Department of Minerals and Energy Pretoria

Capacity Building in Energy Efficiency and Renewable Energy

Report No. 2.3.4-33B

Title: Energy and Demand Efficiency for Commercial Buildings Standard: SANS204 Research incorporation and facilitation of draft standard

November 2005

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Abbreviations and Acronyms

BEE	Black Economic Empowerment
CaBEERE	Capacity Building in Energy Efficiency and Renewable Energy
CB	Capacity Building
CEF	Central Energy Fund
DANIDA	Danish International Development Assistance
DDG	Deputy Director-General
DEAT	Department of Environmental Affairs and Tourism
DK	Kingdom of Denmark
DKK	Danish Kroner
DME	Department of Minerals and Energy
DTI	Department of Trade and Industry
EE	Energy Efficiency
ESETA	Energy Sector Education Training Authority
FIDIC	International Federation of Consulting Engineers
IDC	Industrial Development Corporation of South Africa
IPM	International Project Manager
NT	National Treasury
NER	National Electricity Regulator
NGO	Non-Governmental Organisation
PDI	Previously Disadvantaged Individual
PM	Project Manager
PQ	Pre-qualification
PSC	Project Steering Committee
PTT	Project Task Team
QA	Quality Assurance
RE	Renewable Energy
RSA	Republic of South Africa
SA	South Africa/South African
SALGA	South African Local Government Association
SANGOCO	South African Non-Governmental Organisations' Committee
SARS	South African Revenue Services
SMME	Small, Medium and Micro Enterprises
SP	Service Provider
ST	Short Term Adviser
TA	Technical Assistance
TOR	Terms of Reference
VAT	Value Added Tax
ZAR	South African Rand

Table of Contents

1 Introduction

The South African Department of Minerals and Energy (DME) have initiated projects in support of the development of Energy Efficiency (EE) in a number of sectors. The SAEDES® Guideline (South African Energy and Demand Efficiency Guidelines) emanated from the USA and RSA Bi-national Commission in 1997, and the tabling of this document, and finalisation of the SAEDES Pilot Project in August 2002, was a point of departure for the development of a mandatory standard for EE in Commercial Buildings in South Africa. The SANS 204 project to develop an EE standard for commercial buildings was commenced in late 2002, and the CSIR Working Group was mandated by SC5120.61K – Construction Standards – Thermal Performance and Energy Usage in the Built Environment, in mid 2003 to draw up a SANS 204 Working Draft document.

The CaBEERE programme was established to build the capacity of institutions in the South African energy and renewable energy arena. This programme was funded by the Royal Danish Government and managed by COWI, and concludes its numerous projects in 2005.

A Research Project (Report no. 2.3.4-33) was commissioned by the Department of Minerals and Energy (DME) and contracted by CaBEERE, with StanSA R&D project management, to evaluate the energy usage of commercial buildings in South Africa under various scenarios, in support of the establishment of an energy standard for such buildings. This document is entitled: Energy and Demand Efficiency for Commercial Buildings - Final Report and this project was accepted on 31 October 2005.

An International Survey (Bou/C399) of similar energy standards for other jurisdictions, had previously been tabled by the CSIR Working Group for SANS 204, and suggestions as to the structure of such a standard in South Africa were proposed. This document is entitled: International Building Energy Standards (Codes); Their relevance for the proposed SA National Energy Efficiency Standard SANS 204.The CSIR Working Group had not, at the time of framing of this project, tabled a draft standard, but on 4 November 2005 a document was tabled with the Project Task Team set up to expedite a working draft (WD204) and integrate the Research Project.

The objective of this project is to integrate the useful outputs of the above Research Project into the SANS 204 draft document, and to facilitate the tabling of the Draft South African National Standard 204: Energy standard for buildings excluding those with passive environmental control. To this end this report collates all work done in execution of these tasks.

2. Review of International Energy standards

2.1 CSIR International survey

The CSIR International survey (Bou/C399) draws on a survey document prepared by the Australian Greenhouse Office, and provides an overview of the United Kingdom approved document L. Pertinent aspects of standards in other jurisdictions, including ASHRAE, ISO and CEN documents are referenced.

The requirements of SANS and ISO (Nordic) standard structure requirements and guidelines are set out. The common thread through the standards reviewed is that the Functional requirements are stated explicitly, Performance Requirements are set out, often with reference to the energy usage criteria for a standard or notional building, and Deemed-to-satisfy requirements are developed which will satisfy the performance criteria.

