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# Desk review of International Standards for Energy Audits and recommendations for Mauritius

Prepared for:
Mr Satyajeet Ramchurn,
Environment Programme Officer,
UNDP, Mauritius

23rd December 2010
Revised 6th March 2011 &
8th April 2011

Client report number 268-129

## Prepared by

Names Mr. Tony Johnson and Dr Andy Lewry

Positions Principal Consultants

Signatures and

## Approved on behalf of BRE

Name Dr Paul Davidson

Position Director, Sustainable Energy Group, BRE

Date 5h April 2011

Signature

BRE
Garston
WD25 9XX
T + 44 (0) 1923 664000
F + 44 (0) 1923 664010
E enquiries@bre.co.uk
www.bre.co.uk

## Executive Summary


1. A number of Energy Audit and Energy Performance Certification schemes from various countries have been reviewed. They either address Asset performance (the intrinsic performance calculated on the basis of the building fabric and equipment standards, but excluding the variation due to usage by people) or Operational performance (based on meter readings and so unable to allow calculation of the impact of fabric and equipment changes); in a few rare cases they address both issues.

2. None of them provide a linked analysis, essential to evaluate current performance and determine the impact of improvements that could be replicated in Mauritius. However, the proposed methodology for the Mauritius EAMS based on SBEM will integrate the asset and operational aspects of building performance and thus will give a better overall picture of the energy use within the buildings.

3. The proposed linked analysis between the calculated performance of the building and the metered data reduces the initial need for sub-metered data which is demanded by other energy audit processes. However as the scheme matures, one of the recommendations likely to occur is the installation of sub-meters and associated monitoring and targeting (M&T) programmes. This will encourage a culture of better energy management based on measurement and understanding.

4. iSBEM is a proven building model and calculation procedure for regulative purposes along with a mature methodology with respect to the collection of data and interpretation of results. Using iSBEM as the core of the proposed energy audit tool will provide consistency of approach and reduced deviation of the final output.

5. The review has demonstrated that there are mature Accreditation and Certification schemes which have been shown to ensure that the levels of expertise and competencies required for the energy audits are continually met by the auditors. This is done by appropriate entrance and training requirements backed up by an examination of the auditors and a quality assurance scheme to ensure their work is to an acceptable standard. A similar approach is recommended for Mauritius.

6. We have chosen a building model that is already being used for building regulation compliance, the production of Energy Performance Certificates (EPCs) and to build up national registries. This will help facilitate possible future integration with the proposed Mauritian Building regulations. It will also allow, through the formation of a national registry, a national stock model to be built up over a period of time that could be used to inform future policy and regulatory decisions.

7. We understand that the Contingent Support Mechanism is intended by the Government to support energy audits rather than the implementation of measures. We have proposed a methodology for determining which should be the designated consumers that will undertake the audits and receive funding to do so. Whether the recycling of these funds is feasible is a matter for further discussion with the client while the basis for the Contingent Support Mechanism is finalised.

8. This report has been modified to respond to comments made by the Mauritius National Steering Committee, which were attached to the e-mail from Mr Chaundee dated 22 March 2011.

# Contents

# 1 Introduction

## 1.1 Terms of reference

The UNDP Mauritius Country Office has hired, on behalf of the Ministry of Renewable Energy and Public Utilities, the Building Research Establishment Ltd (BRE), along with its Partners in Mauritius, as consultant to prepare and develop a new regulatory framework for the implementation of an Energy Audit Management Scheme and a Contingent Support Mechanism for the Non-domestic Building Stock in the Republic of Mauritius.

The objectives of this project are to develop:

- an Energy Audit Management Scheme, an Energy Audit Manual and a Compliance Mechanism Scheme;
- a Certification programme for energy audit certifications and secure accreditation of a future Certification body in Mauritius by a recognized accreditation body;
- a Certified Training scheme and materials for energy auditors;
- a Contingent Support Mechanism

The development of the Energy Audit Management scheme will be undertaken within the framework of the Energy Efficiency Bill for Mauritius.

## 1.2 Structure of desk review report

This report summarises the experience gained from other countries' programmes to encourage or mandate energy audits, and recommends how such a scheme should be set up in Mauritius to maximise the benefit to the country.

Section 3 consists of the review of other countries' programmes, and draws conclusions from this experience in terms of how best such a scheme could work on technical, regulatory and motivation levels. Section 4 reviews whether existing regulations in Mauritius might be relevant.

Section 5 proposes the format of the EAM scheme, including why and when audits should be carried out. This section also considers how tools might be developed to enable audits and evaluation of improvements to be carried out consistently, producing results that can be used to determine whether the projects are eligible for possible fiscal support.

It is important to ensure that auditors that carry out energy audits are properly trained and able to produce results of consistent quality, so routes to the accreditation of the Mauritius Energy Audit scheme (EAMs) are proposed in section 6.

Formats for a Contingent Support Mechanism are considered in section 7, together with financial models to enable measures to be applied to as wide a proportion of the non-domestic building stock as possible.

7 Desk review of international standards on energy audits and existing regulations in Mauritius

Section 8 considers the scope for legislation in Mauritius but concludes that it should not be drafted until the contents of this report have been digested and conclusions as to the way forward agreed with the Mauritius Government.

Annex A lists the type of energy efficient refurbishment measures that might be appropriate for Mauritius. Annex B explains how the software tool would work in more detail than section 5, and Annex C contains the original needs analysis for the Contingent Support Mechanism which is summarised in section 7.

# 2 Background to the project

Over the past decade, electricity demand in Mauritius has grown at an average annual cumulative rate of over 8%. The Central Electricity Board (CEB) forecasts that energy generation requirements will increase by approximately 60% over the next 10 years, equivalent to an average cumulative annual growth rate of over 4.5% and a peak demand increase by 17 MW per year between 2004 and 2013. Air conditioning and mechanical ventilation from commercial and residential buildings are major contributors to this growth, and currently account for a load of 40 MW during the day and 30 MW at night, well over 10% of the peak demand.

With an effective demand side management (DSM) programme, which reduces growth by just 14% in the commercial and residential sectors in 10 years, Mauritius stands to save between 290,000 and 540,000 tonnes of imported coal, which is an equivalent saving of US$ 15 - 27 million in "hard currency" foreign exchange at today's prices. Other savings include a delayed investment in new generation capacity. Globally such a DSM programme represents between 126,000 and 245,000 tonnes of $CO_2$ equivalent.

Energy efficiency measures, products and services particularly related to buildings, which arguably are responsible for two-thirds of the electricity demand, are uncommon in Mauritius despite the exponential growth of energy demand in the last 10 years. The cause for this relates to a number of interrelated barriers related to market issues, policy, finance, business management skills, information and awareness as well as technological barriers. These barriers are unlikely to be overcome through current measures.

The UNDP programme "*Removal of Barriers to Energy Efficiency and Energy Conservation in Buildings*" is intended to overcome barriers to energy efficiency in buildings in Mauritius and to stimulate the development of a market for non-residential building energy efficiency in both existing stock and future buildings. In setting out to do so, the project activities will ensure that energy is used cost effectively and rationally throughout the island. The project tackles market barriers in all three areas of a building's energy use: building fabric, equipment, and people (behaviour). The focal point for this within the UNDP is Mr. Satyajeet Ramchurn, the Environment Programme Officer.

This UNDP programme is due to run from July 2008 until April 2012 with financial management through the UNDP Country Office. The technical management will be through the Project Management Unit (PMU) within the Ministry of Energy and Public Utilities, who are the executing agency. This programme is overseen by a steering committee which contains all the major stakeholders.

The initial funding of this programme was from Global Environmental Facility (GEF - 912k USD) and Government of Mauritius (560k USD), with additional funding of 100k USD from Agence Française de Développement (AFD) in 2010.

The main aims of this programme are to:

1. Develop an appropriate legislative framework - Building regulations and codes for energy saving;
2. Provide a market approach - Demand and supply for energy saving services and technology stimulated;

3. Ensure design engineers, architects, builders, compliance officers, policy makers, financial sector, suppliers and public are convinced of the importance and market opportunities for building energy saving.

## 2.1 The Energy Audit Management Scheme deliverables

The Energy Audit Management Scheme contract is being delivered by BRE as part of this UNDP programme. The deliverables comprise:

1. Desk review of International Standards and existing regulations in Mauritius, including
   - A review of international standards and best practices for Energy Audits. This has included consultation with all the relevant stakeholders
   - Identification and specification of measures to improve energy efficiency and energy conservation in existing non-domestic buildings.
   - Consideration of the potential impact on the legislative framework in Mauritius
   - A needs analysis for a Contingent Support Mechanism and recommendations for the degree of support necessary.
2. An Energy Audit Management tool, proposed to be based on iSBEM, tailored for Mauritius by the BRE energy modelling team supported by local contacts who will supply information on local building types, constructions, codes and regulations. This will advise on how well each building performs relative to its capabilities, and give an indication of the impact of improvement measures.
3. Consideration of and recommendations about a contingent support mechanism (to be operated by the Mauritius Government) to encourage the implementation of improvement measures
4. Training for energy auditors and their trainers
5. An accreditation scheme for energy auditors
6. Workshops to increase awareness of the scheme to potential users

## 2.2 Desk review report scope

This desk review report is intended to establish and report on:

1. Whether there are national and/or international standards for the application of energy audits
2. Where no standards exist, what constitutes best practice for undertaking energy audits
3. What legislation is used to underpin energy audits in other countries, and to what extent the detail is given in regulations and other forms of documentation
4. What building codes and practices already exist in Mauritius, and how they might be adapted to support the Energy Audit Management Scheme (EAMS)
5. In what way overseas legislation could be adapted to form the basis of Mauritian legislation and regulation

6. Recommendations for what should trigger the need for an energy audit to take place, and how this might be policed

7. How many audits prompted by the triggers could be completed given the expected number of auditors

8. Which energy efficiency measures would be appropriate in Mauritius

9. Whether tools and/or manual procedures exist to support energy audits, and whether any could be adapted to support the EAMS in Mauritius

10. The specification for an energy audit tool for Mauritius, which will
    a. Compare the performance of each building (or part building occupied by an organisation) (based on information gathered by the auditor) with that expected of similar buildings
    b. Offer a checklist of improvement measures
    c. Allow indicative calculation of the benefits of introducing a range of energy efficiency measures

11. The information that needs to be gathered to feed into the energy audit tool, and who should supply it

12. Recommendations for how a contingent fiscal support mechanism should operate
    a. Which buildings and measures should be eligible
    b. Basis of funding, ie grants, loans, tax breaks etc
    c. Whether the funding pot could be self-sustaining
    d. What level of funding needs to be allocated to it

13. Recommendations for an accreditation scheme for auditors to ensure that the audits are carried out competently

14. Training needs to provide enough accredited auditors to undertake the number of audits prompted by the legislation

The desk study is intended to review legislation, regulation and practice regarding Energy Audits in a range of countries worldwide. It concludes by recommending how an Energy Audit Management Scheme can be set up for Mauritius. The client is asked to approve the recommended course of action so that work can progress towards its completion in a timely manner.

# 3 Review of experience elsewhere

## 3.1 What is an Energy Audit?

The energy performance of a building is derived from a number of factors, principally

1. The intrinsic quality of the building
    a. The standards applied to the building fabric (thermal mass, absorptivity of solar radiation, insulation, glazing light and thermal transmission, weather tightness, etc)
    b. The configuration of the building (its shape, orientation, shading, etc)
    c. The efficiency of the building services (cooling, ventilation, heating, hot water provision, lighting, etc)
2. How it is managed
    a. Temperatures, lighting levels, duration etc that should be maintained when it is occupied
    b. How closely these conditions are maintained during occupancy
    c. The extent to which these conditions are maintained when the building does not need them, e.g. when it is unoccupied.

Section 1 above defines the “Asset” properties of the building. Generally they will have been determined when the building was constructed or last refurbished, according to standards and/or practices prevailing at the time. These will be either be Regulations or technical standards set by some national or international body that have been adhered to by the designers of the building, or perhaps ad hoc standards were applied by the builder, such as best practice defined in advice published by Government, their agencies or professional institutes. Currently Energy Efficiency Building Regulations do not exist in Mauritius, but a parallel UNDP project is seeking to establish them. To change the asset properties of the building generally entails spending money to replace deficient equipment or materials.

Section 2 above defines the “Operational” performance. This is determined more by the attitudes and competence of the people who run the building, and whether they make the best use of the building’s energy performance capabilities. Managing a building’s energy performance is often one of many tasks given to a building management individual and/or team, and so it is sometimes not given a high priority; indeed occasionally energy efficiency actions may appear to conflict with other needs. The building and its systems are there to perform some primary task such as housing a business, so it is tempting to say that these needs override energy efficiency. It is important to recognise exactly what the needs are, and to maximise efficiency within them, rather than over-providing services “just in case” the lack of them might harm the business. Changing the operational performance of a building may not require monetary investment, but does require education and changes in the mindsets of the building users and of the people responsible for managing it.

It is a truism that “you cannot manage what you have not measured” and thus it is important to quantify energy performance in order to manage the resource effectively. This leads to the need for an Energy Audit.

An energy audit needs to cover both asset and operational performance, because ultimately the building performance depends on both. It is predominantly about existing buildings, though it does also help to anticipate how new and refurbished buildings will perform, in order to check as soon as possible that measures applied to them have been worthwhile. This project has been set up to encourage energy audits so as to maximise the efficiency with which energy resources are used by non-domestic buildings of all ages in Mauritius.

## 3.2 Review of international standards on energy audits

The requirement to improve energy performance can be on different levels. Legislation could make it obligatory to make improvements; usually legislation operates at a high level, with regulations to expand on the core requirements at a more technical and practical level and supporting documents to explain them further. At a voluntary level there may be minimum standards for the process of evaluating performance and making improvements, together with good or best practice recommendations to encourage practitioners to aspire beyond the bare minimum. Countries have different attitudes to energy efficiency, which are reflected in the degree of imperative attached to measuring and improving the quality of building assets and operation.

This review of energy audit regulations, standards and best practice needs to clarify whether they deal with asset or operation or both. Where energy performance regulations have been addressed in other countries, they have mostly been on the level of setting asset standards for new build or refurbishment, with very little about the performance of existing buildings. This is no doubt because new build/refurbished buildings come to official notice for other reasons (eg to do with planning use constraints), and so energy performance-related regulations can be enforced at the same time.

Nevertheless, in most countries the building stock mostly comprises buildings that have existed for some time, rather than those newly constructed to latest standards. In the UK, new buildings add approximately 2% to the stock each year, so it will take many years for energy efficiency improvements based on improving standards of new buildings to have an impact on the stock as a whole. To answer this, the European Union Energy Performance of Buildings Directive (EPBD) requires that member states mandate measurement of energy performance of existing public sector buildings, and the display of a certificate indicating performance where the public can see it. In the UK, this has been interpreted as an operational energy rating or “Display Energy Certificate” which, together with a set of recommendations for improvement, is undertaken annually for most public sector buildings. This review has sought to find where similar requirements exist in other countries worldwide.

