,8	16,3	15,1	14,6	417,0	17,4	24,6	1404	9,4	531
26	13,6	14,6	13,5	12,5	11,6	11,1	11,5	15,2	18,3	20,2	21,8	24,0	24,6	24,7	24,5	24,6	23,6	21,1	19,5	17,2	15,6	14,7	14,2	13,6	424,6	17,7	25,0	1536	10,0	638
27	12,8	12,8	11,7	11,1	10,9	10,0	10,5	13,8	18,2	21,6	23,0	24,2	25,0	25,0	25,1	24,7	23,8	22,3	19,5	17,6	16,2	15,6	15,4	15,8	426,0	17,8	25,0	1538	10,0	651
28	14,2	13,0	14,7	14,1	12,8	11,1	11,2	16,0	18,2	20,0	21,0	24,5	24,7	25,0	25,0	23,5	21,8	20,8	20,4	18,5	18,7	17,6	16,1	15,1	437,8	18,2	25,2	1509	10,8	643
29	14,6	14,4	14,3	13,9	13,3	13,0	12,8	14,6	16,7	18,2	19,6	19,8	20,6	20,7	21,2	20,5	16,0	15,5	15,8	15,4	15,0	15,0	14,6	14,5	391,1	16,3	21,6	1449	12,7	630
30	14,2	13,8	13,6	13,5	13,2	13,2	12,8	13,0	14,5	16,8	16,6	16,3	17,4	18,3	18,4	17,8	17,5	16,9	15,1	14,9	15,0	14,7	14,1	13,8	383,0	15,1	19,6	1437	12,5	654
tot	419	2 400	4 389,	0 385,	1 372,	4 383,	7 374,	1 444,	3 909	6 561,	5 607,	6 037	5 864	6 672,	7 672,	5 665,	2 632,	9 597,	3 546,	2 511	1 465,	2 405,	0 446,	3 429,0	12340,		6 658,		7 058	3
avg	14,0	13,6	13,3	12,8	12,4	12,3	12,5	14,8	17,0	18,7	20,3	21,5	22,2	22,4	22,4	22,2	21,1	19,7	18,3	17,0	16,2	15,5	14,8	14,3		17,0	23,0		13,9	