Technical issues are raised in the survey, which needed resolution via research, and which need to be addressed either in SANS 204, or agreed in the SABS Sub-committee 5120.61K for Construction Standards – Thermal performance and energy usage in the Built Environment, and which remain of concern, are:

- South African climatic zones definition
- Air-infiltration parameters to be set in a standard. The extent and cost of measures to be adopted to improve build air tightness, need to be evaluated against other energy saving measures.
- A trade-off methodology which allows compensating performance between building envelope elements, and particularly windows, needs to be developed.
- A consensus around the adoption of ASHRAE 90.1 in South Africa, for it to be line with world class practices, needs to be developed.
- The need for a verification method or computer based evaluation tool is raised, and continues to be an important issue. Whether local software calibration can be provided for and facilitated in the standard needs to be addressed.

2.2 Developments in other International standards

2.2.1 United Kingdom (U.K.)

The UK Energy provisions for commercial buildings (as per Document L) were initially satisfied by one of three methods; Elemental method, Calculation method, and Energy Use Method. The elemental method is such that standard U-values (Thermal Transmittances) are allowed for particular elements of a structure with limits on the ratio of surfaces such windows, doors and roof-lights. Performance criteria for building sub-systems are provided in a detailed deemed-to satisfy section. The Calculation Method allowed for trade-offs between efficient and less efficient components. The Energy Use Method used any other method to demonstrate superior performance (lower energy usage) as compared to the Elemental method as applied to a notional building. Examples of such calculation for the Thermal transmission via the shell of a structure, and another to demonstrate lighting efficiency were given in Appendix H.

Document L2 has retained the Elemental Method. Thus a minimum level of performance is set out for each aspect of the building and the sub-systems or services provided within the building. The Whole Building Method is introduced in the place of the Calculation Method, but in essence it provides a free hand with choice of calculation method to calculate the carbon emission per square meter. The trade-off principle allowed in the previous Calculation method continues to be accepted and the example is set out in Appendix E. An example of the Whole Building Method is set out in Appendix G which details such a calculation for an office building. The Energy Usage Method is replaced by the Carbon Emissions Calculation method, in which the Carbon Performance Rating (CPR) is compared against a benchmark set by the UK Energy Consumption Guide 19 (ECON 19). The appeal of this method is in that the Greenhouse gas production is calculated, rather than the energy usage as a surrogate for CO_2 production.

2.2.2 Australia

The Energy provisions of the Building Code of Australia (BCA) for residential occupancies (Part 1 & 10) were revised as of November 2004. The acceptance of and compliance with the standard by all states within the Commonwealth appears to be advanced. The stringency of the standard has been upgraded for residential accommodation such that a five star rating in terms of the NatHers computer based verification tool is now required (increased from 3.5 stars).

The Annual Energy Consumption Allowances for buildings (Part 2 – 9: including commercial buildings) is set out in tabular format for each town following from the climatic region situate.
No stipulation of load factor or any peak demand limitation is made, however there is a differentiation between electrical and gas energy sources. Any input of energy from renewable sources appears to be regulated to the extent only that AS/NZS 3500.4 governs the efficiency of non-solar applications.

The main feature of the B.C.A. structure and format is that conformance as demonstrated by a computer based tool (NatHers), is the primary compliance method presented. Deemed-to-satisfy solutions are set out in some detail.

It is noted that for the computer based verification of the energy consumption, the air infiltration performance criteria are explicitly stated as being 1.0 ach for an unpressurised building and 0.5 ach for the building with air-conditioning equipment in operation. Detailed requirements for the sealing of buildings to meet the low infiltration rates are prescribed.

2.2.3 New Zealand

An overall Building Performance Index is set and all measures are subservient to the achievement of this energy usage. This structure is similar to the Australian approach and also uses a software programme for assessing compliance.

2.2.4 European and International Standards Organisation

The Centre for European Norms (CEN) project group supporting the 2002/91/EC Energy Performance of Buildings Directive (EPBD) programme of comprehensive interlinked standards provides potential building blocks which could be useful for SANS 204. Many of these are in prEN stage and are not freely available. ISO/CD 23045 Building Environment Design – Guidelines for Energy Efficient Design of New Buildings is in committee draft and provides useful information in tables and develops the definition of a Building Performance Factor.

Other references to standards for the calculation of building heat transfer coefficients (ISO13789), for the standardisation of building material hygro-thermo properties (ISO 10456), for the calculation of thermal resistances of construction elements (ISO6946), specifications for external foundation insulation (ISO12575-1), and for the calculation of thermal bridging through structural elements in support of glazing and thermal insulation etc. (ISO 10077-1,2) could all be referenced in the SANS built environment standardisation.

The adoption of the above standards in support of the SANS 204 and 283 documents should be considered by SC5120.61K.

2.2.5 American Society for Heating Refrigeration Air-conditioning Engineering (ASHRAE)

The publication of the Advanced Energy Design Guide for small office buildings by ASHRAE in 2004 is an effort to overcome difficulties practitioners may have with implementing ASHRAE 90.1. The guideline is a simple reference set out by climatic (USA) regions and gives an immediate specification for most design aspects to be encountered.

