Implementing energy efficiency policy in housing in South Africa

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Abstract

The Thermal Insulation Association of South Africa (TIASA) is supporting government measures to promote energy efficiency in South African buildings. The research document titled: 'New standards of thermal design to provide comfort and energy efficiency in South African housing', has been adopted by TIASA, and details an objective basis for a standard. The S.A.N.S. 283 titled: 'Energy efficiency for naturally ventilated buildings' has as its premise, the same assumptions and methodologies as the research document. The provision of comfort in all housing in South Africa, including the problematic 30/36 m² subsidy house – can be a reality with the proposals.

Keywords: energy efficiency in housing, thermal comfort in housing, residential based carbon reduction, sustainable development in housing

1. The objectives of introducing energy efficiency measures into housing

1.1 International goals of sustainable development

The need for protection of the environment and the adoption of the principles of long-term sustainability for the development of all mankind was embodied in the United Nations Framework Convention on Climate Change (UNFCCC). Various multilateral protocols developed in Kyoto and more recently confirmed in Johannesburg, have the same objectives, and particularly, the reduction of global carbon emissions. As a result, projects that reduce such emissions are tradable between nations in terms of the CDM (Clean Development Mechanisms) (Doppegieter et al., 2002).

Danida, the Royal Danish development organisation is pursuing such a project to provide energy efficiency in 250-500 trial houses with the National Department of Housing. This project may be of great benefit to South Africa, and to the environment, if adopted.

1.2 Energy efficiency objectives in South Africa

The first goal which the South African government wishes to achieve is set out in two white papers and a recent (April 2004) draft energy efficiency strategy developed by the Department of Minerals and Energy (DME 2004). This is the reduction of the production of greenhouse gas emissions, and to move towards sustainable development and minimize the adverse effects of energy use on the environment.

The secondary objective of the implementation of energy efficiency measures in South Africa can be the improvement of comfort and, therefore, thermal efficiency in buildings for all local climatic regions. These measures would reduce the energy costs particularly of poorer households. The standards will need to be such as may be accepted by the various interest groups suitable for incorporation into the building regulations and specifications for subsidy housing in South Africa.

Tertiary socio-economic objectives, which are peculiar to the South African energy scenario, are also possible to attain. These include reducing township air-pollution (Praetorius & Spalding-Fecher 1998), preventing condensation on the interior of walls and ceilings of homes and therefore the development of mould growth and spore production, which is a common cause of respiratory problems in the south and western coastal (SCCPA – Southern Cape Condensation Problem Area) regions of the country. A further objective of introducing energy efficiency therefore might be to solve the health problems caused by poor indoor air quality in homes (Winkler et al., 2002).

1.3 Objectives in response to local energy efficiency design problems

An investigation of the energy usage in housing in South Africa shows a unique energy and thermal design problem. The level of thermal design and insulation required to achieve acceptable percentages of persons comfortable in the typical very small subsidy housing units is found to be considerable and an innovative approach is necessitated (Holm, D, personal communication). The heating necessary in the cooler climatic regions of South Africa in smaller homes places a huge cost premium on comfort for these house occupants (Simmons & Mammon, 1996). A disproportionately large portion of the expenditure of poorer households is spent on energy. By improving the energy standards in buildings, a significant portion of the poorer section of the South African community will have a better quality of life (Simmons, 1997).

1.4 Objectives in response to local electricity generation problems

The deferment of peak electrical demand growth will mean deferment of the construction of power stations, with huge cost savings for the nation (DME, 2004).

2. The energy problem in South African housing

2.1 A review of energy efficiency provisions in housing stock

The shortage of housing stock available to low-income families in South Africa is well documented, and is the focus of the National Department of Housing. Less publicized is the poor thermal quality of housing. Surveys of subsidy housing indicate extremely poor thermal design. Typical middle to upper income homes have been reviewed and analysed as part of this project, and it was found that they needed to be energy efficient. The reason for this may be because the building industry regulatory system presently has no provision for energy efficiency, and most construction design inadequately addresses this aspect.