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DAY	51 3314C h01	h02	9 PRETOR h03	IA WO h04	h05	h06	h07	h08	h09	h10	H h11	OURLY 1996/ h12	DATA h13	TEMP 5 h14	ERATUR h15	E h16	h17	h18	(CO h19	NTINUE) h20	h21	h22	h23	h24	tot	S avg	TATION max	HEIGH meters	T 1326 min	m metres
1	13,3	13,2	12,1	11,9	11,6	10,0	10,2	15,4	14,4	10,1	17,5	19,6	19,8	19,6	18,9	18,9	18,5	10,3	14,3	12,8	12,1	11,2	10,8	9,8	344,3	14,4	20,7	1421	10,1	716
2	9,3	8,7	8,3	8,0	7,6	7,4	8,0	11,5	15,4	18,7	20,7	22,3	23,8	22,5	22,5	21,0	20,5	16,6	16,8	14,7	13,3	12,3	11,4	10,5	350,3	14,7	24,0	1325	7,4	699
3	10,0	9,4	8,8	8,6	8,3	8,6	9,6	12,8	14,8	19,0	22,5	25,5	23,7	24,5	24,6	23,1	21,4	19,2	17,1	15,7	15,4	14,0	13,8	12,7	[illegible]	16,2	24,9	1432	8,3	527
4	11,7	10,6	9,8	9,3	9,2	9,1	9,6	12,6	16,8	20,4	23,2	26,1	26,0	24,5	25,8	25,1	23,0	20,6	18,6	18,1	16,3	14,2	13,2	13,0	[illegible]	16,5	26,0	1454	8,8	540
5	12,6	12,0	11,6	11,2	10,5	9,8	9,8	12,6	19,5	21,7	22,4	22,6	26,4	26,5	24,3	23,9	23,6	20,7	20,0	17,8	17,0	16,0	15,0	14,9	[illegible]	17,7	26,7	1515	8,5	667
6	17,0	17,8	17,3	16,7	16,3	15,8	15,8	16,4	16,3	17,8	19,7	19,6	20,7	20,1	21,0	[illegible]	19,3	16,3	16,2	15,8	15,4	15,1	15,2	15,5	[illegible]	17,6	23,5	1515	14,6	2545
7	15,1	15,1	14,9	14,7	14,5	14,4	14,6	14,7	15,3	15,9	17,9	18,7	20,7	21,2	21,5	20,1	20,0	18,1	16,2	14,6	13,7	11,2	12,2	11,8	[illegible]	16,2	23,5	1503	14,4	[illegible]
8	11,2	10,9	10,3	9,8	9,8	9,5	9,6	12,6	16,0	18,4	20,6	23,0	21,4	23,3	23,0	22,1	20,3	18,6	17,2	15,8	14,4	11,7	10,2	14,9	[illegible]	15,2	[illegible]	1341	9,4	[illegible]
9	14,2	13,3	11,8	11,2	10,5	10,2	10,6	15,2	17,1	18,7	19,8	21,8	21,6	20,1	22,4	22,2	21,1	18,9	18,1	16,1	15,9	13,9	12,4	11,8	[illegible]	16,1	21,6	1424	10,2	[illegible]
10	11,1	10,3	10,0	9,6	9,1	9,3	10,6	12,5	15,6	18,1	21,3	23,1	23,8	24,1	21,9	23,4	22,1	19,9	17,6	16,1	14,8	14,6	13,7	13,1	[illegible]	16,2	24,1	1414	8,9	[illegible]
11	12,8	12,1	11,2	10,7	10,1	9,8	9,6	12,5	17,5	21,5	23,6	24,4	24,6	24,3	25,1	24,0	22,6	19,5	17,5	15,6	14,5	13,6	13,0	13,0	[illegible]	16,6	25,6	1324	9,5	630
12	11,0	10,6	8,8	8,8	9,3	8,8	8,5	11,4	15,6	19,6	22,2	25,1	24,6	24,3	24,1	23,4	22,4	19,0	18,8	16,2	14,1	13,5	12,4	12,6	[illegible]	15,8	24,3	1433	8,3	656
13	11,4	11,3	10,6	10,0	9,7	9,7	10,0	14,5	18,4	20,6	20,6	19,9	19,4	17,1	16,7	16,2	14,3	12,3	12,4	12,0	11,4	11,7	11,6	11,4	[illegible]	13,9	21,1	1115	9,6	506
14	11,3	13,1	10,4	10,3	9,9	10,4	10,8	11,9	13,9	16,5	17,4	18,2	19,6	18,9	20,6	20,2	19,1	17,2	15,6	15,5	13,3	12,2	11,4	10,7	344,9	14,4	21,1	1516	9,8	510
15	10,2	9,2	9,4	10,1	11,2	12,2	13,8	13,9	14,6	16,1	18,3	18,6	20,3	18,6	20,6	20,4	19,2	16,0	16,0	15,3	14,1	13,2	12,3	11,9	[illegible]	14,0	21,7	1619	9,4	296