The SAEDES Guideline is based on ASHRAE 90.1. The acceptance of the practice and measures within ASHRAE 90.1 is fundamental to the adoption of the most modern of practices into general usage in South Africa. This standard is a basic assumption for introducing energy efficiency into South African building and design practice, and its adoption is recommended in SAEDES, in the Research Project and by the CSIR Working Group.

A comparison of energy usage in buildings with the application of this standard versus present practice indicates a 24.4% improvement in peak load reduction and a 36.3% reduction in annual energy consumption for commercial buildings. The Research Project indicates further 9.0% reduction on the SAEDES figures for High rise office buildings. As the assumption of application of ASHRAE 90.1 is common to the two calculations, the close proximity of these numbers is reassuring. However the calculated monthly load factor of 0.279 is lower than that obtained from the SAEDES results and data.

None of the research projects referenced above show the cost of implementing such measures as are contained in ASHRAE 90.1, or their efficacy in reducing energy usage. In the absence of such local research the promise of these measures will have to be taken on trust. It may be necessary for further research to be initiated to validate these assumptions in the South African scenario.

3 Research Project outputs for insertion into WD 204 draft document

3.1 Principle outputs of the Research Project

The Research Project Terms of reference (T.o.R.) was organised to achieve five objectives.
These are set out below as they were intended:
These objectives were only partially met. The Project Task Team clearly achieved two of the five objectives, although the work done particularly in respect of the building shell (3.1.1 below) was very thoroughly covered, and the notional buildings were developed for the purposes of benchmarking the energy usage of various commercial occupancies.

3.1.1 Building shell performance

The principle requirement of the Research Project was to provide guidance as to the thermal performance requirements of the shell of the structure, for the six occupancy types and for the climatic regions considered. To this end the relative efficacy of thermal insulation to the roof, walls and windows, was evaluated for the projected energy usage reduction, and concomitant life cycle cost (LCC) was computed.

3.1.2 Air-infiltration requirements

The Performance Requirements for air infiltration to commercial buildings were not explicitly stated in the Research Outputs. The assumption of ASHRAE 90.1 was made throughout. No evaluation of the cost of the measures inherent in this standard versus the energy saving benefit was performed. The need for restrictions on air-infiltration were discussed and emphasised.

3.1.3 Regional climate definition, and internal air standards

Due to cost constraints only three climatic regions were analysed. The Cities of Johannesburg, Cape Town and Durban climatic data was used as representing the Highveld, Southern Cape, and KwaZulu-Natal/Lowveld climatic regions. No acceptable definition of climatic boundaries was presented in the Research Project.

ASHRAE Standard 62 assumptions were made with regards to indoor air quality and temperature requirements. No cognisance was taken of local acclimatisation.

3.1.4 Renewable Energy technologies

A generalised discussion of the methods by which designers are able to make use of passive means to achieve comfort in buildings without input of energy was presented. The available Renewable Energy technologies were reviewed.

No benchmarking of the efficacy of Renewable Energy technologies, on a basis comparable with the other proposed Energy Efficiency measures was undertaken. Thus the projected costs per kilowatt of energy generation by renewable technology systems cannot be compared with the anticipated costs of saving energy in the building by conservation techniques, as developed in the Research Project...

3.2 Building Performance Indices/Ratings

3.2.1 Overall building performance rating

The overall building performance rating is a measure of the Energy Intensity of the building. Such data can be developed from the Research Project outputs, and is presented in this report in Section 5.
An independent and comprehensive verification project is appropriate, however a comparison with the Annual Energy Usage Allowance for Australian commercial buildings and with SAEDES outputs is somewhat reassuring.
Load factors which will indicate an acceptable peak load for the building should also be prescribed because of the national imperative to reduce energy consumption at the peak hour in South Africa. Such load factors as can be derived from the SAEDES Guidelines, may be acceptable for WD204 (SANS 204 Working Draft).

3.2.2 Sub-indices for energy using systems within commercial buildings

Performance indices can also be individually ascribed to the sub-systems within the operations of a building, although it is envisaged that trade-offs between the efficiency of these systems will be allowed in WD204. See Appendix B for a tabulation of these energy uses in Table 2.

3.3 Tabulations of indices for all climatic regions

The various notional buildings can be separately assigned differing Performance Indices, for each of the three climatic regions modelled. These need to be extended to the climatic regions not covered in the Research Project, by a scientifically based extrapolation process, in a further research project.