### 3.2.1 Australia

Australian standard AS/NZS 3598: 2000 – Energy Audit sets out minimum requirements for commissioning and conducting energy audits which identify opportunities for cost effective investments to improve efficiency and effectiveness in the use of energy.

This Standard covers three levels of audit, as follows:

(a) Level 1.

(b) Level 2.

(c) Level 3.

Level 1 is really an overview based on a desk study on a site, level 2 extends this to a preliminary energy site use survey and level 3 is an audit with the following remit:

> A Level 3 audit provides a detailed analysis of energy usage, the savings that can be made, and the cost of achieving those savings. It may cover the whole site or may concentrate on an individual item, such as a single industrial process or one of the services. The auditor may often employ a specialist to carry out specific parts of an audit or may need to install local metering and logging.
>
> The report from a Level 3 audit often forms the justification for substantial investment by the owner or an energy performance contractor. Detailed economic analysis with appropriate level of accuracy is required.
>
> NOTE: A Level 3 audit is expected to provide a firm estimate of savings and costs. Accuracy of figures would be within +10% for costs and –10% for benefits.

The audit is tied into the process of energy management and operational energy usage as part of an energy management programme with recommended timing between the audits. The standard is a framework in that it defines the tasks to be done by then refers to best practice, such as the UK CIBSE Guide F on how to achieve it.

Auditors are selected in accordance with AS 4121 – 1994 - Code of ethics and procedures for the selection of consultants which sets out the ethics and the obligations of the Principal and Consultants in the selection and appointment of Consultants and sub-consultants through direct negotiations or invitation, proposal and selection process for the procurement of professional services in the construction industry. A separate Standard covers the selection of contractors through the tender process.

Current schemes are State based and domestically orientated although a national bill has been prepared and introduced to parliament on 18th March 2010. The commercial office building energy efficiency disclosure scheme has reached a critical milestone with the Building Energy Efficiency Disclosure Bill introduced to Parliament on 18 March 2010.

The aim of the Bill is to ensure that credible and meaningful energy efficiency information is given to prospective purchasers and lessees of large commercial office space. Once the legislation is passed, building owners will have to provide a Building Energy Efficiency Certificate when they sell or lease office space covering more than 2,000 m².

The scheme is a commitment under the National Strategy on Energy Efficiency. It is being managed by the Australian Government Department of Climate Change and Energy Efficiency. Australian, state and territory government energy ministers approved the policy parameters of the commercial building disclosure scheme in November 2009.

The Bill requires owners and lessors of commercial office space with a net lettable area of 2,000 m² or more to disclose a valid Building Energy Efficiency Certificate to prospective purchasers and tenants when the space is to be sold, leased or subleased. The Building Energy Efficiency Certificate will include three components:

- a National Australian Built Environment Rating System (NABERS) Energy base building rating;
- a tenancy lighting assessment;
- energy efficiency guidance.

NABERS - the National Australian Built Environment Rating System - is a national initiative managed by the NSW Department of Environment, Climate Change and Water. NABERS is a performance-based rating system for existing buildings. NABERS rates a building on the basis of its measured operational impacts on the environment, and provides a simple indication of how well you are managing these environmental impacts. The energy rating is an operational rating based on a tool which seems similar in functionality to the UK's Display Energy Certificate (DEC) scheme OR-calc tool.

There is no link to their own Energy audit standard and indeed there is a statement on the Government website that this is not an audit but a rating. Both the standard and the scheme appear not currently to have any accreditation/certification schemes underpinning them, although NABERS Accredited Assessor Training Courses are reported as being open for registrations by late January 2011.

### 3.2.2 New Zealand

New Zealand's EMANZ (The Energy Management Association of New Zealand (Inc.)) run an Accredited Energy Auditor scheme based on AS/NZS 3598. This requires applicants to have membership of a professional institution and they consider university and similar graduates to have acquired a minimum of 5 years experience in a suitable field after they have qualified to gain sufficient experience to be able to satisfy this requirement. There are then required to submit a Level 2 Audit Report or reports demonstrating their knowledge of energy auditing.

### 3.2.3 European Union (EU)

The EPBD calls on EU member states to promote the improvement of energy efficiency of buildings by laying down standards and assessing and certifying performance. Article 3 of the EPBD calls for a methodology for calculating the energy performance to be applied at a national or regional level. An annex states that the calculation must be based on a general framework covering:

- thermal characteristics of the building (shell and internal partitions, etc) - this may include airtightness;
- heating installation and hot water supply;
- air conditioning installation;
- natural and mechanical ventilation;
- built-in lighting installation;
- position and orientation;
- passive solar systems and solar protection;
- indoor climatic conditions.

The calculation should also deal with:

- active solar systems and other renewable energy sources;
- electricity produced by combined heat and power;
- district or block heating or cooling systems; and
- natural lighting.

Buildings are classified for the purposes of the calculation. Article 3 calls for the calculation to be ‘transparent’, that is, the way it works should be explained.

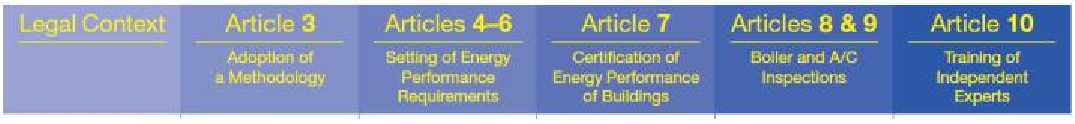
Articles 4, 5 and 6 require standards to be set for new and refurbished buildings, and buildings to be checked against those standards. This is in effect the setting of Building Regulations standards and compliance checking by building control bodies.

Article 7 requires that, when a building is constructed, sold or let, an Energy Performance Certificate EPC, accompanied by recommendations for improvement, is made available so purchasers or tenants can assess and compare its energy performance.  Within these requirements accredited Energy Assessors are required to provide Energy Performance Certificates (EPCs).

This has led to the formulation of national standards and methodologies in order to implement these requirements.

The Royal Institute of Chartered Surveyors (RICS) published a report - Towards an Energy Efficient European Building Stock in December 2009. This was a RICS Status Report on the Implementation of Directive 2002/91on the Energy Performance of Buildings (EPBD) in the EU Member States –


The report reviewed each country in terms of:




Some countries already have audit schemes and have “piggy backed” the additional requirements onto these. This is convenient but does not always result in a good fit.

Other countries, such as Germany, require certificates to be issued by architects and engineers of building-related backgrounds and by other engineers and natural scientists with a building related degree who have either acquired knowledge about energy efficient buildings/ construction during their studies or during further vocational training or who have related professional experience of at least 2 years. Architects and engineers represent the majority of all energy assessors. For new buildings, setting accreditation requirements is the responsibility of the German ‘Bundesländer’ or states. Although there will be no formal system of approval and certification, there will be a penalty if a non-authorised person issues a certificate. In addition, building owners can be fined if they do not make a certificate accessible to a prospective buyer or tenant.

#### 3.2.3.1 Finland

Finland’s Energy Audit Programme (the EAP) is one of the oldest national energy efficiency grant schemes in place. The EAP started as a subsidy policy in 1992 and was developed into a programme level activity in 1993. The EAP was in practice launched in January 1994 and has been a clean-cut and full-scale programme since then.

The EAP is run by Motiva Oy (the Operating Agent), a state owned company. The Energy Department of the Ministry of Employment and Economy (the MEE) is the Administrator, responsible for all official decisions. Consulting companies form the major part of the energy auditors and the clients are industry, services (both private and public) and energy sectors.

The EAP is a voluntary programme promoted by a 40 % to 50 % subsidy by the MEE. In the service sector almost 40 % of the building stock is covered by the EAP. Since 1992 some 6800 buildings have been audited.

One condition for granting subsidies is that the implementation and reporting guidelines are adhered to. Their handbook for energy auditors presents such things as general instructions for the practical implementation of audits, background information and means for energy auditors.

The following energy auditing models are applied in the service area:

- less than 5,000 rm3, Building Energy Inspection;
- 5,000-10,000 rm3, Building Energy Audit or Building Energy Inspection;
- over 10,000 rm3, Building Energy Audit.

The general guidelines of the Ministry of Employment and the Economy state that separate HVAC and E (electrical) auditors must be named for the Motiva energy auditing project, as mentioned in the guidelines and apart from exceptions. The qualification of auditors requires the completion of Motiva’s energy auditors’ training course or other MEE/Motiva approval.

Motiva maintains a directory of auditing firms that have auditors with heat and fuels or electrical auditing competency, and who have reported Motiva's energy audits without significant discrepancies in quality since the beginning of 2005.

In addition to the audit models and the specimen reports, Motiva has created the following tools for auditors:

- the motiwatti calculation programme;
- summary tables;
- reporting tools;
- inspection check lists; and
- measurement records.

The point of these tools is to make the work of the auditors more efficient and to standardize energy auditing.

From the Audit II report on Auditors' tools done as part of the SAVE programme - The MOTIWATTI 2.0 is a practical tool for an energy auditor. The building to be audited is modelled into the programme and then the auditor can start simulations on individual energy saving measures. One idea of the programme is to form a detail breakdown of the energy use, based on the measured consumption data and the actual use and operating information of the building service systems. When all systems have been created and the theoretical consumption equals the measured consumption, the auditor can be quite sure that the saving of a considered measure is at correct level.

There is no link between the audit programme and the production of EPCs except those that already have an audit can issue an EPC without further work because it is considered that the audit is of a much higher standard. It should be noted that due to the nature of the Finnish climate, mechanical cooling is not dealt with in such detail as other EU countries in temperate and hotter climates.

Qualified experts for EPC certification have the authority to issue so-called Separate Certificates. They must be architects, engineers or technicians with education in building, HVAC or electrical engineering. The professional examination can be replaced by at least three years' experience in energy efficiency in the building sector. Furthermore, qualified experts must pass an exam arranged by an accreditation body. The exam tests their knowledge of the certification legislation and the certification system itself. Attendance at training courses is not mandatory.

#### 3.2.3.2 France

The requirements for experts are specified under ISO 17024 - Conformity Assessment - General Requirements for Bodies Operating Certification of Persons. Experts need appropriate knowledge and competence, fluency in French, but no particular degree or experience is necessary. They need to pass an exam organised by a company or organisation accredited by COFRAC. (Comite Français d'Accreditation) (www.cofrac.fr)

A list of accredited experts can be found on the website of the Ministère du Logement et de la Ville, in specialised professional organisations, in organisations accredited by the COFRAC or ADIL (Association pour le Développement de l'Informatique Juridique - Association for the Development of Legal Science).

Best Practice Guidance can be found in AFNOR (Association Francaise de Normalisation) repository of best practices of energy diagnosis in Industry BP X30-120 guide.

#### 3.2.3.3 United Kingdom

France and the UK are part of a group where the EPBD implementation is underpinned by national schemes run by certification bodies, which in turn have the schemes accredited by their national accreditation bodies, for example in the UK this would be the UK Accreditation Services (UKAS).

In the UK, these schemes were pre-dated by the need for competent persons to support the submissions to building control of compliance to the building regulations for energy conservation – i.e. Part L for England and Wales; and Section 6 for Scotland. UK best practice, which also pre-dates the EPBD, is based on the UK Government's Energy Efficiency Best Practice Programme (started in the 1970s, then evolved into Action Energy and now under the management of the Carbon Trust) and UK's Chartered Institution of Building Services Engineers (CIBSE) guidance. The CIBSE Guide F on energy efficiency in buildings is the only current document that captures everything.

As a result the audit methodology and tools for the production of asset ratings were well advanced and with the introduction of EPCs were adapted and expanded in their scope and functionality to meet the additional requirements of the EPBD. The core government-sponsored tool is SBEM. Alongside these in England and Wales, new schemes were developed using similar methodologies and tools (OR-calc) to produce operational rating and Display Energy Certificates (DECs) for public buildings.

Bodies such as BRE Global and CIBSE had, at the time of EPBD implementation, mature accreditation schemes already in place for Building Regulation energy assessors. With EPBD implementation the scope of these schemes was expanded to include the remit of the EPC & DEC assessors. These schemes are currently in the process of being expanded again to cover the new Energy Management Standard: ISO 16001.

#### 3.2.3.4 EU summary

Within the European Union the need for building specific auditors seems to have been overridden by the need to support the Energy Performance of Buildings Directive (EPBD) legislative and regulatory requirements. The only exception to this is Finland, where a voluntary audit scheme has preceded the EPBD by several years. As a result, the subsidised audit schemes have become embodied into "business as usual" and EPCs are seen as an additional and inferior requirement.

### 3.2.4 India

India within its 2001 Energy Conservation Act has the provision to introduce energy auditors and the Bureau of Energy Efficiency (BEE) has statutory powers and functions under this legislation, which are laid out in Chapter IV, Section 13 (o) (p) (r) and (s) of the act.

These subsections cover:

- (o) maintain a list of accredited energy auditors as may be specified by regulations;
- (p) specify, by regulations, qualifications for the accredited energy auditors;

- § (q) specify, by regulations, the manner and intervals of time in which the energy audit shall be conducted;
- § (r) specify, by regulations, certification procedures for energy managers to be designated or appointed by designated consumers;
- § (s) prepare educational curriculum on efficient use of energy and its conservation for educational institutions, boards, universities or autonomous bodies and coordinate with them for inclusion of such curriculum in their syllabus.

In order to support implementation of these sections of the Act BEE are currently developing a pilot scheme to test advanced and cost effective ways to provide information and training to energy managers as well as auditors.

In support of this BEE have produced audit guidelines, however these suffer from being generic and too high level.

In March 2010, BEE also published the Procedures for Accreditation of Energy Auditors and Maintenance of their List under the Energy Conservation Act, 2001. Prospective candidates were invited to apply for accreditation through BEE and were expected to meet the following criteria:

- § be a certified energy manager and have passed the examination in “Energy Performance Assessment for Equipment and Utility Systems” conducted by the Bureau;
- § has five years experience in energy auditing, out of which at least three years’ shall be in any of the Energy Intensive Industries;
- § has been granted a certificate of accreditation by the Bureau;
- § provide five detailed energy audit reports in any of the Energy Intensive Industries undertaken by the energy auditor in an individual capacity or as a leader or associate or active team member of the energy audit team;
- § provide feed back on energy audit received from Energy Intensive Industries.