In the case of the subsidy-housing sector, the provisions of the Housing Act – Norms and Standards requiring energy efficiency, have not been implemented. The present generic specification GFSH-11 of the National Housing Code contains an optional energy efficiency requirement (Soderlund and Schutte, 2003) that has only been amended for the SCCPA, to allow for the minimization of condensation, but which could be used for establishing energy efficiency in housing nationally.

2.2 A review of the electricity supply issues

The electricity industry is in the process of reorganizing in response to political programmes, while a potential debacle looms. The spectre of power shortages resulting from pressure on the distribution network, and a shortage of generating capacity in 2007 is a hard reality. One response of the generator (Eskom) is to introduce DSM (Demand side measures). A DSM programme would seek to reduce specific over-load problems and thereby postpone the construction of new power generating capacity.

The imposition of electricity tariff increases, which would provide cash reserves for the electricity supplier, can be used to fund the construction of new generating capacity. By increasing the cost of electricity, there will be some curtailment of energy consumption, thus possibly further postponing the need for the new capacity. Significant political will for such a policy may need to be summoned.

2.3 Alternative energy sources and greenhouse gas issues for government

The burning of coal and wood for home cooking and heating causes local air pollution in the Highveld townships in winter. Acid rainfall pollution in the eastern Highveld is caused by coal burning power stations. The resource based industries that include aluminium and steel making, pulp and paper manufacture, and metal and mineral refining, are all based on the coal energy source. South Africa is presently the third or fourth largest consumer of carbon product per Rand of Gross National Product in the world (Doppegieter et al., 2002). These factors combine to take a toll on the Southern African and global environment.

As a result of economic forces, the coal-based economy of South Africa is likely to be a fixture for many years. The adverse affects of this huge reliance needs to be mitigated against, by all the players – government, industry and consumers. Government influence in the processes can be significant. Diverse alternative sources of energy are being encouraged. This is noticed by the growth of a natural gas supply (Sasol / Pande field), the approval process for a pebble-bed nuclear reactor at Koeberg, and the Nepad process which may deliver more hydro-generating capacity in Southern / Central Africa.

The penetration of renewable energy sources such as solar (both domestic hot-water and electricity) and wind generation (Darling) appears to have much potential (Holm personal communication) when electricity costs increase.

2.4 Health improvements in housing

The over-whelming housing problem is a shortage of funds to provide housing efficiently to low-income families. The containment of state expenditures on community health (as result of respiratory disease caused by household air pollution) will follow the improvements in thermal design of buildings thus improving long-term sustainability.

3. Comfort and energy efficiency

3.1 Establishing comfort criteria for housing

The relationship between percentage persons comfortable (%P.C.) and dry bulb air temperature (Fanger, 1970) indicates a normal distribution of %P.C. around a thermal neutrality or comfort temperature. Recent research indicates an adaptation of thermal neutrality to seasonal and climatic variation. With allowance for the affects of clothing resistance, air movement and mean radiant temperature, and between absolute humidity bounds, thermal comfort can be predicted for particular temperatures.

The temperature requirements for thermal comfort (thermal neutrality) for both hot and cold seasons for the six major South African climatic regions have been assessed, with allowance for acclimatization in the TIASA research, using the latest available techniques provided by the adaptive theories of Alluciems and Szokolay (Auliciems & Szokolay, 1997; Szokolay, 1998).

An algorithm for Percentage of Persons Comfortable (%P.C.) variation with Affective Temperature is developed in Figure 1, which caters for local, regional and seasonal acclimatization, for naturally ventilated structures. The above is a rational basis for a comfort standard in South Africa, and has been proposed to serve as one of the performance criteria for incorporation into SANS 283 of the Energy Efficiency Standard for naturally ventilated structures, for ultimate incorporation into the National Building Regulations and SANS10-400.

Holm’s (2003) presentation of heating and cooling differences as per the attached maps (see Figure 3) shows the differences between local, seasonal mean temperatures and the thermal neutralities for locations around South Africa, and is proposed as a means of assessing climatic differentiation for the SANS 283 document.