3.4 Deemed-to-satisfy solutions to meet the Performance Requirements

Deemed-to-satisfy solutions for the thermal performance of the shell of buildings can be derived from the Research Project, and are set out in Section 5 below. When collectively applied, these measures will enable designers to be reasonably sure the overall building complies with the required building performance rating.

The recommendations throughout the Research Project in respect of equipment efficiency and plant specifications should be reviewed against the recommendations of the SAEDES® Guideline. The incorporation of this information to the WD 204 document should be handled by an expert in this field.

4 Report and comment on the structure of WD 204 document

4.1 The proposed structure of WD204

The structure of the WD204 document presented on 4 November to the Project Task Committee required some alteration, in the opinion of all concerned, in order to meet the StanSA requirements for a draft standard. The main problem being that the Requirements section was not explicit and was to be found within the Deemed-to-satisfy section. A proposal for rectification of this aspect and suggested wordings which might be common or similar to the WD 283 document for Energy Efficiency in Naturally Ventilated structures was copied to the Convenor of the SANS 204 Working Group. These proposals are set out in Appendix A.

4.2 The proposed modus operandi of WD 204

4.2.1 Performance Requirement

The principles adopted for this document will require that all buildings which are covered by the scope of the document should be designed to consume less energy per square meter than a nominated energy allowance. This principle is used in many National energy standards, and this principle was decided by the SC5120.61K in committee. This Performance Requirement is set out in Table 1.

The Peak Demand (Mean Monthly Maximum Load) is stated in WD 204 as being the principle target, despite the committee decision that the Energy Usage Intensity (EUI) should be the principle Performance Requirement. However the development of a Monthly Minimum Load Factor as a Performance Criteria has much merit when the national imperative to reduce peak hour energy usage is considered.

4.2.2 Compliance methods

The principle compliance mechanism is via a Whole Building energy usage calculation, which will be performed only by a Competent Person as is defined in the Engineering Professions Act of 46 of 2000. This provides clearly for the responsibility of the (Mechanical) Engineer to provide the required degree of Energy Efficiency in buildings in South Africa.

No calculation methodology is set out, and as for the United Kingdom Document L2 rules a free hand is given for the route used to satisfy the Requirements. It is interesting to note that the U.K Document L1 Standard Assessment Procedure for calculation of an SAP energy usage rating never applied for commercial buildings, and was dropped from Document L2 for residential buildings. A detailed Elemental Method is now provided for Non-residential occupancies in Document L2, and such a method could be outlined in the WD 204 document, but this will require further research, and funding.

No software verification route is provided in WD 204. However by virtue of the use of Visual DOE by the Service Provider to the Research Project, and the establishment of Whole Building – Performance Requirements, based on Energy Usage Intensities (EUI), which are based on the Visual DOE modelling of six notional buildings, this route can be developed in WD 204.

Alternative compliance routes are provided by way of a Rational Design provision and for an assessment by The Agrément Board of SA.

4.2.3 Deemed-to-satisfy rules

The Deemed-to-satisfy section is drafted as being subservient to the above compliance requirement. This is to say that the detailed Deemed-to-satisfy requirements are merely a guideline and will not confer compliance, unless the whole building is calculated to comply in terms of the routes set out in 4.2.2 above.

The Deemed-to-satisfy section to WD 204 is thus a Guideline. In the absence of an Elemental Method which would tie all of the Deemed-to-satisfy sections together, this section has reduced value.

5 Research outputs considered appropriate for insertion into WD 204

5.1 Energy Usage Intensity (EUI)

5.1.1 Selection of the Performance Requirement

Sub-committee SC5120.61K – Construction Standards – Thermal Performance and Energy Usage in the Built Environment took a decision to use the Energy Usage Intensity (EUI) as the principle Performance Requirement at a meeting in August 2005.

The early drafts of WD 204 document called for the Maximum Demand per building classification (para. 6.1.1) as the Performance Requirement for buildings to be calculated in a Whole Building Approach.

The Research Project sets out the Energy Usage Intensity (EUI) for the six notional buildings using the Whole Building Approach and presents the energy usage (as per DOE2 software) as relative to the gross footprint area of the building. Life Cycle Costing (LCC) of alternative roof, wall and window configurations, each with increased stringency, are calculated, with the EUI provided in each case.

Thus an Overall Building Performance Index (OBPI) as per ISO 23045 definition or Annual Energy Allowance as per the Australian standard (BCA) can be derived from the research outputs.
The Research Project does not present the Mean Maximum Monthly Energy Loads from the modelling in the main report; however the monthly peak demand data was presented in preliminary papers. The Load Factors for each of the notional buildings can be calculated. Such information may need to be extracted from other research, and the SAEDES Pilot project or ASHRAE 90.1 may provide suitable guidance.