16	11,6	12,6	13,0	13,8	13,4	14,2	14,9	15,6	18,0	16,0	16,0	19,3	20,8	20,2	18,9	20,4	20,0	16,5	16,4	15,3	15,2	15,6	15,7	14,9	[illegible]	16,4	21,4	1309	11,7	45
17	14,5	14,2	14,4	13,4	14,1	14,3	14,2	14,8	16,4	16,6	17,7	18,5	20,2	20,7	20,8	19,6	16,7	17,4	16,8	13,2	14,0	13,1	12,9	12,5	340,4	16,0	21,4	1530	13,3	340
18	12,2	12,1	11,5	11,5	11,0	10,8	11,0	11,5	14,5	15,5	17,4	18,4	19,5	19,9	14,5	14,5	14,3	13,4	13,5	17,2	12,0	12,6	13,0	12,5	[illegible]	13,8	20,7	1242	10,8	615
19	12,5	12,3	11,0	11,3	10,7	9,8	9,1	11,2	13,8	16,9	15,4	16,8	19,9	16,4	18,7	16,6	15,3	15,4	14,1	12,5	12,5	11,8	10,9	10,5	[illegible]	13,6	20,2	1207	9,5	708
20	10,2	9,7	9,2	8,4	8,0	7,8	7,6	10,4	13,9	16,9	19,3	20,3	21,6	23,1	20,8	20,6	19,7	17,4	15,5	14,2	12,8	13,0	12,0	11,0	374,2	14,3	23,2	1359	7,8	658
21	10,6	9,5	8,8	10,1	8,6	7,8	7,6	10,8	14,6	16,8	18,9	19,6	20,4	23,0	21,8	20,9	19,1	17,6	16,5	15,8	15,3	14,6	13,0	13,5	365,0	14,6	22,4	1404	7,6	702
22	13,8	14,3	13,6	14,3	13,0	12,6	12,2	15,5	16,3	16,5	17,1	16,8	18,8	20,0	20,4	17,9	16,2	15,6	14,8	14,4	13,7	12,7	12,0	10,6	[illegible]	15,1	21,2	1526	12,1	839
23	9,6	8,7	8,3	7,6	7,6	7,1	7,5	10,0	13,9	17,5	20,2	22,1	22,6	23,6	23,1	22,2	20,9	18,4	15,9	13,8	13,1	12,2	11,7	10,7	347,3	14,5	23,8	1456	7,1	846
24	10,1	9,1	9,3	7,5	6,9	8,8	7,2	10,7	15,4	18,9	22,3	23,9	23,6	23,9	23,9	23,8	22,1	18,9	17,8	16,4	16,2	14,6	12,9	11,1	370,2	15,4	24,2	1335	6,7	930
25	10,3	9,8	8,7	8,2	7,5	6,9	6,8	10,5	14,5	18,1	20,3	22,0	22,7	22,8	23,2	22,3	20,5	18,6	14,9	13,9	12,9	12,5	12,2	12,4	350,3	14,6	23,4	1335	6,7	646
26	12,3	11,3	11,8	11,3	10,6	10,4	9,6	10,2	11,1	12,2	12,6	13,7	14,7	15,7	18,0	15,0	14,5	13,6	15,5	13,2	12,8	10,5	10,2	10,7	297,6	12,4	18,1	1458	9,0	713
27	10,7	10,7	10,6	10,1	9,9	9,8	9,7	9,4	9,9	10,9	10,9	11,7	12,4	13,4	13,8	13,8	13,3	12,5	11,8	11,8	11,8	11,4	11,1	10,7	272,5	11,4	14,0	1502	9,4	606
28	9,6	8,1	7,2	7,1	6,6	6,0	5,6	8,4	11,8	13,6	14,9	16,8	16,9	17,7	17,3	17,1	15,9	12,6	11,7	10,1	9,2	8,2	7,3	6,7	267,4	11,1	17,8	1523	5,6	653
29	6,0	5,4	4,8	4,5	4,5	4,2	4,8	7,1	10,6	14,5	17,2	17,3	17,7	19,4	20,2	19,2	16,6	16,1	14,3	12,6	10,7	9,6	8,8	8,0	276,4	11,5	20,2	1455	4,1	610
30	7,5	7,1	6,6	6,5	5,9	5,5	5,6	8,7	13,2	16,7	19,1	19,6	21,2	21,9	22,2	21,6	18,3	16,6	14,5	12,7	11,1	9,9	8,9	8,0	310,4	12,9	23,4	1515	5,3	626
31	7,4	6,6	6,0	5,5	5,1	4,9	5,7	8,6	12,5	16,5	19,9	21,2	22,3	22,2	23,0	21,8	20,0	16,6	14,4	12,6	11,2	10,0	9,1	8,4	311,6	13,0	23,1	1503	4,9	552
tot	351,	5 539	6 320,	0 310,	5 300,	9 284	7 209	8 371,	1 461,	0 530,	0 580	0 025,	1 652,	7 060,	5 651,	2 031,	6 506,	8 534,	5 485	0 445,	4 418,	5 304	0 378,	5 359,3	11015		8 667,		6 280	3
avg	11,3	11,0	10,4	10,1	9,7	9,5	9,7	12,0	14,9	17,3	19,1	20,2	21,1	21,3	21,0	20,4	19,2	17,2	15,6	14,4	13,5	12,7	12,1	11,6		14,8	22,2		8,0	