3.2 Designing for energy efficiency

Computer modeling (Quick/Building Toolbox software, TEMM International) of the thermal performance of naturally ventilated residential structures demonstrates that with the appropriate design measures, a desired modification of internal temperature environment will be achieved. Designs which will influence the amplitude ratio or the range of internal temperature fluctuation to external thermal swing, such as to bring the internal temperature to within a swing of 7°C can be simulated. The width of the range of thermal comfort is +/-3.5°C above the thermal neutrality, and normally it would be necessary to heat in winter in many Southern African locations to prevent temperatures from dropping below the lower range of thermal neutrality. It is possible to model passive designs, such that winter solar gain, and summer night-time ventilation, maintain temperatures within the range of thermal neutrality, and will eliminate the need for artificial heating or cooling.

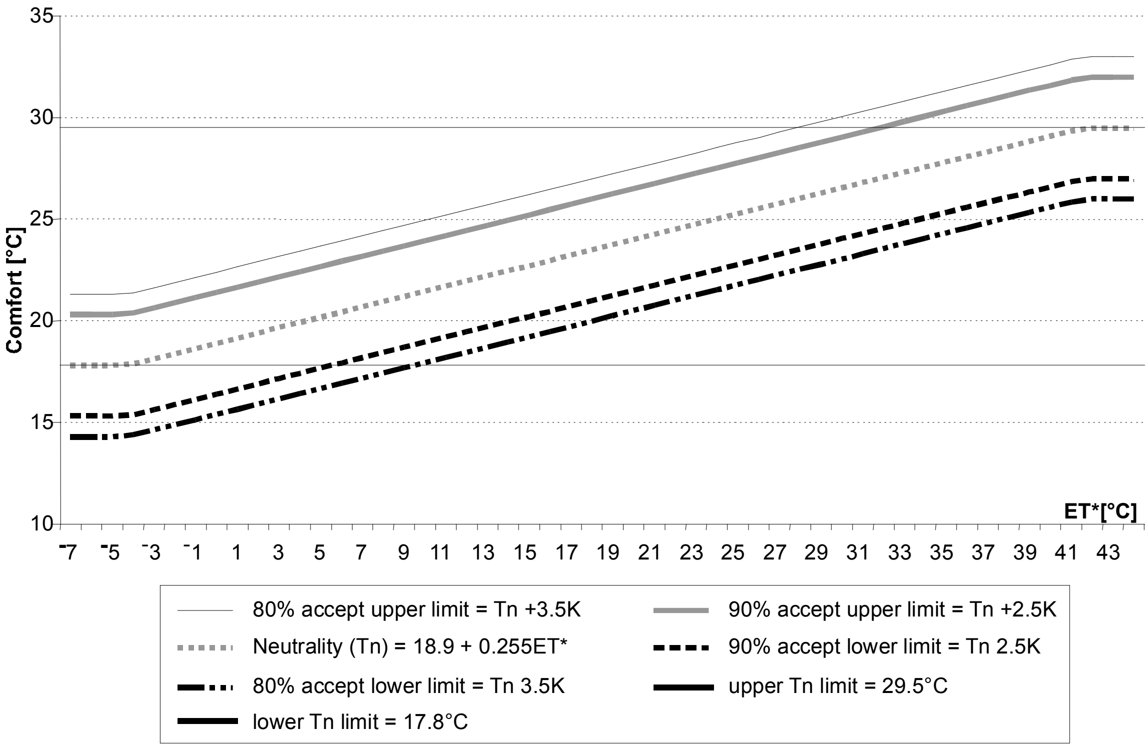

Figure 1: The dependency of indoor comfort with outdoor affective temperature (as per Holm in Section 2 of NOVA Fast-track project for TIASA)

South African climate is relatively mild in comparison with climates of similar latitudes as a result of the affects of altitude and influences of the warm Indian Ocean. This mildness of climate implies that daytime fluctuations of outside temperature do, even in the extremes of summer or winter, enter the range of local thermal comfort at some hours of the day. This enables the following methodology to be employed to devise a level of design intervention, which will achieve comfort with minimal energy input.