5.1.2 Motivation for appropriate stringency of the Performance Requirement

The purpose of establishing a Performance Requirement is to ensure that the DME target for energy usage in Commercial Buildings in 2015 is attained. The target is for usage of energy to be reduced by 15% from expected levels of 2015. As new building stock erected from 2007 onward will by that time represent perhaps some one quarter of all building stock, the new stock will need to use some 60% less energy than present buildings are consuming. It is indicated from the Research Project and from the SAEDES Pilot Project, respectively, that by adopting ASHRAE 90.1 and the SAEDES Guideline methods, that between 50 % to 33.6% reduction in energy usage will be achieved.

In deciding the stringency of measures in WD 204, the Life cycle cost (LCC) data presented in the Research Project has to be weighed against the required level of energy usage reduction. In the current South African context of a shortage of electrical generating capacity, the required reductions in peak load, to be achieved by the stringency of the regulations, are also relevant.

The lowest life-cycle costing (LCC) would appear to be the appropriate choice in all cases, but as is argued by the Service Provider (SP) to the Research Project, the reliability of the data, and particularly the projected energy cost scenario of 1.6% average real cost increase in electricity, requires that a conservative approach is adopted. The margin for error in any of the inputs to the LCC calculation can easily be 5 -10%. The SP to the Research Project has thus recommended that LCC plus 5.0% is the appropriate level of cost burden imposed.

The recommended conservatism in the regulatory provisions is best built into those items which cannot easily be modified in the future. Thus should a further peak demand reduction be necessary to be achieved in the future it will not be necessary to modify the newer buildings. The aspects of a structure to be affected by such a policy would include items such as thermal insulation to the walls and roof.

5.1.3 Methodology for selection of appropriate Performance Requirement

The cost burden carried by Commerce and Industry sectors for mitigating future energy consumption must be seen in the context of the marginal capital cost of extra generating and electrical distributing capacity. If Return-on-investment (ROI) criteria are applied to investment decisions as to energy usage mitigating measures, on a national basis rather than with a parochial view, the marginal capital cost of energy/electricity generating and distribution capacity per kW should be compared with the marginal capital cost of implementing peak load reductions for buildings.

The cost of de-mothballing three Eskom power stations with a capacity of 3612MW was estimated to be R12 billion in early 2004. Thus the current (end 2005) capital cost of electricity generating capacity is approximately R3.60 per kW. The distribution network equipment costs must be added to this cost.

In order to compare the investment cost per kW of energy saving measure, the relationship between the Energy Usage of commercial buildings and the Energy Demand needs to be explored:

The SAEDES Pilot Studies indicate that for an average of six buildings examined, an energy consumption of 269kWh/m^2 p.a. would correspond with a mean maximum demand of 48.5VA/m^2 per month with all measures implemented, and a monthly maximum load factor of 47.7 is indicated.
A Load Factor figure of 0.725 is obtained by using the formula set out in WD204. If the SAEDES data is visited for the large office buildings in the Highveld region the calculated load factor varies between 0.4 and 0.53, indicating that the Pilot Study may be expressing the monthly load factor as a percentage.

The Research Project indicates a base case Energy Usage Intensity (EUI) of 244.6 kWh/m^2 p.a. for a 25000m^2 high rise building situated in the Highveld climatic region. However the calculated monthly load factor of 0.279 is lower than that obtained from similar buildings as per the SAEDES results and data.

We can glean from the above analysis that the relationship between EUI on a monthly basis and mean monthly maximum demand is indicated by a Monthly Load Factor in a range of 0.7 to 0.3 (Average 0.5). Thus a EUI of 269 kWh/m^2 p.a. (22.4kWh/m^2 p.m.) implies a peak demand (mean monthly maximum demand) of approximately 62 W/m^2 p.m. The reduction of EUI by every unit kWh/m^2 p.a. is then justifying a LCC cost increase of R3.60 * 0.062 i.e. R0.223 per square meter of building. If the Load Factor is 0.25 for a building the LCC increase will be R0.45 per square meter. In order then to prevent situations where the load factor is as low as this, and to build in for electrical distribution equipment costs, the rule of thumb figure of R1.00 per square meter rule is proposed to be applied. Thus for a Large Office Block of 10000m^2 it would be worth spending R10000 to achieve a 1.0 kWh/m^2 reduction in the energy usage.

5.1.4 Example of application of principle to determine EUI

If the Research Project has indicated an EUI of 200 kWh/m^2 p.a. for a 10000m^2 commercial building, and has provided a Life Cycle Cost increase of R9999 for the implementation of an Energy Efficiency measure, perhaps for perimeter/foundation thermal insulation. Then if the EUI of 199 kWh/m^2 p.a. is attained by applying the foundation insulation, then measures up to a R10000 of LLC cost increase are justified. Thus the reduced EUI level of 199 kWh/m^2 p.a. is validated, and the performance criteria corresponding with the Energy Efficiency measure is established, for that building occupancy in that particular region.