BEE plan to run their 11th National certification exams for Energy managers and auditors in February 2011. The minimum requirements for entry are set out below:

**For Energy Auditors (EA)**

**a)** A Graduate Engineer (Bachelor of Engineering / Bachelor of Technology) or equivalent with three years of work experience involving use of energy in operation, maintenance, planning, etc. ; or

**b)** A Post-Graduate Engineer (Master of Engineering / Master of Technology) or equivalent with two years of work experience involving use of energy in operation, maintenance, planning, etc.; or

**c)** A Graduate Engineer with post-graduate degree in Management or equivalent with two years of work experience involving use of energy in operation, maintenance, planning, etc.

BEE has retained the National Productivity Council (NPC) as the National Certifying Agency to conduct and administer these exams.

### 3.2.5 Singapore

The Inter-Agency Committee on Energy Efficiency (IACEE), which comprises senior officers from various government agencies, was formed in 1998 to address the concerns over the increasing energy consumption of Singapore. In its report, the committee recommended a number of strategic directions to improve the energy efficiency of the buildings, industries and transport sectors.

The Building Energy Efficiency Master Plan (BEEMP), which is formulated by the Building & Construction Authority (BCA), details the various initiatives taken by the BCA to fulfil these recommendations. The plan contains programmes and measures that span the whole life cycle of a building. It begins with a set of energy efficiency standards to ensure buildings are designed right from the start and continues with a programme of energy management to ensure their operating efficiency is maintained throughout their life span. The BEEMP consists of the following programmes:

§ Review and update of energy standards;

§ Energy audit of selected buildings;

§ Energy efficiency indices (EEI) and performance benchmark;

§ Energy management of public buildings;

§ Performance contracting; and

§ Research and development.

The BEEMP was to be reviewed and updated annually to incorporate the latest plans and changes necessary to keep building energy efficiency in Singapore a sustainable goal.

The Energy Sustainability Unit (ESU) based at the National University of Singapore (NUS) has received a Government grant to undertake 4 programmes to develop the energy services sector in Singapore.

One of these is to accredit Energy Services Companies (ESCOs) for the delivery of services which include specified levels of energy audits to a specific sector, one of which is buildings. As part of this project ESU was tasked to develop the nationally Certified Energy Manager (SCEM) program for Singapore, under the sponsorship of the Economic Development Board's (EDB) Locally-based Enterprise Advancement Program (LEAP) grant. The initiative has received the support of Energy Market Authority (EMA), the National Environment Agency (NEA) and the Building and Construction Authority (BCA).

The company, not the individual is accredited and must have undertaken a minimum of nine similar audits and have a minimum of one named “Key qualified person (KQP)” to oversee, manage and carry out the audits. The KQP must be qualified as a Singapore Certified Energy Manager (SCEM), have a relevant professional qualification, 2 years post graduate experience in a certified or accredited scheme, a relevant engineering degree and completed 3 audits in the last three years.

This scheme is impressive in that it fully defines who is competent to do the work and lays out stringent requirements for the certifiable personnel. However, the description of the audit levels is generic and does not fully describe what the output should look like in terms of content and level of detail, including analysis techniques. They also adopt three levels of audit: Preliminary, Standard and comprehensive. All underpinning standards are imported and those recommended are:

- § AS/NZS 3598:2000 – Energy Audits;
- § ASHRAE RP-669, SP-56: 2004 – Procedures for Commercial Building Energy Audits;
- § CIBSE TM22:1999 - Energy Assessment and Reporting Methodology; and
- § Other equivalent international standards and codes.

There also appears to be a misunderstanding by the ESU of the differences between accreditation and certification.

#### 3.2.6 South Africa

Training of Energy Auditors in the Building Sector of South Africa (BEAT) project has been commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The term of this project is 2009-10 and aims at ensuring that at least 80 of the 100 trained energy auditors are certified and at least 10 energy audits having been implemented by these trained auditors by 2011. Within the programme GTZ provides technical expertise for the development of training material and supports the establishment of necessary structures for a sustainable energy auditor programme. The six-month training course is aligned with the standards of the South African Qualification Authority (SAQA) and will be conducted by accredited training providers in Gauteng, Kwa Zulu-Natal and the Western Cape. Participants are selected amongst graduates according to their basic knowledge in areas such as electronics or plumbing. Successful trainees will receive an official certificate enabling them to compete on the free market. In order to facilitate market entry and provide learners with practical work experience, GTZ and its partners ensure integration of successful trainees into further governmental auditing programmes for a period of at least six months.

One of the partners The National Energy Efficiency Agency (NEEA) was officially established in March 2006 through a directive issued by the Minister of Minerals and Energy. Located within CEF (Pty) Ltd as a wholly incorporated division, the Agency commenced operations on 3 April 2006 and will be subject to review in three-year intervals, in line with the national Energy Efficiency Strategy, which was approved by the Minister of Minerals and Energy in 2005.

The strategy concentrates on three strands:

- § The Industrial and Mining Sectors are the heaviest users of energy, accounting for more than two-thirds of their national electricity usage. They see the potential for the largest savings here by replacing old technologies with new, and by employing best energy management practice.
- § The Transport Sector which uses three-quarters of South Africa’s petroleum products
- § The Residential sector which they view as having great potential for energy savings given they have a National Housing Programme and view building design as the major factor determining the energy use of a household.

The reason for the low level of qualifications and training required for these auditors is that they are aimed at the domestic market, not commercial buildings.

The only initiative found with respect to commercial buildings is a guide to energy management in public buildings published in 2008. This recommends that you refer to energy audit reference documents such as the CaBEERE Building Energy Audit Manual. Capacity Building in Energy Efficiency and Renewable Energy (CaBEERE) was a programme in the National Department of Minerals and Energy which aimed to develop capacity and resources within the department to promote energy efficiency and renewable energy in South Africa.

### 3.2.7 United States of America (USA)

ASTM International (ASTM), originally known as the American Society for Testing And Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. In their March/April newsletter they propose a Standard for Assessment and Disclosure for Energy Use in Commercial Buildings. There are now developing draft standard WK24707, Building Energy Performance Assessment and Disclosure for a Building Involved in a Real Estate Transaction. The International Committee E50 on Environmental Assessment, Risk Management and Corrective Action completed a draft proposal in October 2009; its members hope to have a published standard this year.

They consider the two key drivers for developing a standard are the proliferation of different local, state and regional standards, and the pure economics of energy efficiency.

The proposed process includes five components: a site visit, records collection, review and analysis, interviews and a report. Among other data, the service provider conducting the building energy performance assessment (BEPA) will collect information on building energy consumption and cost over the previous three years or since the last major renovation.

The analysis phase of the process includes converting the collected data to a calendar month basis; determining the appropriate building energy consumption metrics, such as the number of BTUs per square foot per year; calculating the building’s carbon footprint and determining the relationship between the building’s energy consumption and the independent variables that can impact it.

The final BEPA report will describe a commercial building’s historical energy use and cost; how these factors can be affected by weather, occupancy and other conditions; the building’s carbon footprint and an energy consumption disclosure statement with supporting documentation.

WK24707 is not designed as nor is intended to be a benchmarking standard that compares the energy efficiency of one building to another. Nor does it compete with current green building rating, certification and labelling initiatives promoted by the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) rating system; the Capital Markets Partnership’s Green Value Score; the U.S. Environmental Protection Agency’s Energy Star program; or the American Society of Heating, Refrigerating and Air-Conditioning Engineers’ Building Energy Quotient program. This is a framework standard that will only provide a standardized way to collect and report the data.

ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) is an organization that establishes standards for the uniform testing and rating of heating, ventilation, air conditioning, and refrigeration equipment. It also conducts related research, disseminates publications, and provides continuing education to its members.

ASHRAE procedures for commercial building energy audits were published in 2004 as RP-669, SP-56. It sees the objectives of an energy audit to identify modification that reduce the energy use and cost of operating a building. To achieve this it requires:

- Analysis of two or more years of utility consumption, a review of building plans and a walk through of the building;
- Description and analysis of the building services from on-site observation, measurement and engineering calculations;
- From the above and economic calculations analyse annual energy use/cost, and recommend energy conservation measures.

In common with the Australian standard there are 3 levels of audit where:

- Level 1 is a site walk through analysis;
- Level 2 extends this to a energy site use survey; and
- Level 3 is an audit with detailed analysis of capital intensive measures.

There are extensive forms for the collection of data but little on how to analyse the data to prioritise the areas of greatest savings and then to identify which measure are required to achieve them.

The Association of Energy Engineers (AEE) runs the Certified Energy Auditor (CEA) Program for Professional Certification. The candidate for CEA certification must have one of the following:

- A four-year degree from an accredited university or college in engineering or architecture, or be a registered Professional Engineer (P.E.) or Registered Architect (R.A.). In addition, the applicant must have at least three years of verifiable experience in energy auditing, energy management, facility management, or experience related to energy management;
- A four-year non-engineering degree with at least four years of verifiable experience in energy auditing, energy management, facility management, or experience related to energy management;
- A two-year technical degree with at least five years of verifiable experience in energy auditing, energy management, facility management, or experience related to energy management;
- Ten years of verifiable experience in energy auditing, energy management, facility management, or experience related to energy management;
- The current status of Certified Energy Manager.

Examination and Training Requirements are that all candidates must attend one of AEE's preparatory CEA training seminars (3 days), and complete and pass the four-hour written CEA examination, proctored by an AEE-approved exam administrator. The CEA examination questions are drawn from areas of knowledge such as energy auditing methodology; auditing instrumentation; auditing tools; economic analysis; building systems technology; lighting; HVAC; building envelope; controls; boilers and steam systems; water auditing; and reviewing auditing reports.

The exam is open book, and questions are a mixture of multiple choice and true/false. A passing score of at least 70% is required in conjunction with meeting all other eligibility requirements to become certified. The syllabus is linked to the ASHRAE standards and a range of best practice guidance published by AEE.

The US has not got federal or state wide legislation dealing with this issues whilst they appears to be resistance to any initiatives, such as proposed by the New York City Council, on the grounds of cost. For example the July 2009 article in the COOPERATOR – the Co-op and Condo monthly:

*Proposed legislation by the New York City Council to require energy audits, while a nice idea, is extremely cost-prohibitive especially in today's economy. The bottom line is that the spending proposed in this bill (Intro 967) will be taken straight out of the operating budgets of co-ops and condos and not the city coffers.*

*Among the legislation's provisions are that owners of buildings 50,000 square feet or more must retain an approved energy professional to conduct the once-per-decade audit, which the city will require of a specified 10 percent of affected buildings each year for 10 years. The audit would identify both "capital alterations of building systems involving the installation of new equipment, insulation or other proven energy efficiency technologies" and "reasonable retro-commissioning and retrofit measures that would ... reduce energy use and/or the cost of operating the building."*

## 3.3 Conclusions of Review of International Standards

Although many countries have addressed the process of energy auditing, this study indicates that audits of existing building energy are generally motivated by individual organisation requirements, in order to improve profitability or to demonstrate sustainability to stakeholders such as shareholders, customers or the general public. Few countries have integrated the impacts of asset and operation together in their schemes, few have other than high level codes of practice and few have underpinned their energy audit schemes with workable accreditation of assessors.

In European countries there is a legislative or regulatory requirement where the EBPD has driven the need for Energy Performance Certificates (EPCs); in some countries these are based on operational energy performance (though not all, since the decision for the basis of the EPC is for each country to decide), and in some the issues surrounding mechanical cooling are not addressed fully.

From the review we have undertaken, only in England and Wales are all these issues dealt with coherently and consistently. Even there, only public buildings have certification for operational energy, and there is no integrated calculation procedure to evaluate buildings for both asset and operational performance.

We therefore recommend that Mauritius should adopt the energy audit procedures developed in England and Wales, bringing in the operational rating process used for public buildings, and especially using the underpinning accreditation regime to ensure quality of assessors and audits.

We further recommend that the underpinning energy evaluation software for asset rating used in the UK (including England and Wales) should be extended to include comparison with metered energy data, and thus identify the separate indicative benefits of improvements to the building asset and operation.

There is no legislation or regulation that encompasses all this, on which Mauritius could model its legislation/regulation. We therefore propose to recommend a structure than can be inserted into the framework of the Energy Efficiency Bill, extended to cover the linkages required for Mauritius especially the proposed Building Control Bill and Codes for Energy Efficiency. We expect to undertake this once the principles described in this report have been accepted by the Mauritian Government.

# 4 Review of existing regulations on buildings in Mauritius

### 4.1.1 Energy efficiency

We have asked our local partners and other professional contacts in Mauritius to comment on:

- existing building regulations and how they impact on energy use if at all;
- whether there is anything regulatory or from other agencies like utilities, local authorities or insurers that prompts or requires energy audits;
- if any organisations undertake energy audits voluntarily, e.g. to aid management or to demonstrate to stakeholders that they operate sustainably?

The response is that the Building Act, dated 30 November 1981, refers to the permit application process for the construction of a new building or for significant renovation work. However, there is nothing specific which could affect the energy performance of the premises. There is no mandatory provision given about energy auditing. Any energy audits the consultants reported were voluntary; either requested by the client or proposed by consultants as a preliminary investigation of the energy performance for subsequently identifying means to reduce the energy use. An example of such a programme is that run by Enterprise Mauritius.

### 4.1.2 Building permits

We understand that all buildings proposed to be constructed or undergoing significant extension or modification need to submit an application for a building permit. This is needed to obtain approval from the point of view of planning use and building regulation compliance before works commence. The review and approval of the submission, prior to the granting of this permit, is an opportunity to expand coverage to include an energy audit, and to enforce incorporation of energy efficiency measures. However, we understand that the National Steering committee does not wish this to be the prompt for the audits.

### 4.1.3 Recommendation

We recommend that the energy audits should be required for “designated consumers” who meet a set of criteria to be confirmed in discussion with the Government. It is hoped that the CEB will be willing and able to make the selection against these criteria by applying a preliminary check to all non-domestic consumers as part of the billing process. The way in which this could be arranged through the CEB is explained later in this document, although at this stage it has yet to be discussed and agreed with them.

The following sections give an explanation of how the energy audit process and its supporting tools could be set up, together with the accreditation process.

# 5 Proposals for Energy Audit Management Scheme (EAMS)

## 5.1 Overall format of scheme

The purpose of the Energy Audit Management Scheme (EAMS) is to facilitate improvement of the energy management of the non-domestic building stock of Mauritius. The intention is to engage auditors to audit the buildings, in some cases with financial support from the Mauritian Government, in order to determine which need improvement measures to be applied so that the energy consumption of those buildings is reduced.

This section of the report discusses the possible format of the EAMS including how it could engage with the recipients of the service, how it could operate on a technical level including tools to evaluate and prioritise measures, what information would be needed to evaluate building energy performance, which measures are likely to be considered, and what capabilities would be required of the auditors.

### 5.1.1 Policy decisions

Before finalising the format of the EAMS, we suggest that the Mauritian Government needs to take some policy decisions regarding the scope and scale of the scheme. Our recommendations and our understanding of the Government's requirements are indicated by the bold text amongst the following options, and have been assumed later in the document. It is of course open to the Government to choose alternative ways to implement the scheme.