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	ST 3314C		9 PRETOR	IA WO							H	OURLY 1986/	DATA	TEMP 6	ERATUR	E			(CO	NTINUE)						S	TATION	HEIGH	T 1326	m
DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	max	metre	min	metre
1	7.8	7.5	6.8	6.5	6.1	5.7	6.1	8.8	12.9	17.0	19.5	21.4	22.1	20.4	19.1	17.8	16.1	14.4	13.0	11.5	10.3	9.6	8.8	7.8	296.7	12.4	22.3	1516	5.7	600
2	7.0	6.3	5.6	5.3	4.3	3.4	3.0	5.9	9.9	12.0	13.7	15.6	16.6	17.0	17.4	16.4	14.5	11.8	9.6	10.7	10.5	10.6	10.3	10.0	246.2	10.3	17.5	1412	3.0	652
3	6.9	6.6	8.2	9.2	9.3	9.2	9.3	9.5	9.5	9.8	12.2	13.1	14.5	15.8	14.7	10.8	15.2	13.4	11.9	10.7	9.4	6.5	8.6	7.4	269.3	11.2	17.5	1318	6.2	635
4	7.1	6.7	6.1	5.7	5.4	5.2	5.1	7.7	11.9	15.8	17.7	20.2	20.9	21.3	21.4	20.5	18.7	16.2	14.4	11.7	10.1	8.3	8.1	7.6	295.4	12.3	21.6	1644	5.1	655
5	6.9	5.8	5.0	4.7	4.2	3.9	4.4	7.6	11.4	15.2	16.4	16.8	17.6	18.1	19.4	18.6	16.9	14.5	12.8	11.2	9.9	8.6	7.6	7.2	261.1	10.9	20.1	1445	3.9	625
6	6.6	6.1	5.7	5.6	5.0	4.8	4.8	7.3	12.0	15.0	16.8	18.5	20.0	21.1	21.3	20.8	18.0	15.9	14.2	13.2	10.8	9.9	8.8	8.2	290.6	12.1	21.5	1518	4.7	650
7	7.4	6.9	6.3	5.9	5.8	5.5	5.6	7.6	11.3	15.1	18.1	20.2	21.7	22.2	22.5	21.2	19.5	16.0	13.6	11.6	10.6	8.7	7.8	7.0	298.1	12.4	22.6	1412	5.5	644
8	7.1	6.1	5.4	4.8	4.4	4.3	4.4	6.8	12.6	17.5	19.8	21.7	23.3	23.0	23.2	22.4	20.6	17.6	15.4	12.5	10.7	9.8	8.5	7.7	307.0	12.8	23.5	1438	4.2	635
9	6.9	6.3	5.8	5.4	5.1	6.5	7.5	8.5	10.0	12.2	16.3	17.6	20.4	20.7	21.9	20.8	19.2	16.7	15.4	11.8	12.5	13.2	13.4	13.2	306.6	12.7	21.9	1414	5.0	630
10	12.1	11.1	12.1	12.0	11.1	8.4	8.7	10.1	12.4	14.4	16.7	17.8	20.2	21.7	22.7	15.6	11.7	11.9	11.4	11.1	10.8	11.0	10.3	9.6	316.7	13.2	23.7	1418	6.4	644
11	8.7	8.6	8.3	8.0	7.3	6.7	6.4	8.2	11.3	14.8	16.8	18.5	18.9	20.5	20.7	20.8	18.2	15.4	13.5	11.6	10.5	9.6	8.8	8.1	303.6	12.6	20.9	1464	6.3	656
12	7.8	7.4	6.9	7.0	6.6	6.6	6.5	8.1	12.1	16.7	18.5	20.3	20.9	21.7	21.0	20.8	18.5	15.9	13.5	11.5	10.5	9.1	8.4	7.4	302.2	12.6	21.1	1400	6.3	703
13	8.6	8.2	7.1	6.3	5.0	4.8	5.6	7.9	11.9	14.2	18.4	20.9	22.0	21.7	21.7	21.1	19.5	16.2	14.5	12.5	15.6	9.2	8.2	7.3	297.6	12.4	22.2	1445	4.6	621
14	6.5	5.5	5.5	5.2	4.4	4.2	4.5	7.2	11.6	15.1	17.6	20.6	21.4	22.2	21.9	21.2	19.0	15.8	13.6	11.3	9.8	8.6	7.6	7.0	290.1	12.0	22.2	1423	4.1	612
15	6.6	6.0	5.4	4.6	4.4	4.2	4.2	6.5	11.2	16.3	19.6	21.3	22.2	22.4	22.4	22.1	20.1	16.0	14.5	12.0	11.5	9.9	8.8	7.6	299.0	12.4	22.8	1414	4.1	616
16	6.6	6.1	5.4	4.7	4.1	3.9	3.7	7.0	12.4	16.8	19.6	21.6	22.2	23.0	23.5	23.1	21.1	17.8	15.2	12.0	10.9	9.5	8.5	7.5	305.2	12.6	23.7	1451	3.7	700
17	7.4	7.0	6.6	5.5	4.6	5.0	4.8	7.9	11.8	15.4	18.2	20.6	21.4	21.9	22.2	22.0	20.2	16.6	12.1	10.6	8.4	7.1	6.0	5.3	285.4	11.9	21.2	1544	3.8	651
18	4.4	3.6	3.7	2.5	2.5	2.6	3.2	5.7	11.3	15.6	19.0	20.6	21.8	21.9	22.2	21.6	19.7	17.0	16.2	13.8	12.2	11.4	10.2	9.8	290.8	12.1	22.6	1422	2.0	605
19	6.4	8.2	7.9	7.0	6.1	7.6	7.3	8.5	10.8	12.9	14.4	16.2	17.2	18.2	17.8	17.3	16.7	13.8	13.0	12.5	9.9	11.2	10.6	8.7	264.2	11.0	18.5	1431	6.1	411
20	9.5	9.1	8.6	8.6	7.3	5.2	4.8	6.6	9.2	11.8	14.5	15.2	18.1	17.6	18.1	17.1	16.9	13.9	12.8	11.6	11.3	10.3	9.9	11.1	275.6	11.5	16.2	1529	4.7	400
21	9.9	9.5	8.7	8.7	8.2	7.7	7.4	8.7	9.3	9.8	11.6	13.8	16.6	16.4	16.8	16.7	15.6	13.5	12.6	11.6	11.2	10.3	8.6	8.6	273.2	11.4	16.8	1440	7.4	650
22	7.6	6.2	5.3	5.6	5.5	5.2	4.8	6.0	10.6	11.7	13.4	14.0	13.7	13.8	13.8	13.7	15.5	13.9	11.7	11.2	10.0	9.8	9.5	9.0	259.6	10.8	14.2	1126	7.2	446
23	7.0	6.8	4.9	4.1	5.0	6.7	5.1	6.4	10.3	12.1	15.7	14.5	15.3	16.3	17.8	14.7	16.0	13.4	10.1	11.3	9.1	7.6	6.6	5.5	242.1	10.0	17.8	1501	4.1	420
24	4.8	4.5	5.0	5.5	4.9	5.6	5.7	7.3	9.2	12.2	14.8	14.8	15.5	16.2	15.4	14.7	14.3	12.5	11.0	10.0	8.9	8.7	8.2	7.8	237.1	9.9	17.3	1435	4.3	179
25	7.9	7.9	6.2	5.0	4.3	3.5	4.0	6.3	10.5	13.8	16.7	17.2	18.8	18.4	18.4	18.2	17.2	14.8	13.7	11.9	8.7	8.2	7.0	6.0	267.5	11.1	19.8	1457	3.4	627
26	5.5	5.3	5.2	5.5	5.1	5.6	5.4	7.7	11.0	15.7	17.7	19.0	19.6	19.9	20.3	18.7	17.7	15.2	13.8	9.9	7.4	6.1	5.0	6.9	270.5	11.3	20.3	1501	4.8	446
27	4.8	2.6	2.9	1.8	1.3	1.1	1.3	4.2	8.1	16.7	17.2	18.5	20.2	21.5	21.7	21.4	20.5	15.7	12.5	8.9	8.0	7.3	6.6	5.1	250.0	10.4	21.7	1500	0.8	540
28	4.7	3.4	2.6	2.0	1.8	1.6	2.0	5.1	8.3	13.7	16.9	18.0	19.9	21.2	20.9	20.6	18.4	14.3	12.7	9.7	7.8	6.5	5.6	4.7	243.4	10.1	21.2	1400	1.5	1923
29	5.4	3.7	3.1	3.1	1.8	1.5	1.8	4.3	9.2	15.7	17.5	18.6	21.2	22.1	21.9	20.9	18.7	14.5	13.2	10.3	8.3	7.1	6.3	5.4	252.3	10.5	22.2	1540	1.3	650
30	4.2	4.3	3.5	2.9	2.3	2.1	1.7	3.8	6.6	11.5	15.2	17.9	19.1	18.5	19.7	18.5	17.4	13.0	10.4	7.5	5.8	4.4	3.3	2.5	218.4	9.1	20.1	1516	1.5	650
tot	214.	6 197	0 181	0 108.	6 167.	0 150.	6 151.	7 215.	0 322.	0 432.	3 497.	3 544.	3 580.	7 600.	4 602.	0 578.	7 527.	0 443.	5 391.	0 330	0 297.	0 271	4 247	6 226.1	8330		6 618.		2 136	9
avg	7.2	6.6	6.1	5.7	5.3	5.0	5.1	7.2	10.8	14.1	16.6	18.1	19.4	19.9	20.1	19.3	17.6	14.8	13.0	11.3	9.9	9.0	8.3	7.6		11.6	20.6		4.6	