5.1.5 Tabulation of proposed Energy usage Intensity allowances

The WD 204 document calls for the Performance Requirements to be set out over six regions. The climatic region definition as per earlier CSIR publication, and reproduced by the National House Building Registration Council (NHBRC) in the Home Building Manual is preferred over the Research Project map. The regions are described approximately as follows:

Zone 1: Highveld; cooler areas over 1500m elevation

Zone 2: Warm temperate upland areas above an elevation of 500m

Zone 3: Western, Southern and Eastern Cape coastal regions, now probably best defined by Agrément SA as the SCCPA (Southern Cape Condensation Problem Area)

Zone 4: Warm subtropical coastal regions below 500m elevation from north of Port Elizabeth.

Zone 5: Hot Northern Interior, being the lowveld and northern bushveld below 500m

Zone 6: Dry Interior, being the Northern Cape and North West Province not covered in Zones 1, 2 & 3.

The tabulated Performance requirements are incomplete for the Zones 2, 5 and 6. Further research is needed to extrapolate the Energy Usage Intensity data to these remaining three regions.

It is also necessary to define the climatic regions in terms of mean maximum and minimum temperature and humidity levels, and to have them accurately drawn into a map of magisterial districts.

Table 1: Table of Building Energy Usage Allowances (BEUA) or Energy Usage Intensities (EUI)

Class of building Occupancy	Climatic Region	Energy Allowance for climatic region Zone 1	Zone 2	Zone 3	kWh/m^2.a Zone 4	Zone 5	Zone 6
Hospital		444		444	450		
High rise office		226		242	232		
Suburban strip malls		220		221	222		
Low rise office park		261		262	248		
Hotel leisure complex		443		461	425		
Regional shopping mall		366		369	368		

5.2 Deemed-to-satisfy performance for the shell of buildings

5.2.1 Notional building 1- Hospitals

The following levels of thermal resistance in m$^{2\circ}$C/W (RSI) are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Element	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	1.5	1.5	1.5
Walls	1.47	0.68	0.68
Windows	0.17	0.17	0.17

5.2.2 Notional building 2 – High rise office buildings

The following levels of thermal resistance in m$^{2\circ}$C/W (RSI) are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Elements	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	3.75	3.75	3.05
Walls	3.1	3.1	1.72
Windows	0.17	0.17	0.17

5.2.3 Suburban strip mall

The following levels of thermal resistance in $m^{2\circ}C/W$ (RSI) are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Elements	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	1.96	1.5	1.5
Walls	2.64	2.9	0.42
Windows	0.17	0.17	0.17

5.2.4 Low rise office park

The following levels of thermal resistance in $m^{2\circ}C/W$ (RSI) are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Elements	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	2.65	2.65	1.5
Walls	2.64	2.64	0.42
Windows	0.17	0.17	0.17

5.2.4 Hotel and leisure centre

The following levels of thermal resistance in $m^{2\circ}C/W$ (RSI) are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Elements	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	3.75	3.75	3.75
Walls	2.64	2.9	2.9
Windows	0.17	0.17	0.22

5.2.5 Regional shopping malls

The following levels of thermal resistance in $m^{2\circ}C/W$ (RSI)are recommended to be accepted as satisfying the requirements of the regulations in respect to the particular elements:

Elements	RSI Zone 1	RSI Zone 3	RSI Zone 4
Roof	1.27	1.27	1.27
Walls	0.68	1.31	0.42
Windows	0.17	0.17	0.17

5.3 Discussion of recommended Deemed-to satisfy levels

5.3.1 Hospital

The notional building is an 8000m^2 single storey structure. The EUI Performance Requirements of 447.9kWh/m^2 p.a. on the Highveld, can be reduced to a level less than that achieved with the lowest LCC if a greater thickness of fibre insulation is applied to the walls. For the Kwa-Zulu Natal coastal belt and The Southern Cape, the use of an air-space in wall cavities should be required.

The deemed-to-satisfy roof insulation, for all regions, should be increased to RSI of 1.49, which can be achieved without the penalty R22/m^2 additional labour cost added, simply by increasing the thickness to a nominal 100mm fibre insulation (effective 60mm when installed over-purlin/on wires due to loss of thickness and heat bridging), at a small cost premium. The cost premium did in no case exceed 0.5% of base case LCC. Noting here that the RSI contributed by the suspended ceilings is not brought into reckoning as the roof cavity is well ventilated to the air-conditioned area.

5.3.2 High rise office buildings

This notional building is a 20 storey structure with a rentable area of 25000m^2. The EUI Performance Requirements can be reduced significantly (2.3 to 3.0%) from base case modelling by increasing the level of roof and wall insulation, and still reducing the LCC levels.