1. What proportion of the non-domestic building stock is to be addressed, on what time scale? It might be desirable to have all buildings audited and improvements made quickly, but this will have implications for

    a. The number of audits required in a given period

    b. The number of auditors to be trained, and their expectations for long-term engagement with the scheme if work peaks early but then declines

    c. The time profile of Government funding support

    **We suggest that the building stock should be audited progressively** over a period of years, in order to spread the costs and human and capital resources required.

2. To what extent does the Government expect the business community to pay for the scheme, in terms of

    a. The audits themselves

    b. Implementation of measures

    If the business community is expected to pay, what incentives should they be given, or is having legislation/regulation in place thought to be sufficient motivation? If funding is to be provided, where should it be targeted to gain maximum impact?

**We understand that the National Steering committee requires that the audits should be supported, rather than the implementation of measures. BRE will design a process that provides grants through a Contingent Support Mechanism (CSM) (to be explained in more detail later in the document).**

3. Does the Government want to encourage voluntary audits as well as those required by legislation/ regulation? If so, will any incentives be offered to building owners/operators that wish to implement the results of voluntary audits?

**We recommend that voluntary audits be encouraged, but we understand that the Government will not be able to support them through the CSM.**

4. Is it expected that funding, if offered, should be recycled to fund future support? If so, on what timescale is the funding expected to return to the exchequer, since until it has, the Government will have to support the scheme.

**We recommend that funding should be recycled through revolving loans administered by the CSM.**

5. If funding is to be limited, how should it be prioritised? Options are on the basis of

a. First come, first served
b. Largest absolute savings
c. Worst performers against benchmarks for building type
d. Need to provide exemplars in sectors with large contribution to economy or with a high profile
e. Shortest payback first
f. Medium payback first (on the basis that businesses should be able to fund short payback measures themselves)

**We recommend that priority should be given to fully audit buildings that perform worst against typical for each building type. This will be established through the preliminary check process used by the CEB and EEMO to identify "designated consumers".**

### 5.1.2 Process for each audit

For each building to be audited, we envisage the following process:

a. Buildings will only be compulsorily audited if they are designated consumers. Voluntary audits will be allowed, but there will be no support funding
b. We strongly recommend that only independent accredited audit assessors should be allowed to undertake audits, to
   i. Ensure competence at carrying out the audit
   ii. Improve consistency

   iii. Minimise fraud which could occur if the auditor was part of the organisation receiving CSM funding

c. Once the designated consumer has been identified and contacted by the EEMO, contracts need to be set up between CSM and the designated consumer to

   i. To carry out of the audit

   ii. Implement operational improvements

   iii. Implement asset improvements where the business case satisfies the building owner/operator

d. Independent accredited audit assessor will contact the building owner and operator to

   i. Explain the need for the audit

   ii. Request the collection of data (e.g. billing information) to which the owner and/or operator has access

   iii. Arrange a visit to collect information about the building asset and quality of energy management

e. Audit assessor visits the building and any other appropriate location to survey and collect data such as dimensions, constructions, services types and efficiencies, and metered energy consumption, and also to review potential for improvements

f. Audit assessor sets up building models in the EAMS tool, for

   i. Actual building including assessment of energy management quality

   ii. Suggested improvements

g. Tool evaluates building, generates expected savings due to

   i. Asset improvements

   ii. Operational improvements

h. Auditor uses this information and independently gathered information on implementation costs to generate preliminary business case for building owner/operator to invest in improvement measures

i. Capture building details in a registry to start building up picture of stock

j. Revisit building one year after measures are implemented, to check whether measures have reduced energy consumption as expected, and review results.

k. Feed review into central records to inform future decisions.

### 5.1.3 Criteria for establishing designated consumers

Rather than expecting all audits to be carried out simultaneously when the legislation/regulation is enforced, it is recommended that they should be prompted by some other event. This would allow resources to be spread over time.

Possible legislative or regulatory reasons that would prompt the need for an energy audit might be:

- fixed date
- when a building permit is granted or renewed, particularly for
  - extension
  - refurbishment
  - improving weather tightness
- condition of renewal of utility contracts
- associated with local taxation demands
- a preliminary check undertaken by CEB based on billing information compared with benchmarks

| **Prompt** | **Explanation** | **Comment** |
|---|---|---|
| By fixed date | Annual or less frequently, possibly different dates for each building type or some other differentiator to spread the load through the year | Reasonable clarity. Difficult to provide enough auditors. May be problems with maintaining compliance over several years, if results are similar year on year but no action is taken. Does not prioritise initial audit effort on poor performers. |
| Building permit sought | Make an audit of any pre-existing building part of permit grant/renewal process | Easy to capture buildings that are already in the regulatory process. Building owners/operators should be more disposed to undertaking remedial work as it could be aligned with work being done anyway. |
| Condition of utility contract renewal | Not having an audit would mean the contract would incur a surcharge on unit price (could be presented as a discount to those who conform) | “Discount” would be useful motivation, especially compounded with CSM funding and the reduced energy cost if measures are implemented. Link with negotiation on energy contracts would focus attention on energy performance. Does not prioritise initial audit effort on poor performers. |
| Associated with local taxation | Not having an audit would mean a surcharge on local taxation rate (could be presented as a discount to those who conform) | “Discount” would be useful motivation. Easy to capture all buildings. Does not prioritise initial audit effort on poor performers. |
| Preliminary check by CEB | Non domestic energy consumers provide building area and type to CEB, and then every bill would compare actual rolling annual | Every consumer gets a preliminary check, which should help to motivate everybody towards improvement. Only the consumers that most need a full EAMS audit would have to pay for it. The |

| | | |
|---|---|---|
| | consumption/sqm against a benchmark. Only those in a certain band e.g. 200%+ above benchmark would have to undertake the audit. (The band would be set by the Government so that only the worst performers are affected at first, but the limits could be progressively tightened over time so that more of the stock is captured as resources become available.) | Government control of the % above benchmark bands means that (a) eventually all buildings can be audited but (b) only as resources become available to undertake the audits and fund the improvements. However, it could be perceived as complicated and there is an administrative cost imposed on CEB. There could be scope for error/fraud if consumers distort the building area/type information they pass to CEB with the intention of getting CSM funding (but this could be minimised if part of the full audit includes confirming these details and/or the information is corroborated with local authority records). |

We understand that the National Steering committee requires that the audits should be carried out on all “designated consumers”, i.e. those that satisfy certain criteria. BRE proposes that the “preliminary check by CEB” approach outlined above would set suitable criteria that could be adjusted over time to reconcile resources and speed of implementation aspired to by the Government. The precise procedure will be resolved between the National Steering committee, BRE and the CEB as implementers of the check during the EAMS implementation phase.

## 5.2 Tools to support the EAMS

The energy audit process set up in most standards usually involves a comparison of the building’s measured (i.e. metered) energy consumption against a standard metric (eg building area, number of occupants or a unit of production), with a benchmark established from statistical analysis of a significant proportion of the building stock of similar type – for instance, the median on a distribution curve of energy per square meter. Buildings that consume more than this benchmark are deemed more in need of attention and remedial measures than those that consume less. Measures that will reduce the energy consumption relative to benchmark are left to the inspiration of the auditor – typically from a paper list.

While this procedure establishes a priority for action, it is not feasible or adequate to support the EAMS for Mauritius for a number of reasons:

a. Our contacts tell us there is no pool of monitored building energy consumption data which can be statistically analysed, so benchmarks cannot be created that way

b. The scheme requires that there should be estimates of the savings resulting from proposed improvement measures, and this approach cannot calculate savings because there is no model of the building on which to base calculations

We therefore recommend that a calculation is needed to assess the likely impact of any suggested improvement measure on the actual building under consideration.

SBEM, being a whole-building energy consumption calculation based on the characteristics of the building elements (i.e. areas, insulation standards, solar, metabolic and equipment gains and building services plant efficiencies including differentiation between different mechanical cooling systems) is able to estimate the impact of changes to any of those characteristics, and thus fulfils the second requirement.

One solution to the dearth of information on metered building performance in Mauritius is to generate benchmarks within the calculation itself; this involves feeding in “typical” standards for the parameters from information supplied by local practitioners. This is one of the information gathering streams we have set up. However, it should be noted that since the CSM is not required to fund improvements, the comparison with “typical” to determine priority for funding is no longer a necessary part of the procedure.

The process also needs to differentiate between the parts of energy consumption due to “asset” issues (ie the physical characteristics of the building and plant) and the “operational” characteristics (ie the way the building is managed differently from the assumptions built into the calculation). This will determine whether the suggested improvements will be to change physical assets or to modify the way the building is managed (or both). In general the former require capital expenditure, the latter require revenue expenditure or may be free.

Also to be resolved is how the benefits of improvement measures should be presented, given the fact that many of the inputs to the tool will not be known precisely by the auditor. It is expected that they will be presented as ranges between confidence limits.

In order for auditors to evaluate building performance consistently, it is important that they use the same tool to provide the framework for the energy audit. Such a tool could be provided in a number of ways:

| Method | Comment |
|---|---|
| Paper-based procedure to be adopted by all auditors, using look-up lists | Appears simple but individual auditors may make errors; difficult to check afterwards; calculation of savings due to measures laborious with inconsistent results. |
| Spreadsheet based on assumed savings for each measure | Regularises procedure but calculation of savings would not take account of interactions between measures. |
| Software package to estimate savings based on characteristics of each individual building | Regularises procedures so that all auditors should get same results for same inputs; calculation can take account of interactions between measures; calculation can separate to impact of asset and operational improvements on consistent basis; future scope for feeding back results to central records to monitor progress towards energy efficiency for country as a whole. |

## 5.3 A software tool to support the EAMS

The software support tool for the EAMS needs to include the following:

1. a model of the building and its systems, and a calculation procedure to determine asset energy consumption; this would form the “well managed” estimate for the current building

2. a calculation that takes account of the interactions between different parameters – for instance an increase in glazed area might allow lighting energy to be reduced because there is more daylight, but could increase solar gain and thus increase cooling energy. The calculation needs to take account of such conflicting influences to estimate the net changes in energy consumption.

3. the facility to modify asset parameters (e.g. glazed areas, shading, plant efficiency, etc) to determine the differences that improvements would make to the asset energy consumption

4. a means of apportioning the differences between energy consumption as estimated above and actual metered energy consumption, to asset and operational aspects of the building. It is important to determine which parts of any savings due to proposed improvements might be due to (low cost or possibly free) operational improvements and which to asset improvements that could require capital funding from the building owner.

5. ways of avoiding inconsistencies in how different auditors might use the tool.

SBEM and its interface iSBEM have been developed in the UK to answer requirements 1, 2, 3 and 5 above (the latter with additional rules and training of auditors) for building regulation compliance and energy certification. For Mauritius, BRE has developed the concept that enables requirement 4 to be addressed, as explained in the following section.

Thus the SBEM software, in conjunction with a separate questionnaire-based procedure to assess the quality of management of the building, will be customised to assess both the asset and operational energy performance of the building. It will also differentiate between the benefits due to asset and operational improvements. The result of this is the Mauritius Building Energy Audit Tool (MBEAT). This is a Calculation software tool for calculation of Energy Ratings and Recommendations Reports and consists of:

- An interface tool based on the iSBEM (interface to Simple Building Energy Model);
- A spreadsheet tool to calculate the Energy Management Score.

### 5.3.1 Concept of apportioning potential savings between asset and operational measures

The same calculation engine (SBEM) can be used to determine the energy consumptions of a number of different datasets, as follows:

a. The asset performance of the current building. This is based on the physical, constructional and plant characteristics of the current building. The operational characteristics are based on standard databases for temperatures settings, duration of operation, equipment and metabolic heat gains and other parameters that, if input at the whim of each auditor, would give unacceptable inconsistency between assessments.

b. The “poorly managed building”. This is the same data set, except that certain of the operational characteristics are adjusted to the worst expected for a building that is not managed carefully. For instance, temperature set points during cooling might be lower than recommended by official sources, and durations of operation allowed to run longer than people would actually be expected to be present.

c. The building energy consumption as actually measured (not calculated) will also be input into the assessment.

d. Finally, the energy performance of the “improved building” including the improvement measures proposed by the auditor will be calculated. These measures can be inspired by the list in Appendix A, although others can be suggested by the auditor based on the needs of the building being audited.

In addition, a score will be derived for how well the building is actually managed, based on responses by the auditor to a standard questionnaire. This will place the actual performance (c) on a range between perfectly managed (i.e. operated as indicated by the databases used by the asset calculation) and poorly managed.

Two parallel scales are envisaged, for the calculated and actual performance. Building performance indices a, b and d sit on the calculated scale. The metered performance c and the management range sit on the actual scale. The ratio of the differences between zero, a and b on the calculated scale will be used to set up the relationships on the actual scale between zero, c and the top end of the metered range, which corresponds to the predicted actual performance of the building if poorly managed. This will also give the position of the “well managed” actual building; from this the proportions of energy consumption due to asset and operational aspects of the building can be determined.

Likewise the position on the actual scale of an “improved building” can be determined from its position relative to the other buildings on the calculated scale, and again the proportions of energy consumption due to asset and operational aspects of the improved building can be resolved. The predicted savings due to measures will thus have been recalibrated onto the actual scale.

It should be recognised that neither SBEM nor any other tool can produce reliable absolute differences of energy (hence cost or carbon) that can be validated against the actual building performance, because building use data cannot be found reliably. So, we recommend that the audit tool should be used to produce a ranking of measures in bands with savings with wide confidence limits. These would feed into the business case for improvements when the building owner is considering whether to invest.

### 5.3.2 Further potential applications of the calculation

The desk review is pointing towards the adoption of UK best practice combined with local experience with the aim of producing an energy audit tool, based on iSBEM. This would produce the functionality required for auditing using data collected locally and gives consistency of approach. This tool can also output files which could be the basis of a registry system for the Government of Mauritius that offers administrative support to the controlling body (Government or accreditation scheme). Using this registry, a stock model could be constructed that would be the basis of benchmarking and provide underpinning evidence for future regulation and market transformation.

The other advantage to adopting such a tool is that it can be adapted in the future to carry out compliance checks that all new buildings meet a minimum standard for Energy Efficient Building Regulations and produce the associated documentation. As a result this can be used as a starting point for an integrated approach to the improvement of the building stock with respect to energy efficiency of new buildings and in the future for Energy Performance certification of the existing stock. These EPCs could be in the form of A-G ratings, similar to those already used in the EU for buildings and white goods.

In order to meet the project milestones we recommend that this approach to the audit process be adopted as soon as possible. BRE will then set about producing an SBEM version that will be reconfigured for energy audit purposes in Mauritius. Although the software is owned by the UK’s Department of Communities and Local Government (DCLG), who are responsible for UK building regulations and energy performance certification of buildings, we are pleased to note that the Mauritius Government has obtained permission from DCLG for the tool to be used in Mauritius.