As is illustrated graphically in Figure 2(a), by applying heating to the extent of the mean heating difference for any region, we effectively bring the line labelled 'Required Air Temperature' up to the line designated 'Heated Air Temperature', and we bring the structure into comfort throughout the day. This heating requirement is minimized if the 'Required Air Temperature' has been engineered to have a swing of seven degrees only, or less over the same period. That is, if the correct thermal design is used and the internal swing is kept to 7°C, the heating requirement is minimized. This level of thermal performance is therefore proposed as the performance requirement for residential structures in South Africa.

The comfort performance requirement necessitates different levels of stringency for the various regions of South Africa. The maps of heating requirements in winter and cooling requirements in summer provided by Holm in Figures 3(a) and (b) are clearly illustrative of the need for this differentiation. The level of thermal design deemed necessary for the prevention of condensation and mould growth on the ceilings of houses in the Southern Cape Condensation Problem Area, will appear to be complementary to that required for comfort and reasonable energy efficiency.

Performance standards for the thermal resistance of the shell of structures are proposed, which when used with other design measures, will meet comfort standards, and provide houses that can be heated effectively at a reasonably low energy cost. It is possible to bring even the smallest home into affordable comfort, with the measures proposed and which are to be included in draft SANS 283.

3.3 Building and promoting an energy efficiency scale

A Star Rating System has been proposed in SANS 283, which will enable the rating of new and existing houses from an extreme of inefficiency through to an energy efficient passive design, using a software package approach. The software proposed to be used in South Africa is *Building Toolbox or NewQuick* or calibrated software produced in terms of ISO 13790 (Thermal performance of buildings – calculation of energy use for space heating) and ISO 16389 (Calculation of Energy Losses and Gains in Buildings).The same principle is proposed for an alternative compliance route for the satisfaction of the requirements of SANS 283.

In terms of the SANS 283 proposal, an energy efficiency level per square metre of floor area is calculated. This is the heating and cooling requirement per annum measured for variations of internal tem-