5.3.3 Suburban strip mall

The strip malls are groups of eight 200m^2 shops with large shop front windows. The EUI Performance Requirement is reduced by nearly 2.0% on the Highveld and in the Southern Cape by increasing the wall and roof thermal resistance from the base case without adding LCC. If the R22/m^2 premium for fixing additional roof insulation is dropped, as there is only extra thickness of material, then the R-values can justifiably be increased slightly.

5.3.4 Low rise office building

Office buildings are two storey structures of 2000m^2 with a naturally ventilated parking basement.
The EUI can be improved/reduced over the base case by significant increases in wall thermal resistance (equal to 100mm fibreglass batts for Inland and Southern Cape regions), and some increase in roof thermal resistance (equal to 50mm of Extruded Polystyrene Insulation), without adding to the LCC.
It is submitted that the naturally ventilated basement area should not enter into the energy usage calculation, and hence EUI figure proposed are greater than those derived from the Research Report. An error was detected in the hot water energy calculation and a figure from the high rise office has been used in its place.

5.3.5 Hotel and leisure complex

The hotel notional building showed much potential for reduced energy usage below the base case.
As result of a EUI reduction potential of between 4.6 and 7.7% from the base case, significant levels of thermal resistance in the shell are justified. On the Kwa-Zulu Natal coastal belt the use of low ε glass is justified. The LCC cost is decreased with these seemingly expensive measures.

5.3.6 Regional shopping malls

The recommended levels of thermal performance of the shell as per the Research Report are confirmed for this occupancy. Additional thermal resistance in the shell simply increases energy consumption.

5.4 SAEDES Guidelines and integration with Research Outputs

5.4.1 SAEDES principles for determining thermal resistance of the shell

The Guideline given in the Deemed-to-satisfy sections of WD204 relating to the Thermal Resistance requirements of the shell of structures is contained in sections 5.10.13 through to 16. The provisions of WD204 call for the prescriptive requirements of SAEDES Section 8.4 to 8.6 to be applied.

The methodology used in SAEDES is for the Heating Degree Days to be obtained for the region/centre and for the appropriate thermal transmission for each element to be selected from graphs, set out in Figure 1 to 8. For buildings with cooling an Overall Thermal Transmittance Value is to be calculated which may not exceed 26.8W/m^2 for roofs, and a figure for walls which varies with latitude, according to Figure 9.

5.4.2 Comparison of Research Project thermal resistance of the shell with SAEDES

The Research Project outputs are set out above in section 5.2. The SAEDES comparatives can be calculated (if the numerical references of the horizontal axes of the graphs of Figure 1 to 8, can be linked to the Heating Degree Day tables). The stringency recommended for the deemed-to-satisfy provisions above in section 5.2, require to be compared to those calculated for the SAEDES Guidelines, before comment can be made as to whether the WD204 proposal to use the SAEDES methodology can be endorsed.

This is a further task for the CSIR Working group or for a new Research Project.

6 The establishment of energy efficiency into buildings in South Africa

6.1 Cooperation between parties and consensus building

The establishment of Energy Efficiency in commercial buildings in South Africa will be determined by numerous parties over the next year. The parties which will need to work in co-operation with one another are Government (DME and DTI), Government Agencies such as StanSA, and the CSIR, Industries such as Air-conditioning, Building Material suppliers etc., and Professionals who will be required to design according to the standard.

The involvement of Industry Associations such as TIASA (Thermal Insulation Association of South Africa, AAAMSA (Architectural Aluminum Association of South Africa), and the Air-conditioning and Refrigeration Industry Associations could be significant to producing a workable SANS 204 document. Independent Consultants with the relevant knowledge and much experience in the various aspects of the Energy Efficiency sphere also have a valuable contribution to make within the SC5120.61K forum.

The comments of Dieter Holm and Lisa Reynolds (written), and also Sidney Parsons and Jason Schaeffler (Private communication) among others, to this project are acknowledged, and the contribution of members of the Project Task Team – Charles Murove, Tony Golding and Solly Peter for their guidance and comments are also acknowledged as a valuable contribution to the furtherance of the SANS 204 process.

6.2 Funding for further research and document development

Gaps have been identified in this report, and the Research Project did not achieve all of the required objectives. (e.g. Climatic Regions, Verification of Energy Usage data, incorporation of Renewable Energy applications). References to further research and the need for verification of some of the Research Project Outputs, are contained throughout this document. Thus much work requires to be done for input to the WD204 document, and to finalise the standard. There is a need to involve experts to develop the SANS 204 document, and to involve the Professionals who will be implementing the requirements, in order to ensure a high standard of document, which can be implemented.