### 5.3.3 Information needed to set up energy audit tool

During the visits by Dr. Andy Lewry to Mauritius in September and October 2010, he established contacts with a number of potential sources of information to feed into the Energy Audit tool that BRE will develop by adapting SBEM for the purpose. In particular, there is a need to establish:

1. building types that need to be audited, and typical occupancy patterns
2. typical standards of construction (insulation, glazing area and thermal mass all have an impact on any predictions that the energy audit calculation tool may make)
3. weather data for Mauritius
4. which energy efficiency measures are feasible in Mauritius
5. typical existing energy consumption for each building type, to act as the basis for comparison.

Contacts have been made to acquire this information either directly or by contracting project partners to obtain it locally. Our preliminary discussions with stakeholders within the construction sector, including the professionals, have concluded that data on the building stock is sparse and fragmented. In spite of these the following general conclusions can be drawn:

- Insulation is virtually non-existent. We may need to advise how to modify the building fabric to reduce cooling demand in terms of shading (louvers etc.), solar glare films, low-e glass, insulation etc. Buildings do make use (domestically) of air movement through the roof and walls to provide cooling, but older commercial buildings appear to be 1960s and 70s European clones.
- Regulations from 1919 are basically about structural integrity and fire control/ prevention, not energy. Due to the cyclonic events of the 1960's construction has followed a path of being concrete based, to the extent that even the internal walls are constructed from concrete, which increases thermal mass but reduces flexibility and functionality.
- Lighting is predominantly fluorescent or tungsten, with the CEB running a campaign to replace tungsten with CFLs. The control of lighting is poor and even where controls have been installed and commissioned the poor choice of lamp type means they are not totally effective.
- Air conditioning is generally by split units rather than central plant systems. This is cost rather than performance driven with Chinese imports dominating the market. There a general lack of control systems and those which are installed are often not commissioned properly leading to removal or their being overridden by the user.
- There is a culture of running plant uncontrolled (except in hotels) whereby somebody comes in and turns the plant on and off at fixed times of day. This leads to high ramp-up profiles and late ramp-down rather than the energy efficient operation of plant.
- Air conditioning is seen as a status symbol for commercial and domestic sectors– they have already moved away from natural ventilation solutions – which is a pity. It is difficult to retrofit natural ventilation but it could be encouraged in new build.

Despite all of this local professionals have promised to help with listing constructions, services and plant, and where possible, dating them. This would allow an initial snapshot of the type of buildings within the stock.

| | Part of calculation | Information required | Reason |
|---|---|---|---|
| 1 | Asset | Information for activity database to define standardised occupation periods, temperature set points, occupation densities, ventilation rates, equipment heat gains, etc for each of a number of activities expected in the buildings | For a given activity in each part of a building, these parameters will be standardised in the calculation. This means that the audit rating will be consistent regardless of the actual operating patterns, or possibly spurious claims by the building operators (eg “my building should have a higher target because it is occupied 10 hours a day instead of 8”). BRE can supply the schedules for the UK, to be tailored for local conditions. |
| 2 | Asset | Information about typical constructions employed in the country (are there any standard details used by designers?) that can be placed in a constructions database, to be identified by an unambiguous description. | This is not mandatory (users would be able to enter data in numeric form) but would help consistency, especially where the information is supplied by people unfamiliar with U and Kappa values of different constructions. BRE can supply constructions that are used in UK, but these should be tailored for local conditions. |
| 3 | Asset | Information about the constructions that are typical for each time period and building type in the country. | BRE can show how this works for UK constructions, but it is important to apply local knowledge. |
| 4 | Asset | Typical performance and design characteristics of building services systems, depending on installation date - plant efficiency, specific fan power, duct leakage characteristics, hot water vessel sizes, etc | Although users would be able to input the parameters from designers or manufacturers data, this is often not available for older installations. This would enable defaults to be set up, to allow the calculation to operate in the absence of detailed information. |
| 5 | Asset | Information about any novel constructions, shading or ventilation methods, operating modes, building services systems, etc that are not currently available through iSBEM, so that they can be added | The current options are based on UK and European practice. Although we expect this to be similar in Mauritius, it is important that all common actual practice can be reflected in the ratings. It is probably easier to let whoever is supplying this information review the options available in iSBEM rather than supplying lists. |
| 6 | Operational | Basis of energy data availability - is it kWh, litres of oil, $m^3$ of gas, kg of biofuel, etc; is this data readily available to the auditors; do some energy users pay a service charge | The software needs to accommodate the ways that auditors will have the information made available to them. |

| | | | |
|---|---|---|---|
| | | to an intermediary (e.g. landlord's agent) and so don't see energy bills? Are the data available for the same calendar periods each year, or do they change slightly? | |
| 7 | Operational | Current practice for adapting energy benchmarks, i.e. are they adjusted for weather-related temperature changes year on year, or for occupation hours? | To adapt the software to account for these adjustments – though it could be debated whether they should be allowed as the claims (eg for extra operating hours) can be overstated. |
| 8 | Operational | Need to define the "poorly managed building" | To form one end of the range on the actual energy scale, thus enabling the proportion of energy expended on operation to be separated from that on asset aspects of the building. |
| 9 | Both | Text for recommendations reports, and logic for presenting them | Currently the recommendations generated by the software are based on generic measures applicable in the UK. The measures, the reasons for offering them and the text all need to be reviewed to suit the country. |
| 10 | Both | Preferred format for presentation of savings, especially for non-technical people | This needs to be debated. |

A "Typical" weather year is needed to drive the calculation, but this does not have to be statistically justified. For the purposes of generating the tool, we just need to avoid an atypical year (which was perceived as abnormally cold or hot or windy or sunny by the professionals in Mauritius). This can be done by Mauritius Meteorological Services who are in the best position to make this judgement.

We understand that the Mauritius Government ultimately desires two weather locations to account for variations in climate within the country. BRE has supplied specifications of the weather data parameters required as the source for the audit calculation. However, at the moment the Mauritius Meteorological Service has only been able to provide complete data for one weather station (Vacoas), and so the audit tool, as supplied, will run with that data only.

We understand that we are expected to demonstrate how, in future, the SBEM software can be customised locally for multiple weather zones by EEMO/MEPU staff. As we have previously stated in response to your enquiries last year during the contract negotiation stage, that we believe that this would be a very steep learning curve for your staff. Usually the countries we have dealt with have let a supplementary contract with us to maintain the software after the initial bugs have been ironed out, and have let additional contracts to increase the functionality. Inserting extra weather data sets would entail running the data through the tool that we use to reformat it for SBEM, checking for any anomalies, and adjusting the SBEM code in several places to deal with extra weather stations. We could train UNDP/EEMO/MEPU staff up but they would have to be experienced energy modellers with experience of writing code and programming in C++, VisBasic, Access and PHP. To fully understand the implications of any changes they make to the code, we estimate that given the right background somebody could get up to speed in a minimum of three months full time. This could be done by distance learning or by working alongside our modelling team. We would have charge extra to provide a training programme and to supply the data reformatting tool as these are not covered in the current contract.

## 5.4 Outputs needed from Mauritius Energy Audit calculation

The outputs from the tool need to inform the building owner/operator about their building's performance, how it can be improved, and should give the information to be presented to the contingent support mechanism in order to determine whether funding would be appropriate. The subsidiary information would be useful for the purpose of auditing by the accreditation organisation, and perhaps to feed into a Government-maintained database (valuable but outside this project).

The output should include:

- Identification of building or subsection of building
- Date of analysis, name of auditor
- Split of actual energy consumption for building, broken down into
    - Asset energy
    - Operational/Management energy
- Suitable improvement measures (as confirmed by the auditor)
- Quality of management score
- Estimate of energy cost savings for measures to be implemented
    - For a specific package of measures
    - Split into asset and operational energy
    - Confidence limits

**Subsidiary information**

- Metered energy consumption split into electricity & fossil fuel
- Dates for audit period
- Adjusted consumption for whole year split into electricity & fossil fuel
- Data reflection (a record of building specific data as entered by the auditor)
- Meter readings split into electricity & fossil fuel

- Unit energy costs (as supplied by auditor)
- Building type
- Confirmation of weather location
- Improvement measures chosen by auditor from list offered
- Implementation costs (MUR) as input by auditor

#### 5.4.1 Audit Assessors capabilities and training needs

The proposed pre-qualifications and capabilities required of auditors, together with training needs, are discussed in Appendix C of this report.

# 6 Accreditation and certification of audit assessors

## 6.1 The need for accreditation and certification

In terms of the end user, whether the end user is the public, business or Government, there is the perception that the supplier should provide *“what is detailed on the can”*. The role of certification and accreditation is to ensure that *“what it says on the can is actually in the can”*.

The certification process checks that the supplier has processes and procedures in place to ensure the product they are delivering is:

- Fully and adequately defined ;
- Consistent with respect to its performance ;
- Has minimum and/or defined level(s) of performance.

A certification body is there to check that the supplier is providing the product to the stated specification, whilst the accreditation body ensures that the certification body has sufficient processes and procedures in place to carry out this task. Both bodies will have to comply with International, Continental and National standards in order to carry out these functions and normally the supplier will have to provide products to meet standards if they exist. If they do not exist a scheme document will have to be constructed in conjunction with relevant stakeholders.. The result will be the product is certified whilst the certification scheme is accredited.

## 6.2 Other certified audit schemes

Our research has shown that there are very few fully certified dedicated energy audit schemes world-wide and those that do exist do not provide a “good fit” in terms of being fully comprehensive of their requirements, i.e. they have the requirements of the audit, the audit procedures, the content of the audit, who is competent to carry out the audit, the monitoring of the quality of the audits etc. fully defined.

For example, the Energy Sustainability Unit (ESU) based at the National University of Singapore (NUS) has received a Government grant to undertake 4 programmes to develop the energy services sector in Singapore. One of these is to accredit Energy Services Companies (ESCOs) for the delivery of services which include specified levels of energy audits to a specific sector, one of which is buildings. The company, not the individual, is accredited and must have undertaken a minimum of nine similar audits and have a minimum of one named “Key qualified person (KQP)” to oversee, manage and carry out the audits. The KQP must be qualified as a Singapore Certified Energy Manager (SCEM), have a relevant professional qualification, 2 years post graduate experience in a certified or accredited scheme, a relevant engineering degree and completed 3 audits in the last three years.

This scheme is impressive in that it fully defines who is competent to do the work and lays out stringent requirements for the certifiable personnel. However, the description of the audit levels is generic and does not fully describe what the output should look like in terms of content and level of detail, including analysis techniques. There also appears to be a misunderstanding by the ESU of the differences between accreditation and certification.

India within its 2001 Energy Conservation Act has the provision to introduce energy auditors and the Bureau of Energy Efficiency (BEE) has statutory powers and functions under this legislation. These include maintaining a list of accredited auditors, qualifications for these auditors, the manner and time intervals in which audits shall be conducted, and preparing an educational curriculum for academia et al. They are currently developing a pilot scheme to support the implementation of this Act and have produced audit guidelines. These again suffer from being generic and too high level.

Within the European Union the need for building specific auditors seems to have been overridden by the need to support the Energy Performance of Buildings Directive (EPBD) legislative and regulatory requirements. Within these requirements accredited Energy Assessors are required to provide Energy Performance Certificates (EPCs) for buildings on completion, let or sale. This has led to the formulation of national standards and methodologies in order to implement these requirements. These are underpinned by national schemes run by certification bodies, which in turn are accredited by their national accreditation bodies, for example in the UK this would be the UK Accreditation Services (UKAS).

In the UK, these schemes set up to support the EPBD were pre-dated by the need for competent persons to support the submissions to building control of compliance to the building regulations for energy conservation – i.e. Part L for England and Wales; and Section 6 for Scotland. As a result the audit methodology and tools for the production of asset ratings were well advanced and with the introduction of EPCs were adapted and expanded in their scope and functionality to meet the additional requirements of the EPBD. Alongside these, new schemes were developed using similar methodologies and tools to produce operational rating and Display Energy Certificates (DECs).

Certification Bodies, such as BRE Global and CIBSE had, at the time of EPBD implementation, mature certification schemes already in place for Building Regulation energy assessors. With EPBD implementation the scope of these schemes was expanded to include the remit of the EPC assessors. These schemes are currently in the process of being expanded again to cover the new Energy Management Standard: ISO 16001.

## 6.3 Accreditation standards

In terms of an energy audit scheme our study has revealed:

- That there are currently no standards in place that fully define the processes and procedures required, although there are standards that define these generically. In some cases, these are underpinned by national best practice which lay out the operational details.
- In the European Union, the Energy Performance of Buildings Directive (EPBD) legislative and regulatory requirements for accredited Energy Assessors to provide Energy Performance Certificates (EPCs) has led to the formation of national standards and methodologies in order to meet these requirements. These are underpinned by national schemes run by certification bodies, which are turn have these schemes accredited by their national accreditation bodies.

In order to accredit such a scheme the accreditation body should comply with the following standard:

- ISO 17011 - Conformity assessment General requirements for accreditation bodies accrediting conformity assessment bodies - First Edition 2004; Corrected Version 2/15/2005.

ISO 17011 specifies general requirements for accreditation bodies assessing and accrediting conformity assessment bodies (CABs). It is also appropriate as a requirements document for the peer evaluation process for mutual recognition arrangements between accreditation bodies. Accreditation bodies operating in accordance with this International Standard do not have to offer accreditation to all types of CABs.

For the purposes of this International Standard, CABs are organizations providing the following conformity assessment services: testing, inspection, management system certification, personnel certification, and product certification.

The route that has been used in the UK to roll out the successful certification schemes to provide certified energy assessors in support of building regulation compliance checking, and production of EPCs and DECs is to accreditation standard EN 45011:1998 - General requirements for bodies operating product certification systems. BRE therefore recommends that EN 45011 should be used in Mauritius.

Other alternatives are to use:

- ISO 17020 - General Criteria for the Operation of Various Types of Bodies Performing Inspection. Or
- ISO 17024 - Conformity Assessment - General Requirements for Bodies Operating Certification of Persons

As the vehicle for the scheme they are not as good a fit as EN 45011. However, it has been decided by the National Steering Group (NSG), after consultation with Mauritas, to follow the ISO17024 route as this approach is the one that best fits the Mauritian context.

The extra requirements of ISO17024 are that this standard requires an entrance examination for the auditors as well as evidence of competency. It also requires a pro-active surveillance process to monitor the auditor’s compliance. BRE will recommend a Quality Assurance process to meet this requirement and also recommends best practice which is to fully re-assess assessors every 3 years, and this could include a re-sit of the exam. The exam must be under the control of the certification body or their agents plus there **must be** a clear divide between the certification body and those organisations providing the training, i.e. you cannot train and examine the candidates.