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	ST 3314C		9 PRETOR	IA WO							H	OURLY 1986/	DATA	TEMP 7	ERATUR	E			(CO	NTINUE)						S	TATION	HEIGH	T 1326	m
DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	max	metre	min	metre
1	1.6	0.9	0.4	-3.2	-3.9	-0.8	-0.3	5.6	10.4	14.9	19.4	21.3	23.3	24.7	24.8	24.3	22.0	17.3	13.3	10.9	9.2	9.4	7.0	6.3	264.8	11.0	25.2	1516	-4.0	510
2	5.4	4.4	3.7	3.4	2.6	7.6	3.1	6.7	10.9	15.9	19.6	21.4	23.3	20.1	23.1	22.4	20.3	16.4	13.1	8.8	8.1	8.6	5.8	5.0	271.7	11.3	23.6	1415	2.6	550
3	6.5	3.6	3.3	2.6	3.6	1.7	2.4	6.9	10.6	15.8	18.3	19.6	20.7	21.6	21.4	21.1	19.4	16.0	13.8	12.2	9.5	7.7	6.3	5.1	263.2	11.0	21.8	1418	1.5	617
4	4.1	3.5	3.0	2.6	3.3	3.7	4.2	7.7	12.3	16.2	19.3	20.4	21.4	22.1	22.1	21.0	19.2	15.4	13.4	9.6	9.3	6.9	6.0	5.6	271.2	11.3	22.4	1448	2.5	421
5	5.3	4.7	3.6	3.2	3.3	2.6	5.5	7.3	12.1	16.0	16.6	17.0	19.0	19.9	20.1	19.3	16.6	14.1	12.4	11.1	9.3	8.6	7.5	6.7	260.4	10.9	20.2	1341	2.6	502
6	6.8	5.4	4.7	4.1	3.1	2.8	2.1	4.6	6.3	9.7	11.9	13.0	13.2	13.5	13.4	13.6	12.1	9.4	8.0	7.7	7.2	5.2	4.8	4.8	185.7	7.7	14.6	1326	1.9	708
7	5.1	4.2	4.0	4.0	4.0	4.2	4.3	4.5	6.7	7.7	8.6	9.8	9.7	8.3	8.4	7.3	6.6	5.8	5.6	5.4	5.6	5.4	4.8	3.7	144.1	6.0	10.2	1426	3.8	341
8	2.9	2.5	3.3	2.5	1.5	5.0	0.6	5.5	1.9	3.8	7.7	8.4	11.5	12.5	12.7	13.2	11.6	8.3	6.7	5.6	4.8	4.3	3.5	2.7	135.0	5.6	15.4	1634	0.4	843
9	4.6	1.8	2.4	1.6	1.7	1.6	2.1	3.7	6.1	8.4	13.9	15.6	17.1	17.5	17.6	17.3	15.6	12.5	11.0	9.7	9.5	6.8	7.1	6.8	208.8	8.7	18.6	1530	1.0	143
10	8.7	4.9	4.6	3.2	2.6	4.1	3.9	6.3	10.5	13.6	15.7	16.8	18.0	18.7	18.6	18.5	17.4	15.6	14.3	13.0	11.9	11.5	10.2	9.0	264.0	11.0	19.7	1529	2.4	541
11	8.4	6.7	5.1	4.5	4.0	4.6	6.6	8.1	12.4	14.9	16.9	18.1	19.4	20.4	19.5	19.6	18.4	15.5	12.6	10.5	12.4	11.6	8.6	9.7	293.0	12.2	20.9	1417	4.0	611
12	8.2	7.5	6.6	4.7	3.8	3.8	3.9	7.6	11.5	15.4	17.8	18.7	20.0	21.2	20.8	20.7	19.2	14.7	12.6	9.7	9.3	6.5	5.9	4.8	273.8	11.4	21.4	1402	3.3	541
13	4.3	3.6	2.7	2.0	1.3	1.2	0.8	5.9	8.9	13.3	17.0	18.1	20.2	20.7	20.4	20.1	16.6	14.6	11.7	8.5	7.9	6.7	5.4	4.6	238.5	10.0	20.8	1312	0.5	719
14	6.1	4.4	5.0	4.6	7.1	6.4	6.6	7.4	10.1	12.2	14.7	18.0	17.0	17.6	18.8	17.7	16.6	13.2	13.0	10.5	6.3	8.5	7.2	6.7	251.5	10.5	18.8	1504	5.8	727
15	6.1	5.3	4.2	4.2	3.6	3.8	4.0	5.6	8.9	12.1	14.0	16.7	16.8	17.7	18.1	17.5	15.9	13.1	11.6	10.4	9.2	8.0	7.1	6.1	240.0	10.0	18.2	1513	3.5	636
16	6.0	4.0	3.6	3.4	2.6	2.4	2.7	5.2	8.0	11.1	13.5	15.0	16.1	16.9	16.3	15.6	14.5	12.1	11.4	9.6	6.4	6.5	6.3	6.2	223.2	9.3	17.0	1625	2.4	611
17	6.4	7.8	7.3	6.7	6.2	5.7	5.6	5.7	5.8	6.1	8.0	8.6	6.6	6.6	6.4	6.5	6.4	6.4	6.6	7.2	6.9	6.2	6.1	5.7	155.4	6.5	7.3	1649	5.5	620
18	6.5	6.8	4.5	4.5	4.0	3.8	3.8	5.4	7.9	9.4	11.0	12.9	12.0	13.5	16.0	14.5	13.1	10.0	9.3	8.0	7.2	5.5	4.4	3.4	195.7	8.1	16.1	1459	3.6	403
19	2.9	2.1	1.6	1.2	0.0	0.6	1.1	3.5	7.6	10.3	12.1	13.4	14.5	13.9	14.5	15.2	14.5	11.8	9.8	8.1	6.4	5.1	4.3	3.6	177.8	7.4	15.6	1512	0.6	533
20	2.8	2.2	1.6	1.4	0.9	0.7	0.7	4.0	8.0	11.6	14.3	15.5	15.8	15.5	17.8	17.1	15.0	12.7	10.3	6.4	7.2	5.7	5.4	4.6	196.7	8.3	17.5	1450	0.6	657
21	3.2	2.7	2.4	2.0	2.0	1.3	3.0	4.2	6.6	10.6	13.6	15.6	15.7	17.1	16.7	17.1	15.5	13.0	11.8	6.5	6.1	8.4	9.5	6.9	214.4	8.9	17.5	1614	1.0	708
22	7.6	7.5	7.3	10.4	7.1	5.8	5.7	7.7	11.7	13.5	15.4	16.0	17.8	16.9	16.6	15.9	15.4	14.1	13.7	12.5	12.1	11.0	10.0	9.2	281.7	11.7	18.1	1252	6.4	610
23	8.9	8.8	8.4	8.2	8.5	8.1	7.0	8.8	9.4	11.4	13.0	14.3	15.1	15.3	14.6	14.2	13.9	12.9	12.0	11.2	11.1	10.8	10.3	9.9	267.2	11.1	15.9	1410	7.6	712
24	9.6	8.2	9.0	7.7	7.3	7.0	6.6	8.4	9.8	12.2	11.6	13.2	12.9	12.6	12.6	12.7	12.2	11.4	10.7	10.4	9.0	8.6	8.6	6.5	240.1	10.0	13.9	1142	6.3	655
25	7.8	7.7	7.6	7.7	7.7	7.5	7.3	7.6	8.1	9.3	10.0	11.5	12.1	12.4	13.1	13.0	12.7	11.6	11.2	10.8	10.4	9.9	9.6	9.3	236.2	9.8	13.2	1444	7.3	856
26	9.1	8.7	8.5	7.9	7.4	7.4	7.1	8.6	9.7	13.0	14.3	15.6	17.0	16.9	16.4	17.2	16.5	15.4	14.3	13.0	11.6	11.3	10.5	9.6	289.0	12.0	18.6	1517	7.1	704
27	8.6	7.6	7.4	7.1	6.8	6.1	5.8	8.0	12.0	15.6	17.4	19.7	21.1	21.2	21.8	20.7	20.0	17.0	14.7	13.1	11.4	10.2	8.4	8.4	309.6	12.9	21.8	1400	6.4	651
28	7.8	7.2	6.5	6.7	5.9	5.1	4.9	8.5	14.2	18.5	19.3	20.7	22.5	23.2	23.7	23.3	22.4	19.6	16.6	13.8	13.7	15.9	10.8	9.4	337.1	14.0	24.0	1449	4.9	622
29	8.2	7.3	6.7	6.2	5.9	5.8	8.0	9.1	14.0	17.3	19.5	22.0	23.3	23.7	23.1	23.4	22.8	20.1	17.8	16.1	13.8	11.7	10.3	11.1	344.7	14.4	24.0	1640	5.8	557
30	9.8	7.9	7.2	6.7	6.0	5.8	7.0	8.4	13.2	17.9	18.2	20.3	20.8	22.1	22.0	22.2	21.1	19.2	17.2	15.9	13.7	12.4	11.3	10.4	336.0	14.0	22.4	1657	5.6	545
31	10.0	9.5	9.2	8.7	8.4	8.4	8.4	9.8	11.3	13.4	15.8	17.5	18.1	20.8	21.1	20.8	20.3	18.4	16.2	15.2	13.3	11.8	10.7	10.1	327.4	13.6	21.2	1456	8.3	547
tot	189	7 167	1 156	9 142.	9 130	5 124	0 127.	3 109	6 286	3 365	5 455.	8 502.	3 531	0 546	1 552	9 543.	0 505	3 429.	4 372.	9 327	9 295	(288	5 237.	2 216.3	7705		8 571.		6 110	6
avg	6.1	5.4	5.0	4.6	4.2	4.0	4.1	6.4	9.6	12.4	14.7	16.2	17.1	17.6	17.8	17.5	16.3	13.9	12.0	10.6	9.5	8.6	7.7	7.0		10.3	18.4		3.6	