6.3 Stages in the process and time-lines

The various stages in the process are set out in the attached flow-chart in Appendix C. The time periods for each stage in the Standards process are set out in stages 17 to 20 referenced in this document. This process is estimated will take up to 12 months to complete.

The flow-chart does not set out a definitive route as there may be ways in which the process can be shortened, or there may be problems which will extend the process.

7 Conclusions and recommendation

The main conclusion of this report is that the Research Project and the CSIR Working Draft 204 document have now reached a stage where significant progress has been made such to be able to recommend to the SC5120.61K that the document is taken to the stage of being Working Draft, under the control of a fully mandated Working Group.

The success of the SANS 204 process will be dependent on the co-operation of the parties listed above, and their willingness to seek a consensus on the major issues.

The need for research gaps to be filled is evident. The provision of funding to support this work is therefore a priority for all the role players.

If the time lines set out in the flow chart are examined it must be concluded that the finalisation of SANS 204 before the end of 2006 is a reasonable and possible target.

Appendix A

Recommendations to the CSIR Working Group as to the structure of WD

The following proposal for the Requirements section was forwarded to the CSIR Working Group, for guidance as to the structure of WD204:

4. Requirements

4.1 Functional requirements

Buildings, including the services provided therein, shall to the degree stipulated in this standard, conserve energy and therefore give rise to issue of the minimum of greenhouse gas emissions, and contribution to global warming.

4.2 Performance requirement – Whole building

Any building, other than those which have passive environmental controls, when considered as a whole, shall to the degree necessary, have design features, be built of materials and employ equipment that facilitates the efficient use of energy, appropriate to comply with the requirement that energy usage does not exceed the Building Energy Usage Allowance (BEUA), as is set out in Table 1 below, and with regard to the occupancy class and climatic region of the location of the building.

4.2 Performance criteria

4.2.1 Elemental performance

Subject to the provisions of section 4.1 the Building Energy Usage Allowance sub-indices set out in Table 2 below will guide as to the maximum energy usage allowable for the provision of the services indicated.

The Deemed-to-satisfy provisions of section 5 provide additional guidelines as to the Energy Efficiency requirements of many elements of a structure.

4.2.2 Deemed to satisfy performance

As is provided in the Deemed-to-satisfy provisions of Section 5, an elemental approach may be followed as a guideline to the achievement of the BEUA.

Performance criteria are developed in the Deemed-to-satisfy provisions, however these criteria need to be assessed in combination for the whole building, to ensure compliance with the BEUA of Section 4.1

4.3 Compliance

4.3.1 Whole Building Method

Calculation methods which are recognized as established and accepted in terms of Building Physics, Scientific Principle or Engineering Method, by incorporation into International or National Standard, or as adopted by International or National Professional Association or Society, may be applied or used by a member of such Association or Society in good standing, to show compliance with the requirements.

4.3.2 Compliance using Visual DOE

The Building Energy Usage Allowances have been calculated using the Visual DOE software with reference to six notional buildings. Accordingly, the assessment and verification of the designs, for compliance with the BEUA requirement, can be established by modelling buildings with this software.

4.3.2 Alternative software

Calibration of alternative software packages can be achieved by modelling the notional buildings according to the inputs and results as reported in the CaBEERE Research Project 2.3.4-33.

Such software method should be designed in accordance with the scientific bases and principles set out in ISO13790 – Thermal performance of buildings – Calculation of Energy use for space heating and cooling.

4.3.3 Rational Design

Any of the above methods of compliance or alternative calculation methods which are recognized as established and accepted in terms of Building Physics, Scientific Principle or Engineering Method, by International or National Standard, or by official adoption by International or National Professional Association or Society, may be applied or used by a Competent Person to show compliance with the requirements.

4.3.4 Agrément Board of South Africa

Agrément SA may assess any building for compliance with the requirements of the provisions of this Standard by application of any of the above methods.

Appendix B

WD 204 Energy standard for buildings excluding those with passive environmental control

Table 2 – Detailed annual energy allowances for building classifications and climatic region (kWh/m2)

Climatic region	Zone1		Zone 3		Zone 4		All zones		
Occupancy	Total	Heating & cooling	Total	Heating & cooling	Total	Heating & cooling	Hot water	All lighting	Other services
Hospital	444	269	444	269	450	275	100	57	18
High rise office	226	110	242	126	232	116	12	68	37
Suburban strip malls	220	43	221	44	222	45	1	148	27
Low rise office park	261	113	262	114	248	100	11	88	49
Hotel leisure complex	443	285	461	303	425	267	82	51	24
Regional shopping mall	366	148	369	151	368	150	1	186	31

Appendix C

Flowchart indicating time-lines for the establishment of Energy Efficiency in SA