This standard also requires the certification body to meet the following requirements:

- Have a scheme steering group in place, which consists of stakeholders from Government, Industry and the accreditation body, along with an expert from the field covered by the scheme.
- This steering group has to undertake a full review and evaluation of the scheme and its members every five years but best practice is to do this three years.
- The certification body will need an internationally recognised management standard such as ISO 9001 in place for this scheme.
- The certification body will need to appoint an appropriately qualified and trained Scheme manager.
- The certification body will need to appoint an appropriately qualified and trained Technical manager.

## 6.4 Certification and Accreditation bodies in Mauritius

Following our meetings with MAURITAS (the Government Accreditation body) and with the Mauritius Standards Bureau (MSB), in September, we recommend that:

- MAURITAS be accepted as the accreditation body for this scheme, in light of their experience of accrediting ISO 9001 and 14001 management schemes.
- MSB be the first certification body. They have experience of certifying ISO 9001 and 14001 management schemes amongst others, and keeping the process initially within one certification body gives an element of control when ironing out minor problems and setting standards. Later it can be rolled out to private certification bodies

At this point we recommend that the certification process should be as follows:

- The applicant to be an audit assessor must have minimum qualifications of an honours degree or equivalent in a relevant construction based subject plus membership of a professional body such as the Council of Registered Professional Engineers (CRPE) or the Mauritius Architects Association. During this application process the applicant should provide evidence of this and their experience in relevant skill sets – e.g. surveying, building services, energy modelling etc. (see Appendix C for details).
- The applicant would undergo a training program which covers the following competencies:
    - Using the Mauritius Building Energy Audit Tool (MBEAT) based on Simplified Building Energy Model (SBEM).
    - Commercial building construction, zoning and surveying.
    - Building Services.
- After a period of practice with the tool (we recommend at least a week's worth), the applicant then sits an exam. This exam should be set by a technical manager(s) who should be based in the certification body. The proposed technical manager would need to have the same qualifications and training as the applicants, and will need further training in the production, marking and quality assurance (QA) of the exam. We envisaged training the proposed technical managers directly after the first training programme and showing them how to produce the first exam. BRE will also support them by responding to queries on the marking of the first examination. BRE could produce, invigilate, mark and Q/A to exam but this would have to be costed separately.
- On passing the exam the applicant would be registered with the certification body. We recommend that a national registry of auditors should also be kept by the EEMO.
- The certification body would then QA the scheme by regular auditing (e.g. by checking a sample of energy audits), with a disciplinary procedure to deal with poor performance.
- All energy audits would be passed through the certification body and then lodged on a national register held by the EEMO.

Since our initial meeting with Mauritas we have been in constant dialogue, which led to BRE proposing that the preferred route for certification of the Energy Audit Management Scheme (Mauritius) by an accredited certification body was EN45011. This is because this was the vehicle for the successful UK schemes. Mauritas are working towards complying with ISO 17011 in order to accredit certification bodies to this standard as they do not have the other accreditation standards in place to make certification of this scheme possible.

It was envisaged that ISO 17011 will be used as a vehicle for product certification under EN 45011 (or ISO Guide 65 equivalent). BRE would produce the scheme documentation for certification under EN 45011 and help the Mauritas as the Accreditation Body with a roadmap for the scheme to achieve product certification EN 45011 under ISO 17011.

Recent correspondence from Mauritas indicates that they do not have the ISO/IEC 17011 in place yet, but have started work and expect to complete the preparation work for it by October 2011. They will then be ready for pre-peer-evaluation and peer evaluation by the International Laboratory Accreditation Cooperation (ILAC) and International Accreditation Forum (IAF) in mid 2012. This project is being implemented with the financial assistance of Agence Française de Developpement (AFD) and technical assistance of their French counterpart (COFRAC/AFNOR).

In addition they have not embarked on Product Certification for the simple reason that the only Certification Body in Mauritius offering the programme has not shown any interest yet in applying for this particular accreditation. In the light of the scheme proposals made by BRE they originally agreed that suggested approach by BRE should be carried forward, i.e. EN 45011 product certification under ISO 17011 operations. However, they also informed us that resources may be an issue and they will need further internal discussions before taking the final decision on any implementation.

The issues arising from this are:

- The EAMs project ends May 2011 and Mauritas will not be ready until Oct. 2011 to mid 2012;
- Even when Mauritas have obtained ISO 17011 they may not offer EN 45011 which is essential for the accrediting the certification body to run the scheme.

Further discussions and decisions of the NSG have shifted the focus to the use of ISO 17024 - Conformity Assessment, as the accreditation vehicle. However, the issues above still remain and there is a need for an interim solution.

Options to deal with these issues are:

- Run an uncertified scheme through the Mauritius Standards Bureau until Mauritas is ready. The scheme documentation will be ready by the middle of March and we estimate it will take a month for MSB to get certification systems/procedures in place. MSB would also need to form a scheme steering group, which would consist of stakeholders from Government, Industry and the accreditation body, along with an expert from the field covered by the scheme. Also MSB will need in place an internationally recognised management standard, such as ISO 9001, and to appoint appropiatetely qualified and trained Scheme and Technical managers. When Mauritas is in compliance with ISO 17024 they would then accredit the scheme and retrospectively allow MSB to certify the auditors. Any handholding and training of MSB staff during this process is not covered by our project specification and would have to be costed separately.
- BRE Global could help set-up MSB as a certification body to run the scheme until Mauritas is ready. Once MSB have the certification systems/procedures in place, we estimate that BRE Global would take a further month to certify the scheme. MSB will the run the scheme; set, run and mark the examinations; with the documentation of each candidate passed onto BRE global for final

certification. Again, once Mauritas are in a position to accredit MSB the documentation etc. of each auditor could be passed back to MSB for certification under the auspices of Mauritas. This is not covered by our project specification and would have to be costed separately.

## 6.5 BRE's obligations under the existing contract

We think it would be best at this time to reiterate what BRE is expected to provide under the existing EAMs contract:

- A scheme framework will be developed to provide the procedural and management criteria for scheme operation; this will include development of the following procedures and documentation (please see Appendix D for details of the output):
    - Scheme Document;
    - Code of Conduct;
    - Complaints Procedure;
    - Appeals Procedure;
    - Membership Agreement;
    - Application form.

- Technical input for the scheme (including the production of the examination template materials – both papers and computer files), marking and process/quality control documentation and processes. We envisage that the proposed Mauritian certification body technical managers would need to have the same qualifications and training as the applicants. They would also need further training in the production, marking and quality assurance (QA) of the exam; this training would take place directly after the auditor training.

- Provision of the materials, roadmap and technical advice necessary for the accreditation of a future certification body in Mauritius by a recognised accreditation body. This would be achieved by provision of the following services:
    - Advice on the structure of the accreditation standard and the types of documentation likely to be required.
    - Advice on the governance structure required for a certification body.
    - Advice on key issues such as competency, certification decisions, conflicts of interest and impartiality.
    - Advice on internal audit, corrective actions and management structure.
    - Review of top level documents the body prepares following the above advice and feedback on improvements – this will require top level documentation from the proposed certification body.
    - The roadmap would be a clause by clause guide to what they should do and prepare in order to comply with 17024. This will pick up and advise on some particular areas which are easily overlooked or where there are quite significant impacts on the service they provide. A couple of examples are:
        - governance and how to set up a governing body; and
        - requirements for dealing with candidates who may be handicapped or have other similar difficulties.

### 6.5.1 Additional tasks

To help set-up the certification body is an additional task to those agreed to in our bids – both original and revised. We have already discussed this issue with the steering group representatives through two teleconferences. As a result we provided the following quote for these additional services:

1. To help set up the certification body we would estimate that the cost would be: £17K including travel and subsistence for up to two trips to Mauritius. This would include:

- Some on-site training
- More in-depth advice on required documents
- Checking operational documents and procedures

This quote is on the basis that BRE will guide and advise MSB but MSB will be responsible for the actual preparation and writing of procedures and quality documents.

An important point that may have been missed by previous emails and telephone calls is that in giving the above help and advice, the MSB should be in a good position to deliver other certification schemes should they wish to do so in the future. Other than specific scheme documents for individual schemes much of the other documentation for the certification body is generic. The quote above will concentrate on the energy schemes; if at a later date MSB want help extending their scope we could help for an additional contract.

2. To run the scheme until Mauritas is ready

The aim would be for BRE to initially conduct all the work with MSB staff observing and gradually hand over more and more of the work to MSB so that eventually BRE would only make the certification decision and issue the certificates whilst MSB do all the rest of the certification work. This will help MSB to become accredited in the own right.

Assuming BRE had conducted 1above. The cost would include:

- On-site hand holding for the initial QA audits in conjunction with 1 above

- Certify energy audit assessors at £600 each. This is based on the candidates having passed the appropriate qualifications and having the appropriate experience and that the evidence is presented in consistent application packs for evaluation.

- BRE would help MSB staff to define the contents of the evidence packs required to be submitted by the candidates. BRE would assess each application in conjunction with MSB staff and make the appropriate recommendations and issue the certificates.

- Quality assurance of the initial batch of energy audit assessors £5000.

- Thereafter assuming MSB staff are fully trained and conducting the QA audits BRE would charge a fee based on the fee charged to assessors by MSB. This was originally quoted as 10% but as there is no indication of the fees MSB intend charging this would need to be negotiated to monitor and manage the certification QA audit process.

- BRE would conduct an on-site audit every 6 months to ensure everything is working well - £3000 per audit plus travel and subsistence. This could be extended to annually if everything was going well after the first two audits.

As explained in a previous email BRE is an accredited certification body for similar schemes however if MSB want BRE to specifically get the MSB scheme accredited by UKAS there would be at least a further fee of £10000

3. To prepare and mark the exam

The price is £600 per exam to prepare the papers and £125 per candidate to mark. This assumes that MSB print the papers, invigilation the day and send the papers to BRE. It also assumes a minimum of 10 candidates per exam.

## 6.6 Other certified audit schemes

The national steering committee has decided that Mauritius Institute of Training & Development (MITD) will be the future Training and Examining Body. Under the prescriptive clauses of ISO17024, the certification body (which acts as the examination body) must be split from the role of the training providers. Therefore the exam must be under the control of the certification body or their agents and there **must be** a clear divide between the certification body and those organisations providing the training, i.e. you cannot train and examine the candidates.

## 6.7 Recommendation for the accreditation and certification of the EAMs

- MAURITAS be accepted as the accreditation body for this scheme, subject to the issues raised above being resolved.
- ISO 17024 would be the Accreditation Standard, which would then be used as a vehicle for the scheme to achieve personal certification of auditors.
- BRE would support the accreditation of a future certification body in Mauritius by provision of a roadmap for the scheme to achieve accreditation for personal certification under ISO 17024.
- MSB would be the first certification body because keeping the process initially within one certification body gives an element of control when ironing out minor problems and setting standards.
- BRE would support MSB by the production of the EAMs scheme and examination documentation for certification under ISO 17024.
- EAMS would be run an uncertified scheme through the Mauritius Standards Bureau until Mauritas is ready. When Mauritas has the Accreditation standards in place (ISO 17024) they would then certify the scheme and retrospectively allow MSB to certify the auditors.

# 7 Proposals for Contingent Support Mechanism in Mauritius

This section looks at the definition of the Contingent Support Mechanism, how it might operate, potential sources of funding and the scope for recycling funds to enable continuing support, and a needs analysis containing estimates of the costs of the scheme. A review of other possible funding can be found in appendix E,

## 7.1 Brief for Contingent Support Mechanism

The project includes the requirement for a Contingent Support Mechanism. It is assumed that

a. This means a financial support mechanism, dependent on criteria set by the Government that will determine whether an audit will be (part) funded

b. The prospect of financial support in the form of a conditional grant will encourage building owners/operators to undertake energy audits

c. However the CSM funds will not be used directly to motivate building owners/operators to make improvements

    i. It will be for the building owners/operators to make the business case for improvements

    ii. Funds will need to be sought from financial institutions by the building owners/operators for the implementation of recommended measures

    iii. Up-front funding will need to be arranged, either from internal sources or from financial institutions, to conduct the audits. Only when certain conditions have been fulfilled will the CSM reimburse the building owners/operators for parts of the audits cost.

d. Government funds will be limited. They have told us that they will assist audits for 30 small buildings and 20 large buildings.

e. The audit tool MBEAT will provide technical information about the energy cost savings potential for measures, but it will be for the audit assessor to determine the business case for measures using installation cost information gathered specifically for the project.

BRE will help to develop a Contingent Support Mechanism that includes the following elements:

- A definition of “small” and “large” buildings in the context of selecting designated consumers
- A method for selecting 50 designated consumers whose buildings need to be audited, based on specific energy consumption (ie energy consumption per unit area)

- A means of deciding what level of retrospective support (according to the Government, dependent on project size) should be given to the audit so that the cost of energy audits will be shared with the building owner/manager.
- Possible sources of loans and other financial schemes to provide the up-front funding for the audits, and terms and conditions for the repayment of loans, including those where the conditions for contingent support have not been fulfilled.

The Contingent Support mechanism developed will:

- Provide guidelines on the management of the audit funding by Government Institutions such as EEMO and MEPU
- Direct those seeking funding for implementation of recommended measures to a financial institution.

## 7.2 Options to consider for Contingent Support Mechanism (CSM) methodology

In determining the format and cost of the CSM, the following needs to be considered. Our understanding is that the Mauritius Government has selected the options in bold; BRE will include these decisions (pending further discussion) in the full implementation of the scheme.

1. If the eventual intention is that the entire non-domestic stock should be audited, how long should this take and what level of funding can be given to it
2. The level of human resource (i.e. audit assessors) that could be envisaged to be available – we understand that there will be 50 initially
3. In order that the audit process should progress at a speed to match available resource, there needs to be a method for deciding which designated consumers should undertake energy audits. The possible alternatives are:

    a. When a permit is granted for refurbished buildings (but this does not capture buildings that are not undergoing major refurbishment)

    b. Regular cycle (e.g. yearly, biennially or longer periods), perhaps depending also on size of building or electricity bill

    c. Preliminary check by some central body, e.g. the CEB on all electricity bills

    d. Any other cyclical event that happens to all buildings that, if it was not allowed to proceed until an energy audit has been completed would be enough of a driver.

    Our recommendation is that the selection of designated consumers should be undertaken by the CEB on the basis of electricity consumption per square metre. In order to let the number of audits match the resource available, we recommend that only those consumers above an agreed threshold should be designated as requiring an audit in a given year. This threshold can then be reduced progressively year on year, gradually capturing more buildings at a rate that matches available resources. The details of this process will be resolved during the implementation of the CSM.