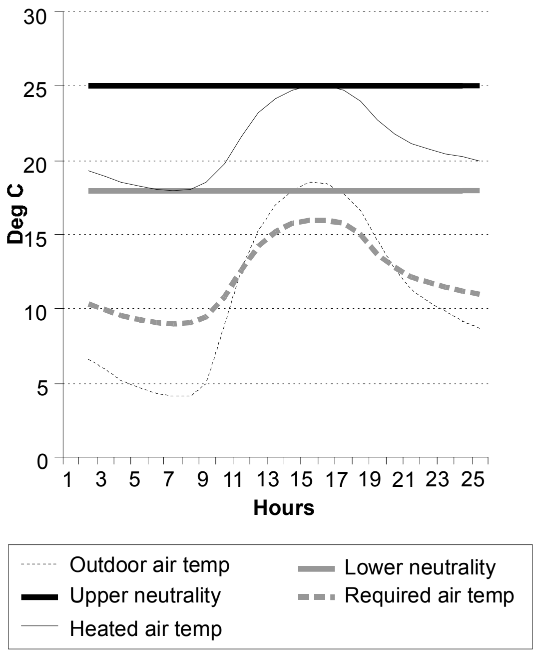

Figure 2(a): Typical cold condition – winter temperature data

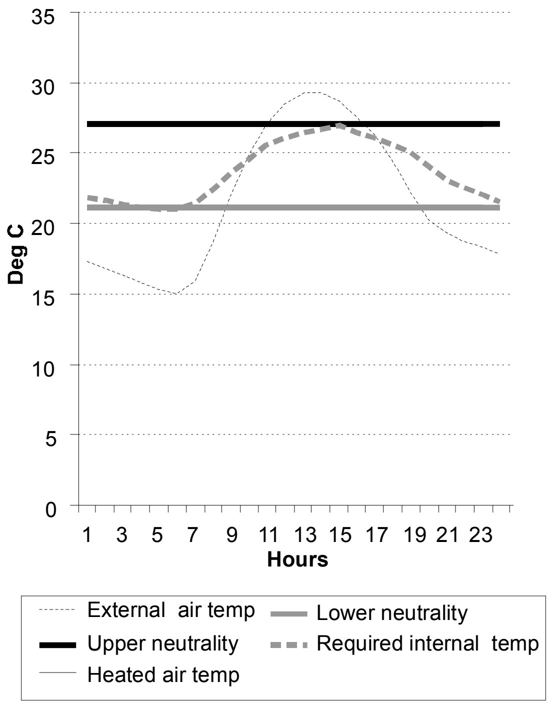

Figure 2(b): Typical hot condition – summer temperature data

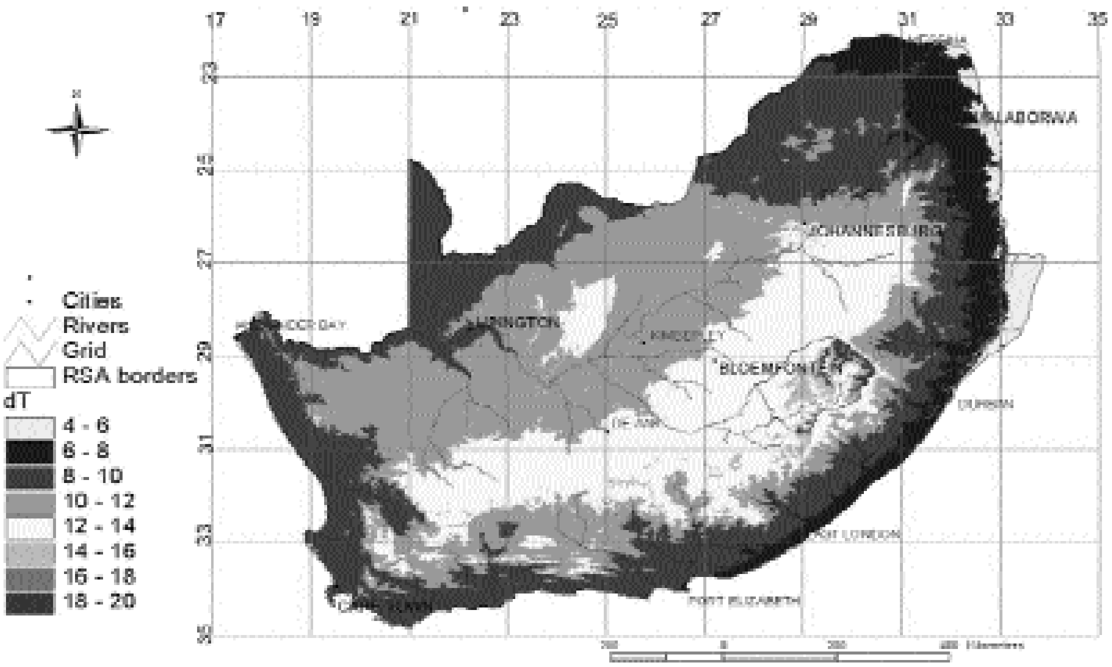

Figure 3(a): Heating requirements (Winter) as per Holm

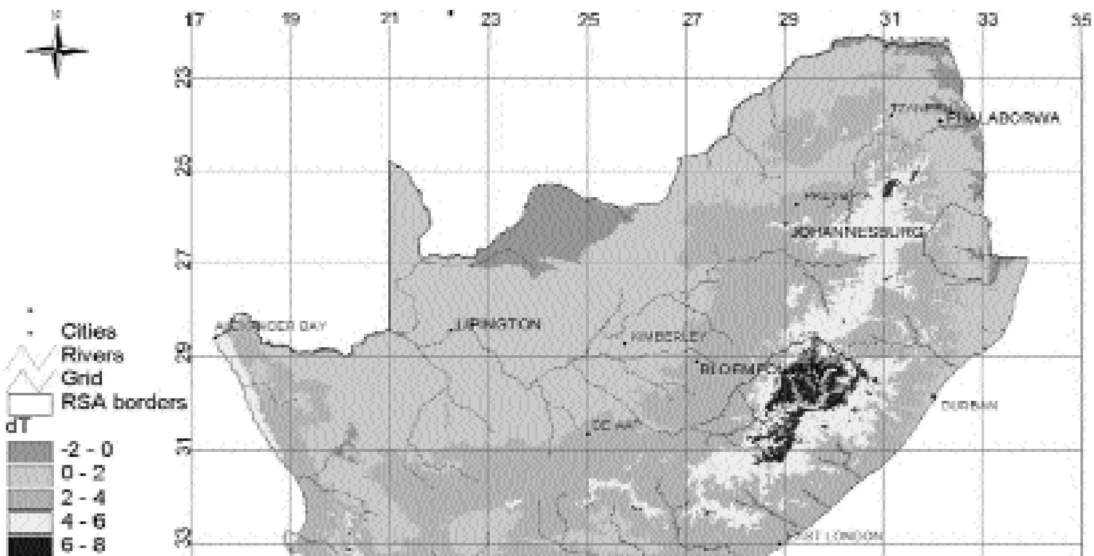

Figure 3(b): Cooling requirements (Summer) as per Holm

perature, which are outside the band of comfort (thermal neutrality).

A benchmark energy efficiency for a standard house is selected to be at the three & half star rating of the range. This design of house has different energy efficiencies for each climatic region, but the same star rating. It is the energy efficiency necessary to meet the comfort requirement of 80% of persons at all hours at the design intervention level. The standard $53m^2$ Agrement design of house has been agreed to be used, to establish the benchmark energy efficiency level and necessary intervention stringency.

The Star Rating System will result in energy efficiency being introduced as a criterion for the valuation of houses. This will have the effect of introducing comfort and energy efficiency as criteria for the house resale market. With the appropriate publicity, the advantages of thermal efficiency can then be popularized.

That the prolific habits of society can be changed is evident from international experience (Holm, 2003). European countries report improvements in energy efficiency of 30+ % since the adoption of mandatory standards.

If a comfort requirement is built into a national energy efficiency standard for houses, and it is sufficiently publicised, along with measures such as the introduction of a time-of-use tariff by electricity suppliers, conservation of energy can become part of peoples' lifestyles. This will offer consumers a cheaper way of living and a more virtuous lifestyle, which is mindful of the needs of future generations.

4. A residential based carbon reduction programme

The potential of residential energy savings or consumption pattern change, to generate reductions in carbon usage and greenhouse gas reductions in South Africa has been investigated. It has been estimated as averaging 7.3 million tons per annum, through to the year 2025.

A means of achieving the successful implementation of a greenhouse gas reduction programme, can be to introduce DSM measures and energy efficiency in housing, in conjunction with one another. An appliance switch from inefficient coal or wood based space heating to electricity or gas, is also part of the solution towards the reduction of greenhouse gasses (Praetorius & Spalding-Fecher 1998).

5. Appropriate level of stringency in a South African energy code

The establishment of energy efficiency in the building sector in other foreign regulatory systems, by way of energy efficiency standards and amendment to the building regulations, has had a significant effect on consumption in this sector (Australian Greenhouse Office, 2000).

The Nordic framework required for all South African National Standards (and proposed for the implementation of energy efficiency in housing), performance requirements to be established (Soderlund & Schutte 2003), from which performance criteria can be set out. The intervention package devised herein is entirely performance related. The stringency levels recommended for the thermal transmission of the shell are coincidentally fairly similar to the South African Energy Demand and Efficiency Standard (SAEDES) – Guideline for commercial buildings (Flemming, 1999).