7 ..

	ST 3314C		9 PRETOR	IA WO							H	OURLY 1986/	DATA	TEMP 8	ERATUR	E			(CO	NTINUE)						S	TATION	HEIGH	T 1326	m
DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	max	metre	min	metre
1	0.0	8.3	7.5	7.4	6.6	6.7	7.5	10.2	14.9	18.0	20.2	21.1	22.3	23.6	24.1	25.0	22.7	20.9	19.5	17.1	15.8	14.6	14.0	15.5	372.6	15.5	24.5	1440	6.7	656
2	14.7	12.7	10.4	6.9	6.6	7.8	8.1	10.1	15.3	17.0	19.5	21.6	22.2	23.4	23.0	22.8	21.6	16.7	15.9	13.5	11.4	10.0	9.2	9.0	354.0	14.6	24.1	1406	7.7	640
3	10.2	9.0	9.5	10.6	8.5	9.7	9.3	9.9	11.1	13.0	14.7	16.6	17.7	19.4	18.8	19.1	17.2	15.5	13.6	13.0	12.5	12.0	11.6	11.7	330.3	13.2	24.2	1418	8.5	224
4	11.0	11.7	11.7	11.4	11.5	11.4	11.5	11.5	11.3	10.7	10.9	11.3	12.4	12.6	13.1	15.0	12.9	13.5	12.2	12.0	11.6	11.7	10.9	10.7	281.9	11.7	15.3	1405	10.7	1010
5	10.6	10.5	9.8	9.7	9.2	9.2	9.1	9.1	9.1	9.4	9.7	9.7	9.7	9.9	10.3	10.7	11.3	10.6	10.4	9.2	8.8	7.8	7.0	6.4	230.8	9.5	11.4	1717	8.0	838
6	8.5	5.1	4.6	4.5	3.9	3.3	3.5	6.1	7.5	10.1	11.4	12.7	14.5	15.3	15.4	15.3	14.4	12.6	10.6	9.2	8.3	6.6	5.6	3.6	210.9	8.8	16.0	1447	3.2	805
7	2.7	2.2	1.4	0.8	2.6	3.4	4.1	6.4	9.2	12.4	14.3	15.7	16.1	17.7	17.0	17.1	16.0	12.9	12.3	11.0	9.9	8.6	7.7	7.5	230.9	9.6	18.3	1420	0.6	[illegible]
8	7.3	6.3	5.5	3.6	4.2	2.9	3.5	8.6	10.5	15.5	15.3	17.0	16.3	18.9	20.7	20.0	19.2	18.0	13.4	10.5	5.4	7.0	5.7	4.8	260.4	10.9	21.0	1514	2.3	650
9	3.6	2.8	2.2	1.5	1.2	0.5	0.4	4.5	10.6	14.5	17.6	19.5	20.4	21.5	23.0	21.2	20.3	17.1	13.8	11.2	9.7	8.0	7.2	5.8	257.0	10.7	23.0	1500	0.3	614
10	5.2	4.5	4.4	3.9	3.3	3.1	3.2	7.3	13.6	16.8	19.2	21.8	22.7	23.6	24.5	23.9	23.7	21.2	18.9	17.0	14.5	12.8	12.2	11.5	332.5	13.9	24.6	1458	3.0	556
11	11.7	9.9	9.2	8.4	7.5	7.3	6.9	10.1	14.9	19.1	21.4	23.6	24.5	25.2	25.5	24.8	24.0	22.2	20.1	18.5	18.2	16.8	15.5	14.2	399.3	16.6	25.0	1447	6.7	645
12	13.5	12.5	12.5	12.0	11.9	11.8	11.8	12.8	14.3	16.4	18.2	18.9	21.7	23.7	24.6	24.1	22.8	21.1	19.7	19.3	19.0	18.6	17.8	17.4	417.3	17.4	26.2	1531	11.6	700
13	16.8	14.0	11.4	10.7	10.5	9.9	9.9	13.5	17.7	19.7	20.9	22.4	23.9	24.9	25.3	24.6	24.3	21.8	18.8	19.1	17.6	15.0	12.6	12.7	418.1	17.4	25.6	1515	9.8	542
14	11.0	10.5	8.8	0.8	5.8	5.1	5.5	10.4	13.0	15.5	17.3	17.9	19.6	20.6	20.8	20.7	19.9	17.6	16.0	14.8	13.8	13.2	11.6	10.7	327.0	13.7	21.3	1445	5.1	558
15	9.0	10.3	10.2	10.0	9.8	9.4	9.5	9.4	10.1	10.9	12.3	13.1	13.8	14.4	15.2	15.6	15.2	14.0	13.4	12.7	11.7	10.4	9.2	9.0	279.4	11.6	16.1	1522	8.2	731

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DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12–h24, tot, avg, max, station height columns
16–31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
tot	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
avg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

HOURLY DATA TEMPERATURE

ST 33140 PRETORIA WO

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12–h24, tot, avg, max, station height columns
1	10.4	9.9	9.4	8.7	8.5	7.9	8.0	12.9	17.8	21.4	23.6	[illegible]
2	15.0	15.1	14.2	13.7	13.2	13.1	12.7	15.5	17.5	19.4	21.8	[illegible]
3	12.0	12.0	11.6	10.5	10.1	10.7	12.0	15.4	16.1	20.3	25.1	[illegible]
4	14.3	14.1	12.7	11.1	10.6	12.6	13.1	13.5	15.1	18.2	20.7	[illegible]
5	14.7	13.6	12.2	11.3	10.9	10.4	11.4	16.0	18.5	21.2	23.2	[illegible]
6	12.2	12.1	11.7	11.1	9.6	8.5	10.3	15.5	20.6	23.0	26.1	[illegible]
7	11.0	11.6	11.0	10.1	9.0	8.5	10.1	14.8	18.6	21.1	25.5	[illegible]
8	15.4	14.5	14.4	13.0	13.6	13.2	13.4	16.8	21.6	23.8	25.2	[illegible]
9	17.6	16.3	15.4	14.5	15.4	14.5	14.0	15.5	22.6	25.6	27.6	[illegible]
10	17.1	20.3	16.6	14.5	13.6	13.0	14.5	18.4	22.7	25.6	27.7	[illegible]
11	21.4	20.6	20.4	19.5	18.4	16.9	19.6	25.4	22.7	25.6	27.6	[illegible]
12	19.3	18.7	16.6	16.3	18.5	17.9	18.3	20.1	22.4	24.9	26.8	[illegible]
13	16.6	16.6	13.6	12.5	11.5	11.2	11.6	13.3	16.3	17.7	19.9	[illegible]
14	11.7	10.5	8.6	9.3	8.7	7.8	9.1	12.3	16.0	18.0	20.5	[illegible]
15	11.6	14.4	13.1	12.4	11.7	11.3	11.8	13.2	15.7	17.4	19.3	[illegible]
16–31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
tot	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
avg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

HOURLY DATA TEMPERATURE

ST 33140 PRETORIA WO

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12–h24, tot, avg, max, station height columns
1–31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
tot	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
avg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

H OURLY DATA TEMP ERATUR E 10 -- (CO NTINUE)