**We understand that the Mauritian Government has decided to undertake the selection on the basis of information supplied by CEB (electricity consumption) and the potential designated consumers (building area and type). BRE will propose the CSM to work with this selection mechanism.**

4. A decision on whether the legislation should demand that every time a consumer is designated, an audit must take place; then a choice of whether or not the measures should be implemented. It should be noted that if there is no financial incentive to carry out the measures (other than the provisional business case developed by the auditor), so it would be difficult to obligate the consumer to implement the measures. Nevertheless, it can be expected that a percentage of consumers will take up the recommended measures in the audit.
5. We understand that the Mauritius Government intends that the project will support up to 80% of the audit cost for smaller projects and up to 30% for larger projects. BRE will suggest thresholds for “small” and “large” projects to help the decision of funding level.
6. If there is to be an obligation on “designated consumers” to undertake an audit, the scenario where the designated consumer is unable to fund the remainder of the audit cost needs to be resolved in discussion with the Mauritius Government.
7. We understand that the Mauritius Government intends that the project support funding is to be regarded as a conditional grant, contingent on whether staged obligations have been met:
    a. That the audit has been completed
    b. That the main audit recommendations have been realised.

    Thus the designated consumer will need to obtain a loan or internal funding in order to undertake the audit, in advance of the support funding, and will be motivated to complete the audit and implement the recommendations in order to be reimbursed by the contingent support. The recipient of funding will be expected to bear the risk that no savings are realised (e.g. because the recommended measures have not been implemented correctly, because the savings have been taken in terms of improved comfort, or simply because the business size has increased). BRE will formulate a reasonable and fair payment mechanism for the grant, at the stages of completion of the audit and implementation of the measures.
8. Which energy improvement measures would be appropriate to these buildings, e.g. those in appendix A.
9. The cost of implementing these measures, how long they would take to implement them and how long a payback could be anticipated/allowed, e.g. based on experience from Mauritian consultants.
10. The source and size of the funding pot for implementing measures that is available through financial institutions and banks. However, we understand that this funding is no longer part of the CSM. Unless the Government can arrange for special rates to be available by negotiation with the financial institutions, this funding stream will probably operate as a conventional loan. BRE, through its Mauritian partners, will assist by exploring which financial packages are available, identify suitable funding institutions, and capture the appropriate terms and conditions for the loans.
11. Assuming that the funding pot will be limited in size, there needs to be prioritisation of the allocation of funds to the buildings which most need attention, e.g. those which are

a. **the most intensive energy users per unit area**

b. furthest above building typical, compared with benchmarks for their building type.

The latter option would be preferable, but more difficult to identify if the selection of designated consumers is to be undertaken by the CEB. The selection criteria are currently under discussion with the Government and the CEB.

## 7.3 Needs analysis

This needs analysis explores what resources need to be allocated to the CSM by Government. The Government resource needs will be determined by:

a. How many audits are undertaken; in turn this depends on
   i. Whether the Government wishes the scheme to be ongoing or for a limited period
   ii. If the criterion for “designated consumer” is set at a constant level, or whether it is tightened over time
   iii. How many assessors are available to perform the audits and their spare capacity to carry them out
   iv. The level of compliance with regulations that require the audits
b. Where the funds to undertake the audits will come from

In the future it may be possible to audit a larger proportion of the building stock, and the costs of this would then need to be re-evaluated. However, at this stage we understand that the National Steering Committee wants to limit the audits to 50 projects. We have therefore confined the cost calculation to a single scenario.

Assumptions:

Number of projects: 30 small, 20 large

Cost of audit assessor: 2000MUR/hr = 150000MUR/day

Time for audits: Content – Survey building, collect metered and other data from client; Process data, enter into audit tool; Gather costs for implementing measures; Prepare report for client; Discuss with client.

Small projects: 5 days Large projects: 10 days

For 50 projects, using proportions required by Government to be reimbursed:

Total cost to Government when audits complete: 750000MUR

Total cost to Government when measures realised: 1950000MUR

Total potential grant cost to Government if all audits completed and all audit measures are realised: 2.7millionMUR

Total remaining audit costs to be repaid by designated consumers to financial institutions: 2.55millionMUR

# 8 Amendments to legislative framework in Mauritius

## 8.1 Legal background issues

There are several tiers of legislation/regulation, such as:

a. Primary legislation, which would be high level, e.g. “comply with the regulations set from time to time by the Minister”. This would refer to regulations for what actually has to be done. Only the primary legislation has to be put before parliament/legislative body – they would not expect to have to approve technical or administrative details.

b. Regulations, which would be set by the Minister advised by his Ministry, who in turn might look to the reports which form the outcome of this project. Regulations’ purpose is to

   i. Lay down the overall format of the scheme, principles of how it operates

   ii. State whether there is funding associated with the scheme and how it would be allocated

   iii. Be amended without going back to the parliament

c. Approved documents, which give the technical detail of achieving compliance with the regulations. It is at this level that issues like the standards to be met would be reported.

2. At the moment we envisage the scheme will comprise

   a. A set of criteria to select “designated consumers” whose buildings need to be audited, administered by a body such as the CEB as an addition to their billing process

   b. Once the designated consumer has been identified and contacted by the EEMO, contracts need to be set up between CSM and the designated consumer to

      i. To carry out of the audit

      ii. Implement operational improvements

      iii. Implement asset improvements where the business case satisfies the building owner/operator

   c. The offer of a grant to support a proportion of the audit costs on completion of the following stages:

      i. When the audit is complete

      ii. When the main audit recommendations are realised

   d. Audit assessor visits building, collects data on building, plant and current quality of energy management

e. Audit assessor processes data using energy audit tool, MBEAT

f. Audit assessor generates recommendations for improvement, including approximate energy cost savings

g. Audit assessor undertakes cost effectiveness calculation for improvements, based on local knowledge of implementation costs, then ranks measures in terms of energy management effectiveness/cost effectiveness

h. Auditor uses this information and independently gathered information on implementation costs to generate preliminary business case for building owner/operator to invest in improvement measures

## 8.2 Recommendations on legislation/regulation

Pending further decisions by the Government on the directions to go, which we anticipate would in part be based on the earlier content of this report; we suggest that it is not appropriate at this stage to prepare draft legislation and regulations.

We await feedback on the options offered in this report.

## Appendix A – Measures to improve energy efficiency in existing buildings

This is a comprehensive list of possible measures that has been resorted and reduced since the previous list, and will be prioritised further when the building energy audit model and its' supporting software have been fully developed.

| Group | **Operational measures** | **Asset measures** |
|---|---|---|
| Manage-ment | Has an occupant survey been carried out recently? | |
| | Any problems reported by users for poor performance of HVAC system on very hot days | |
| | Has a walk-around energy audit been carried out in accordance with the approved method? | |
| | Is energy managed effectively : for example is there good evidence that responsibility for energy is allocated to specific person(s), building users are encouraged to save energy, and monitoring and targeting is in place? | |
| | Is there a previous Energy Audit Report? | |
| | Are sufficient meters in place to enable the energy use to be subdivided by end use? | |
| | Do the building occupiers understand the various modes of ventilation and cooling operation? | |
| Building fabric | Is the condition of the building fabric regularly inspected from the point of view of energy efficiency? | Consider introducing or improving insulation and high reflectivity coatings of flat and pitched roofs, especially at the same time as measures to improve water tightness |
| | Are any obstructions or partitions preventing free cross flow of air? | Consider ventilated roof structures to remove heat gain before it reaches the occupied space |

| | | |
|---|---|---|
| Glazing | Are the means to control solar gain easily operable by the users? | Consider applying reflective coating to windows and/or fit shading devices to reduce unwanted solar gain. |
| | Are windows and skylights cleaned regularly and kept free of obstruction to maximise use of natural lighting? | Some glazing is poorly insulated. Replace/improve glazing and/or frames. |
| Air tightness | | Carry out a pressure test, identify and treat identified air leakage to reduce heat gain. |
| | | Consider how building fabric air tightness could be improved, for example sealing, draught stripping and closing off unused ventilation openings, ducts etc. |
| | | Consider constructing draught lobbies to reduce unwanted air infiltration. |
| | | In commercial premises, consider adjusting existing or installing new automatic external door closers or adopting revolving door solutions instead of air curtains. |
| | | Consider fitting existing air curtains with energy saving controls such as door interlocks and occupancy time switches. |
| | | For goods bay doors, consider installing automatic closers to loading bay goods doors or shutters, high speed shutter doors, flexible plastic curtains and/or using expandable entrance collars to connect the back of delivery vehicles to limit heat gain from loading areas |
| Air condition-ing | Does lack of cleanliness of air inlets and outlets indicate potentially poor system performance? | Have the air inlets been sited properly, away from smoking areas and other air pollution sources? |
| | Are the filters checked regularly? | Do the mechanical ventilation systems have variable volume controls? |
| | Is there a servicing and maintenance plan in place that addresses ventilation and air conditioning plant energy efficiency? | Consider installing interlocks between cooling systems and loading bay or vehicle access doors. |
| | Are exhaust systems properly controlled according to requirement, e.g. presence | Ductwork leakage is high. Inspect and seal |

| | | |
|---|---|---|
| | detection or when lights are turned on | ductwork. |
| | Has an air conditioning energy performance inspection been carried out in the past 5 years? | If any new ductwork is installed, ensure that it is designed for a low pressure drop (aim for specific fan power 1w/l/s) |
| Central plant | Do pumps have adequate control mechanisms? | Consider a small scale Tri-Generation (heat, cooling, electricity) system as an alternative to conventional separate boiler and chiller systems |
| | Are maintenance records available for motors? | The default heat generator efficiency is chosen. It is recommended that all heat generator systems be investigated to gain an understanding of its efficiency and possible improvements. |
| | Are equipment datasheets available, together with the commissioning report and building plans? | Consider introducing variable speed drives (VSD) for fans, pumps and compressors. |
| | Is there a real need for process steam? | |
| | Has a boiler plant energy performance inspection been carried out in the past 12 months? | |
| | Are the air conditioning systems' heat rejection equipment (condensers) clean and positioned in un-obstructed surroundings away from other heat sources? | |
| Chillers | Are the chiller evaporating and condensing temperature as per manufacturer's recommendations? | Chiller efficiency is low or the default chiller efficiency has been chosen. Investigate the chiller system to gain an understanding of its efficiency and possible improvements. |
| | Are the chiller systems in good condition i.e. free from any leaking, fouling, corrosion, blockages and is it suitably insulated? | |
| Central controls | Have system controls been set up according to the building occupancy schedule? | Consider installing optimum start/stop controls on heating and cooling systems. |
| | Have the HVAC time and temperature settings been checked by suitably qualified persons in the past 12 months? | Consider installing weather compensator controls on heating and cooling systems. |

| | | |
|---|---|---|
| | Are any mixed mode changeover controls appropriately set and are adjustments delegated to a suitably qualified person? | Consider installing timer controls to other energy consuming plant and equipment and include optimum start/stop or adjust to suit current building occupancy |
| | If there is a Building Energy Management System, is it operated by suitably qualified staff? | |
| Local controls | Is the building humidity tightly controlled (ie not allowed to float between 40 & 70% RH)? | Consider fitting zone controls to reduce over and under heating where structure, orientation, occupation or emitters have different characteristics. |
| | Check controls to avoid simultaneous operation of heating and cooling systems. | Add local time and temperature control to any local heating systems |
| | Are HVAC controls vulnerable to tampering? | |
| HWS | Is the temperature for hot water appropriate? | Improve insulation on HWS storage. |
| | Is there the schedule for DHW changed for unoccupied periods? | Add time control to HWS secondary circulation |
| | Are electrically heated HWS cylinders or electric point of use heaters fitted with time controls? | Consider installing building mounted solar water heating. |
| | Are the HWS systems in good condition e.g. free from any leaking, fouling, corrosion and suitably insulated? | If HWS is used only for occasional hand washing, consider replacing centralised HWS with point of use system. |
| | Are water saving measures fitted to hot taps/showers etc (e.g. flow restrictors, diffusers)? | Consider replacing HWS boiler plant with high efficiency type. |
| | Have the HWS systems been assessed as effectively and efficiently matching current demands? | Consider switching water heating boiler to biomass. |
| | | Consider installing a ground source heat pump. |
| Lighting | Has the building lighting strategy been reviewed by experts to ensure that it matches current needs while using minimum energy? | Replace tungsten GLS lamps with CFLs |

| | | |
|---|---|---|
| | Is lighting maintenance, cleaning and lamp replacement planned and carried out regularly? | Replace tungsten spotlights and tungsten halogen reflector lamps with LED equivalents |
| | Replace 38mm diameter (T12) fluorescent tubes on failure with 26mm (T8) tubes. | Consider bulk replacement of 38mm diameter (T12) fluorescent tubes with 26mm (T8) tubes. Consider replacing T8 lamps with retrofit T5 conversion kit. |
| | Are the reflectivity of ceilings and other room surfaces appropriate to help reduce lighting power? | Introduce HF (high frequency) ballasts for fluorescent tubes and reduce number of fittings to match lighting requirements |
| | | Whenever fluorescent lighting is due to be replaced to suit new ceiling or partition layouts, install T5 fittings, reducing number of fittings to match lighting requirements |
| | | Replace high-pressure mercury discharge lamps with plug-in SON replacements or with complete new lamp/gear SON (DL). |
| | | Ensure that lighting manual switching allows areas with different occupancy or activity patterns to be switched independently |
| | | Arrange manual switching of lamps in rows parallel with windows so that the row nearest the window can be switched off independently if there is sufficient daylight |
| | | Consider occupancy sensing for intermittently occupied areas where individuals are not responsible for control of lighting, eg toilets, meeting rooms, etc |
| | | Consider daylight sensing with dimming control in rooms where daylight levels vary considerably. Arrange control of lamps in rows parallel with windows so that the row nearest the window can be dimmed independently by the controls without compromising lighting standards for parts of the room distant from the windows |
| Electrical plant | Are transformers switched off for extended no-load conditions? | Consider installing wind turbine(s), either building mounted or within the curtilage of the site |

| | | |
|---|---|---|
| | Are ambient conditions transformers operated in according with manufacturer's recommendations? | Consider installing building mounted photovoltaic electricity generating panels. |
| | | Consider installing a hydro-electric generator if any streams or rivers are close by. |
| Ancillary Equip-ment | Does the ancillary equipment typically operate during peak load time? Can its operation be delayed without compromising business needs? | |
| | Are occupiers encouraged to economise on the use of energy consuming equipment such as business and industrial machinery? | |
| | Are power saving options on IT equipment enabled and effectively utilised? | |
| | Are there any items of equipment used within the building that would benefit from automated controls? | |
| | Is a policy in place that ensures energy efficient equipment is procured, for example 'Energy Star' rated items? | |
| | Is equipment left on standby overnight and at weekends – can it be switched off manually or by time switches during these periods? | |
| Vertical trans-portation | Are stairs open and an attractive alternative to lifts and escalators? | |
| | Have lift and escalator systems been reviewed by experts for match with current occupiers' needs? | Are lift and escalator systems fitted with energy meters? |
| Swim-ming pools | Is the pool complex fitted with energy meters? | Are heat recovery devices installed to pool water and pool hall temperature control systems? |
| | Is the pool hall and ancillary wet rooms sealed with air-locked doors or similar? | Consider solar water heating for pool water and showers |
| | Is the swimming pool fitted with covers? | Is the pool hall ventilation system controlled on humidity rather than constant |

| | | |
|---|---|---|
| | | volume? |
| | Where pool covers exist are they used correctly and on a regular basis? | |
| Catering | Are the kitchen facilities fitted with energy meters? | |
| | Is a kitchen energy efficiency plan in place? | |
| | Are catering staff trained in measures to reduce energy waste? | |
| | Does utilisation of large pieces of equipment vary throughout the day i.e. ovens or dishwashers operated at less than maximum capacity? | |
| | Are refrigerators located away from heat producing equipment such as ovens and dishwashers for thermal isolation? | |

# Appendix B – Further discussion on structure of software tool

## How does the SBEM energy calculation work?

Please note that this description is based on the procedure for the UK version, which is used for Building Regulation compliance checking and the production of Energy Performance Certificates. Hence some of the references may not be relevant to the adaptations for Mauritius, which are dealt with at the end of this appendix. Nevertheless, the underlying methodology for calculating energy will be the same.