The logic of the SAEDES relationship between the Heating Degree Days of any climate, to a U-value requirement for the shell of a structure, has attractions, although its linkage mechanism is not detailed adequately in the document (Flemming, 1999). In order to marry the logic of the SAEDES U-value proposals with those of this study, complementary data will need to be provided in *SANS 204: Energy Efficiency for Buildings*, which are not naturally ventilated, to link heating and cooling differences with Heating or Cooling Degree Days. The appropriate deemed to satisfy U-values (thermal transmittances) or R-values (thermal resistances) for ceilings and walls etc. can then be linked to the severity of the local climate.

The following table is illustrative of the standard proposed for the ceiling and roof assembly of a structure.

Table 1: Table of thermal resistances for regional average heating requirements

Heating requirement	*Ceiling U-value ($W/m^2°C$)*	*Ceiling R-value ($m^2°C/W$)*
Less than 10°K	0.67	1.50
10 to 12°K	0.56	1.79
12 to 14°K	0.47	2.13
Over 14°K	0.42	2.40

The above levels of stringency for the shell of residential or naturally ventilated structures in various parts of the country have been calculated to meet the comfort requirements for each region for the standard 53 m^2 Agrement house design, and assuming certain minimum wall thermal resistances, window size and agreed infiltration, occupancy and internal loads.

The proposals are lax in terms of foreign energy code intervention levels, (mainly as a result of the historically cheap electricity in South Africa). Typically, a European level of stringency would be twice the above basic R-value. The survey of opinion amongst insulation manufacturers and acceptance by the World Bank consultants as to the suitability of the design intervention proposals herein, indicates that consensus in favour of the proposed measures has been developed in this group.

The same levels are proposed by TIASA, as a starting point minimum standard for air-conditioned structures, in order to avoid a dual standard for the two classes of buildings. The logic of minimizing energy usage via the shell of a structure will also be a sound basis for the development of an energy code for air-conditioned buildings.

6. Proposals for successfully implementing energy efficiency policy in housing in South Africa

For all South Africans, and the world community at large, the threat of global warming resulting mainly from excessive carbon combustion emissions, hangs like the sword of Damocles over the viability of humanity, if continuing on the present course.

As to how or whether governments can influence this course of events, without destroying economic growth, is the challenge. If governments do not act, then the sustainability of society is jeopardized. To this end, energy efficiency is built into the policies of the various South African government agencies and departments. The detail of how to implement these policies, and the political will to press on with implementation, remains the challenge.

In the South African context, if comfort and energy efficiency standards are to be built into low-cost housing, a reduction in state expenditures on community health (in respect of respiratory diseases) may be achieved. Absenteeism and productivity in the work place will be similarly improved if in-door air quality in homes is improved.

If comfort and energy efficiency are to be built into middle and upper income homes, and other targeted DSM measures are successfully implemented, it is anticipated that reductions in peak hour electricity demand will result. The continued provision of affordable energy for poorer households in the community will then remain an economic possibility.

7. Conclusions

In order for appropriate housing policy decisions to be taken with regard to energy efficiency, the state of know-how on the subject, both local and international, need to be collated. For legislation, regulations and specifications to be drawn up, the know-how and expertise on the subject needs to be presented or disseminated to those who can use the information.

The process of developing this technology and collating this know-how, and the process of discussing and debating the options, need to be in the public arena for reasons of transparency and in the interests of a more widely acceptable and a better end result. TIASA intends to be central in this process, by producing and publicizing world class research.

Watermeyer and Schlotveldt have suggested in the *Draft Report on Standards for Energy Efficient Housing in South Africa*, for the National Department of Housing (June 2003) (Soderlund & Schutte, 2003) that a national standards committee is the logical forum for such processes to take place. The adoption of energy efficiency standards in housing, in the National Building Regulations, and in the subsidy housing specification, is then possible in terms of agreed functional requirements. With the adoption of the TIASA proposals via the standards process by industry professionals, thermal design experts and representatives of the building and energy sectors, the general public can be sure of a locally developed and world class energy code for South Africa.

With ever increasing public sentiment and support for the concepts of energy efficiency and comfort in buildings design in South Africa, the enactment of the proposed concepts into South African law via the amendment of the National Building Regulations and Standards Act No. 103 of 1977, should be a political formality.

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