51 3314C PRETOR IA WO 1986/ 11 — S TATION HEIGH T 1326 m

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	17,1	16,5	15,5	14,5	14,2	14,4	16,3	22,0	24,3	26,3	27,7	28,7	30,1	30,0	31,0	30,9	30,6	29,4	26,5	24,2	22,8	21,4	20,6	19,6	554,7	23,1	31,1	1500	15,8	446
2	18,7	18,2	17,5	16,8	16,9	16,4	19,9	23,8	26,2	28,2	29,9	31,4	32,0	32,2	32,1	32,5	31,9	30,5	27,8	27,8	24,8	22,7	21,3	20,5	598,0	24,9	32,7	1450	16,2	611
3	19,5	18,6	17,9	17,4	17,0	17,2	20,3	25,0	27,0	28,6	29,9	31,1	31,9	31,8	32,2	32,7	33,1	31,6	29,0	28,0	27,1	26,3	25,0	23,0	605,0	25,8	33,9	1500	16,7	536
4	20,9	20,1	21,4	21,4	21,1	20,9	21,8	24,8	26,0	27,8	29,8	31,0	31,5	32,5	32,6	32,6	31,7	30,1	26,8	26,6	24,5	24,2	24,2	22,8	634,6	26,4	33,0	1430	20,8	527
5	25,0	22,4	21,3	21,9	20,9	20,9	24,6	24,0	26,0	28,3	30,6	31,0	32,2	32,6	30,4	33,5	32,1	30,4	28,4	27,0	26,5	25,6	24,3	23,5	647,2	26,8	33,0	1325	20,6	530
6	21,2	20,5	20,0	20,3	20,5	20,0	20,7	23,3	24,7	26,6	26,0	26,9	27,6	28,1	28,4	26,1	27,0	25,1	24,0	23,1	21,6	20,5	19,4	18,5	565,4	23,5	28,8	1500	18,0	500
7	18,2	18,1	17,2	17,3	16,5	16,6	17,1	19,6	20,6	21,5	22,8	24,1	24,7	25,1	26,0	26,2	26,0	25,0	23,7	22,5	21,3	20,3	19,8	19,2	509,9	21,2	26,5	1447	16,3	514
8	18,9	18,8	18,4	18,1	18,0	17,8	18,8	19,7	19,6	21,5	23,2	24,8	24,7	24,4	21,3	23,7	24,0	23,8	22,3	21,4	20,3	18,9	18,0	14,3	490,2	20,4	25,0	1204	17,7	610
9	17,6	16,6	15,2	14,9	15,3	16,3	19,9	20,4	22,5	24,5	26,6	27,4	28,8	29,4	30,0	29,3	28,6	27,1	25,7	23,7	22,6	22,2	20,5	20,2	548,4	22,8	30,3	1529	14,8	412
10	21,5	20,8	20,4	19,6	19,6	19,6	20,6	23,7	24,8	26,8	27,3	28,4	29,8	30,6	29,6	28,8	25,5	24,2	23,9	22,9	22,5	22,0	19,7	18,1	567,2	23,6	30,6	1447	18,4	514
11	17,6	18,2	18,6	19,1	18,4	19,3	19,1	20,0	23,0	24,1	25,6	25,8	26,8	26,7	26,5	26,3	24,1	23,5	22,4	21,9	21,5	20,9	21,0	20,5	529,6	22,1	27,2	1348	17,6	182
12	19,6	19,7	19,4	17,7	17,2	18,1	20,6	23,0	25,8	27,0	26,3	26,8	29,1	30,6	29,0	29,9	28,0	27,9	26,9	26,2	25,4	23,6	23,6	22,7	577,3	24,6	31,4	1453	17,1	516
13	21,6	21,8	21,5	21,5	19,6	20,1	20,6	18,8	18,5	18,0	19,4	22,3	26,1	25,0	25,7	25,7	24,0	22,5	21,1	20,5	20,3	20,2	19,8	19,5	517,6	21,6	27,2	1445	16,6	[illegible]
14	18,6	18,3	18,0	17,9	18,1	17,1	16,2	19,7	21,6	22,5	21,8	20,7	20,0	19,0	18,5	17,0	16,7	15,4	15,4	14,2	14,5	14,2	13,6	14,8	422,3	17,6	22,7	1025	14,8	[illegible]
15	13,8	13,5	12,2	13,0	13,0	13,9	13,3	14,0	14,0	15,3	16,0	16,6	20,7	21,9	22,4	23,0	21,1	20,2	19,1	18,7	15,4	15,1	17,6	16,8	409,1	17,1	23,6	1353	12,8	[illegible]
16	16,6	16,2	16,1	16,0	16,3	16,7	16,9	16,2	17,2	17,6	17,3	17,6	16,5	18,1	17,6	17,2	17,2	16,6	16,8	16,7	16,4	16,2	16,2	16,6	[illegible]	[illegible]	[illegible]	[illegible]	15,6	[illegible]
17	15,9	15,6	15,5	15,2	14,0	14,0	15,3	17,7	18,2	18,5	19,8	19,8	21,0	21,5	20,5	21,0	21,4	20,1	19,9	19,3	17,4	16,9	17,4	17,1	[illegible]	18,1	[illegible]	1542	13,6	535
18	16,7	16,8	16,7	16,4	13,9	14,1	16,6	18,7	20,2	21,6	23,6	24,4	22,6	25,5	25,9	24,7	25,0	20,3	17,6	17,6	18,0	17,3	17,3	16,6	[illegible]	[illegible]	21,6	[illegible]	13,5	492
19	16,5	16,2	15,5	15,2	14,8	14,6	15,7	17,3	19,5	20,6	20,4	23,1	23,1	24,2	17,5	18,6	18,0	17,7	16,6	16,6	16,6	16,2	14,1	14,4	[illegible]	17,6	[illegible]	1527	14,5	[illegible]
20	15,9	14,7	14,6	12,9	13,8	13,4	16,1	17,6	19,6	20,6	23,4	23,4	24,9	24,2	24,7	25,1	24,2	22,5	22,9	21,6	21,6	20,1	18,1	16,2	[illegible]	19,6	[illegible]	1600	13,1	[illegible]
21	14,3	15,1	14,8	15,5	15,1	15,4	17,3	19,6	19,8	20,1	21,6	21,4	21,8	25,6	27,0	27,1	24,4	22,5	24,5	23,0	21,5	19,1	16,1	14,3	[illegible]	20,2	21,6	1549	14,7	[illegible]
22	13,5	12,3	11,3	10,7	9,5	9,9	12,1	14,1	16,0	17,5	19,2	20,7	21,7	25,2	24,1	24,2	23,5	22,7	20,5	19,5	18,7	17,2	16,8	16,7	[illegible]	17,3	24,2	1640	9,0	[illegible]
23	15,4	13,2	12,9	11,5	10,8	10,8	18,0	18,3	21,2	23,0	24,3	24,5	25,2	25,5	26,4	25,8	25,6	25,0	20,5	21,5	21,1	20,4	19,1	19,2	480,2	20,0	26,9	1549	10,7	530
24	17,4	18,6	16,7	16,1	15,2	15,1	15,5	17,4	18,4	18,9	20,8	21,6	22,9	22,7	22,7	21,6	21,5	21,1	19,7	18,7	17,9	17,7	17,3	16,5	450,5	18,8	23,4	1550	15,1	535
25	15,9	16,2	15,4	16,4	16,1	16,2	16,6	19,3	21,9	23,2	24,4	25,6	22,7	24,2	25,2	26,0	25,9	25,0	23,3	21,8	21,0	20,7	10,4	16,8	[illegible]	20,9	26,4	1631	15,3	240
26	17,1	16,7	16,6	15,5	15,3	16,2	18,5	21,3	23,4	24,4	20,7	28,0	20,5	20,0	29,6	26,7	26,7	27,8	19,1	19,3	20,2	21,0	20,5	19,5	533,6	22,2	30,2	1612	15,1	456
27	18,4	17,7	17,5	17,1	16,6	16,2	16,9	17,4	18,0	18,8	19,0	18,7	16,6	18,3	20,1	19,4	16,6	17,5	17,2	17,1	18,9	18,5	16,2	16,4	425,5	17,7	20,7	1437	15,9	507
28	14,4	13,2	13,8	13,8	13,0	13,1	12,6	12,8	13,0	13,2	13,5	13,5	13,8	13,8	13,9	13,9	13,9	14,0	13,7	13,9	14,0	13,9	14,0	14,1	325,5	13,6	15,3	800	12,7	644
29	14,2	14,3	14,2	14,1	13,5	13,8	14,3	16,3	16,8	18,0	20,1	20,9	22,5	23,8	24,0	24,4	22,9	22,9	21,5	20,3	19,1	18,0	18,5	18,2	445,4	18,6	24,7	1603	13,3	516
30	17,2	16,4	15,5	15,0	14,5	14,9	17,8	21,8	24,1	24,9	26,2	27,6	26,5	27,8	25,6	19,6	21,0	20,9	20,6	20,0	16,8	18,3	18,3	17,8	481,3	20,8	28,9	1333	14,5	571
tot	527,	4 515	7 501	3 492	6 478	8 479	1 524	3 586,	1 635,	6 668	6 700	0 722,	0 761	2 770,	6 705	5 765,	7 739	4 709	0 662	1 635,	4 613,	0 592,	0 569,	9 549,0	14874,		2 803,		4 464,	9
avg	17,6	17,2	16,7	16,4	16,0	16,0	17,5	19,6	21,2	22,3	23,5	24,4	25,4	26,7	25,6	25,3	24,6	23,7	22,1	21,0	20,4	19,8	19,0	18,3		20,6	26,8		15,5	

H OURLY DATA TEMP ERATUR E 11 -- (CO NTINUE)

51 3314C PRETOR IA WO 1986/ 12 — S TATION HEIGH T 1326 m

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	17,5	17,1	17,4	16,4	16,1	16,5	17,9	20,0	22,0	23,2	23,7	24,8	26,8	27,5	27,2	27,7	28,3	27,5	25,6	23,8	22,4	21,4	20,2	19,4	[illegible]	22,3	28,8	1620	16,0	500
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
tot	586,	6 575	9 562	6 552,	0 545	4 547	9 574,	1 625	2 670	1 714	4 761	7 765,	7 811	8 832,	0 844	7 840	4 811,	1 774	4 731	2 688	3 654	0 631,	3 614,	6 598,8	16120		3 868,		7 531,	8
avg	18,9	18,6	18,1	17,8	17,6	17,7	18,6	20,7	21,8	23,0	24,2	25,3	26,2	26,9	27,2	27,1	26,2	25,0	23,6	22,2	21,1	20,4	19,6	19,3		22,0	28,1		17,2	

H OURLY DATA TEMP ERATUR E 12 -- (CO NTINUE)

51 3314C PRETOR IA WO 1987/ 1 — S TATION HEIGH T 1326 m

DAY	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	tot	avg	mx	mxtm	mn	mntm
1	10,5	18,6	18,8	17,4	16,9	17,5	16,5	22,5	25,8	26,8	27,1	28,1	28,8	28,6	29,2	31,0	31,4	29,5	28,8	26,5	25,3	24,5	22,6	22,0	580,5	24,6	32,4	1604	16,9	408
2	22,2	20,6	20,8	19,7	18,1	18,9	19,2	19,1	19,6	21,2	22,7	25,4	26,3	27,8	27,7	26,8	27,1	25,7	25,1	24,1	23,5	22,3	21,5	21,1	547,4	22,8	26,1	1410	18,7	532
3	19,6	19,0	19,6	18,5	18,1	17,7	18,4	20,8	21,2	23,7	24,7	25,4	26,0	27,0	29,3	29,5	29,0	27,2	26,5	25,1	24,3	24,1	23,8	23,6	562,4	23,4	30,0	1520	17,6	550
4	20,5	19,0	17,5	17,4	16,6	17,3	18,7	19,6	20,5	23,2	24,1	24,5	25,2	26,5	26,7	27,1	26,6	23,6	22,3	22,2	21,8	21,3	20,4	19,7	520,2	21,7	27,6	1545	16,6	506
5	19,1	18,7	18,4	17,9	17,1	18,6	17,9	20,3	21,0	22,5	24,4	25,2	25,5	27,0	27,6	27,4	27,4	26,2	25,3	24,5	23,0	21,7	20,8	20,1	530,1	22,3	28,4	1612	18,8	503

APPENDIX E

EXAMPLE OF MEASURED DATA: HOUSE 1

DATA ELECTRONICS DT5 DATA LOGGER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

4083
219
MD2000T
*
SERIAL NUMBER :-
11869
*
MEASUREMENT UNIT :-
Temperature
*
APPLICATION :-
afi-comfort
*
START DATE :- 2 May 1996
2/5/96
*
START TIME :-
21:30:00
*
RECORDING INTERVAL (seconds) :-
900
*
GRAPH Y AXIS LEGEND :-
TEMPERATURE DEG C
*
GRAPH X AXIS LEGEND :-
TEMPERATURE
*
GRAPH Y AXIS MAX VALUE :-
60
*
GRAPH Y AXIS MIN VALUE :-
-40
*
GRAPH Y AXIS INCREMENTS :-
5
*
DUAL channel logger
*
*
*
Zero scale = -40.00
Full scale = 85.00
Event count scale = 1.00
*
*
*
RECORDED DATA :-
18.1
18.1
18.1
17.8

17.6
17.5
17.6
17.4
17.2
17.2
17.1
17
16.9
16.9
16.9
16.9
16.5
16.5
16.5
16.4
16.3
16.3
16.1
16.1
16.1
15.9
15.9
15.9
15.9
15.8
15.6
15.6
15.5
15.5
15.5
15.5
15.4
15.4
15.4
15.4
15.3
15.1
15.3
15.4
15.4
15.6
15.9
16.1
16.1
16.6
16.9
17.2
17.2
17.6
17.7
18
18.1

18.3
18.5
18.6
18.7
18.9
19.1
19.4
19.6
19.8
19.9
20.2
20.2
20.2
20.2
20.3
20.3
20.4
20.4
20.4
20.3
20.4
20.2
20.2
19.9
20
19.9
19.7
19.7
19.4
19.3
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APPENDIX F

PARTICIPANTS IN COMFORT STUDY

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Participants of the case studies.

Name	Address	Tel	Insulation
VDS (Van der Spuy) Brink House 1	381 Wisteria Road Faerie Glen Ext 2 Pta	(012) 6726765 (w) 083 264 0414 (cell) (012) 991 1868 (h)	**50 mm**
Mike Krynaugh House 3	373 Wisteria Road Faerie Glen Ext 2 Pta	(012) 991 0614 (h)	**75 mm**
Rollie Schoeman House 4	369 Wisteria Road Faerie Glen Ext 2 Pta	(012) 991 2330 (h) (all hours)	**100 mm**
Elmarie van Loggerenberg House 8	70 Villa Street Sunnyside Pta	(012) 344 0622 (h) (afternoon)	**50 mm**
Carlo Piani House 6	612 Villa V.S.A. 281 Serene Str Garsfontein Pta	(012) 420 2749 (w) (012) 47 7206 (h)	**50 mm**
Marius Kleingeld House 5	39 Gunib Crescent Erasmuskloof Ext 3 Pta	(012) 420 2195 (w) (012) 45 1904 (h)	**100 mm**

Control (insulate in 1998)

A Kock House 2	20 Riverview 810 Delfi Ave Garsfontein Ext 15 Pta	(012) 98 5044 (h)	
C S B Piani House 7	169 Duvernoy Str Constantia Park Pta	(012) 98 3618 (h)	