SBEM takes inputs from the user and from various databases, and calculates the annual $CO_2$ emissions resulting from the energy used by the building and its occupants. Some inputs are standardised to allow consistent comparisons in new and existing buildings.

### Inputs and information sources

The inputs to the calculation include:

- physical configuration of the building ('geometry')
- internal conditions in each zone
- external conditions
- factors affecting fabric and ventilation heat losses, including insulation levels, airtightness, natural ventilation and building geometry
- heat gains determined by the occupancy pattern and equipment (including lighting and IT)
- solar heat gains (which depend on glazing areas), thermal mass and orientation
- information about the heating, cooling, lighting and other services systems.

The software should draw information from the sources shown in Table 1.

**Table 1: Information sources for Building Regulations or Energy Performance Certificate purposes**

| Information | Source |
|---|---|
| Geometry, areas, orientation etc of the building components and zones | Location plans, architectural drawings, measurement on site |
| Zoning of spaces (see 'Zoning rules') | Suitable zones identified by examining the building or drawings |
| Conditions and occupancy profiles for spaces with different activities | A database inside the software selected by building type and zonal activity |
| External conditions | Weather database selected by location |
| U-value and thermal mass of building elements | Internal databases, 'inference' procedures, or directly input parameters |
| HVAC system efficiencies | Internal databases, defaults or directly input efficiency parameters |
| Energy for lighting; impact of controls | Internal databases, defaults or directly input parameters |

**Standardised parameters**

As noted in Table 1, some of the information comes from internal databases. This:

- minimises variations between assessments

- satisfies the EPBD Article 2 requirement to compare buildings on a standardised basis
- reduces the input requirements for the building description, so saving time.

These databases are explored in more detail below.

**Activity database**

The user selects the activity in each part of the building, and the software derives from the database the conditions to be maintained in each zone and their duration. Identifying spaces in which different activities take place allows a more consistent rating of buildings of similar type (eg offices or schools) but different mixtures of activities. For instance, 'office' may mean a building with cellular offices, meeting rooms and circulation spaces occupied during the working day, or a 24-hour call centre. Setting up multiple activity spaces allows such buildings to be defined more precisely.

Parameters assigned to the spaces when the activity is defined include set point temperatures for heating and cooling, occupation density and duration, fresh air supply requirement, and heat gain from equipment. Information on hot water requirements and lighting standards is also taken from this database.

The parameters vary between building types (for instance offices in schools are different to those in office buildings). For buildings where the nature of the activities has not yet been determined, or may change after occupation, some generic activities are available. From 2010, it is the intention to revise the building typology and activities to relate them to planning use classes in England and Wales.

By importing these parameters from a standardised database, buildings with the same mix of activities differ only in geometry, construction, building services and weather location. This enables buildings to be compared on the basis of their intrinsic potential performance regardless of how they may be used in practice.

Data in the schedules are drawn from sources such as CIBSE Guide A: *Environmental design*, supplemented and modified where necessary. They have been chosen to enable standardised comparisons between buildings, so they represent typical rather than actual performance; hence the energy and $CO_2$ emission calculations are not predictions for the building in use.

**Constructions database**

The energy calculations use thermal properties of components, which should ideally be taken from the 'constructions database' (Figure 2), set up by BRE using CEN standards, for example, EN ISO 13786 and EN ISO 13789 to derive U-values and thermal capacities, respectively.

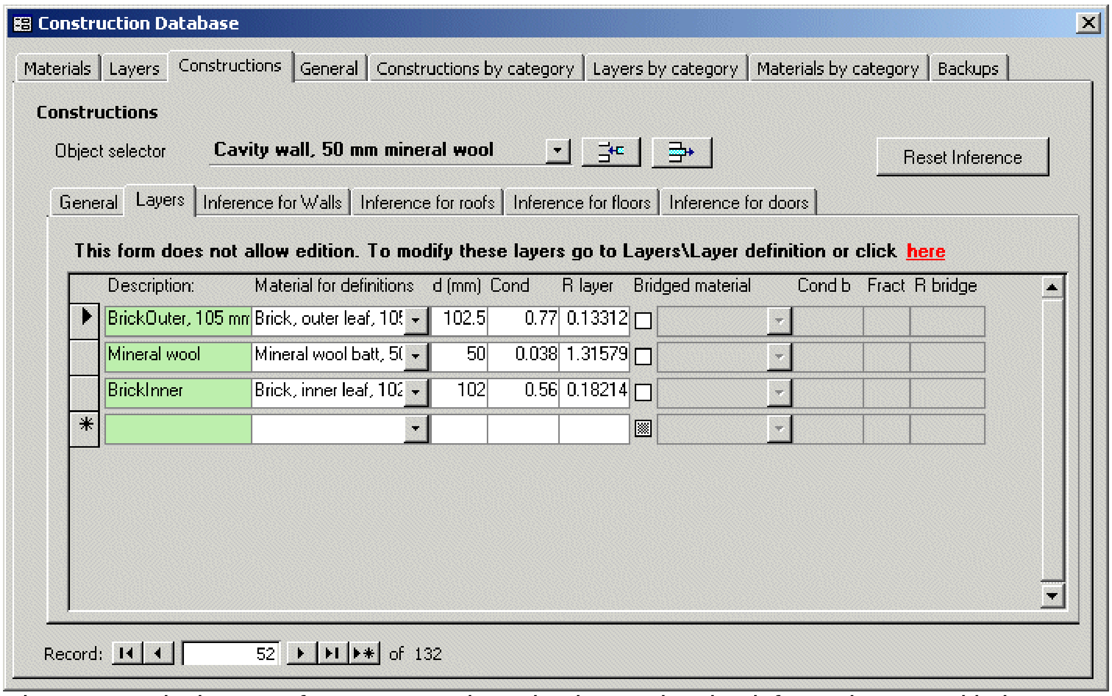


*Figure 1: Typical screen from constructions database, showing information stored in layers*

The databases have been compiled from basic parameters such as specific heat, conductivity, density, absorptivity, vapour permeability and thickness for opaque elements; and conductivity, transmittance and reflectance for solar, visible and infra-red radiation for glazing.

Thermal bridging in composite construction is incorporated in the calculated values for the whole construction (e.g. window frames in glazing systems).

When repeatability is required the construction types listed in the database should be used. The input parameters for SBEM have been compiled using the CEN standard procedures and the databases can be checked at www.ncm.bre.co.uk. Users can apply constructions not in the databases (eg for a novel construction during a Building Regulations compliance check), but must explain how they derive the parameters.

### HVAC systems efficiency database

SBEM needs information on the services systems in each zone or group of zones to determine the relationship between energy demands for heating, cooling, ventilation and lighting in each zone, and the delivered energy required to meet them.

SBEM follows EN 15243 in using three system performance parameters instead of the more familiar two (seasonal heating and cooling system efficiency). Auxiliary energy used by pumps, fans etc is accounted for separately. This avoids the need to decide how to attribute auxiliary energy across different services (heating, cooling, ventilation) provided by the same system. The three parameters are:

- **System Seasonal Energy Efficiency Ratio (SSEER)**. The combined cooling demand of all the zones served by a particular system is divided by SSEER to give the energy consumption of the cold generator (for example, a chiller or chillers) and ancillary equipment including heat rejection plant. SSEER takes account of factors including the seasonal efficiency of the cold generator, thermal losses and gains to and from pipework and ductwork, and duct leakage. It does not include energy used by fans and pumps

- **System Seasonal Efficiency (SSEFF)**. The combined heating demand of all zones served by a system is divided by SSEFF to give the energy consumption of the heat generator (usually a boiler or heat pump) and ancillary equipment. SSEFF takes account of factors including the effective heat generator seasonal efficiency, thermal losses and gains to and from pipework and ductwork, and duct leakage. It does not include energy used by fans and pumps

- **Auxiliary Energy Value (AEV)** is applied to the total floor area conditioned by a system. It covers the energy used by fans, pumps and controls and depends on system configuration and whether it operates when only some of the spaces are occupied.

SBEM calculates heating and cooling demands monthly but applies the same HVAC parameter values for each month.

The values of SSEER, SSEFF, and AEV for 25-plus HVAC systems in the database have been calculated and validated against real systems from UK and European projects in which BRE has collaborated. Some values are adjusted depending on plant rating or age. SSEER and SSEFF are derived from values for the cooling generator seasonal energy efficiency ratio and effective heat generator seasonal efficiency (defined in the SBEM User Guide) respectively. As with the construction details, the database values for the cooling and heat generator efficiencies (and other parameters such as specific fan power, which has an impact on auxiliary energy) can be overridden if alternative validated information is available.

### Weather database

To calculate the reaction of the building and systems to the loads from the external environment, SBEM needs average monthly data for the building location:

- global solar irradiation on horizontal surfaces and vertical and inclined surfaces for different orientations
- external temperature.

Weather data is readily available in the CIBSE Test Reference Years, but these use an hourly format more suited to hourly simulation tools. For consistency the data have been converted to monthly values for the SBEM database.

Data are available for Belfast, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds, London, Manchester, Newcastle, Norwich, Nottingham, Plymouth, Southampton and Swindon. A restricted range is offered if the building being assessed is in Scotland or Northern Ireland. Other locations have been added for non-UK versions of SBEM.

### Building specific inputs

SBEM needs the user to decide how the building is zoned, and to input the dimensions, orientation and composition of the building elements surrounding each zone, including parameters that are not in the standard databases.

### Zoning rules

The zoning process in SBEM defines a set of zones, each distinguished from adjacent ones by differences in:

- activity ascribed to it

- HVAC and lighting systems which serve it

- access to daylight (through windows or roof-lights).

These zones are not necessarily the same as building service control zones. A process has been devised to deal with these issues, and to provide consistent zoning by different users. This is explained in detail in the iSBEM User Guide, which also deals with merging zones with similar characteristics, and small and narrow zones (see Figure 3).

SBEM can calculate how much of a zone is affected by daylight in zones where the electric lighting is controlled to respond to daylight (manually or automatically), or the user can stipulate what proportion is affected. However, the user should understand the limitations of this option, as explained in the iSBEM User Guide. For instance, it is still necessary to subdivide zones according to activity and HVAC system.

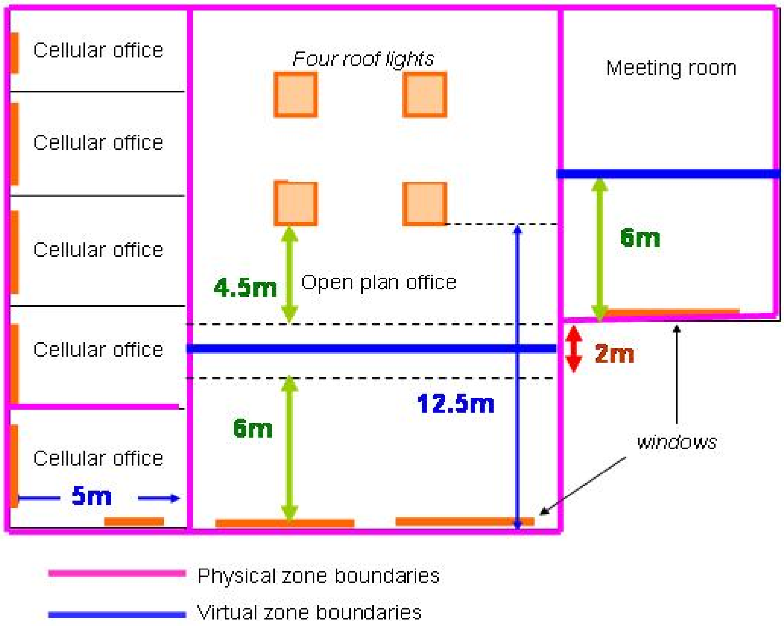



*Figure 2: Example of a zoning procedure. Cellular offices with glazing on the same orientation are grouped, and zones are split according to their access to daylight*

### Building geometry

Each zone should have its envelope (the building constructions surrounding it) described (area and properties of each physical boundary). Even where there is no heat, cooling or light transfer across a boundary, information about, for instance, internal walls is needed to assess the impact of their thermal mass. The following elements must be defined:

- area of zone
- area and composition of surrounding building fabric elements (walls, windows, doors, floor and ceiling)
- their orientation and adjacency (i.e. whether the other side of the element is conditioned space, exterior or other thermal conditions) .

This information is unique to the building being evaluated, and has to be abstracted from design drawings or schedules for new building designs, or drawings, site measurements and observations for existing buildings. Where information on the construction is not available (for instance in existing buildings where this could be obtained only by breaking into a wall), help is given in the database with inference procedures based on appearance, building type and supposed construction date.

### Thermal bridges

SBEM requires information on thermal bridges. Repeating thermal bridges in a particular construction, eg frames in windows, are accounted for in the calculation of U-values in the construction database.

Non-repeating thermal bridges are those at junctions between envelope elements in contact with the outside air. SBEM includes a method for calculating the lengths of thermal bridges which occur as a consequence of obvious junctions (eg between walls and roof, at corners and around windows and doors), but requires input (or default) values for the psi values of each junction. Non-obvious 'additional' thermal bridges (eg the projection of a floor slab through an external construction to form a balcony) need both length and psi value to be defined.

**SBEM calculation algorithms**

Where possible, SBEM uses CEN standards as the basis for calculation procedures. Where the standards do not cover a particular issue, the SBEM approach uses either:

- Dutch standard NEN 2916, mainly for heat recovery
- algorithms developed by BRE for fixed lighting with different control systems, hot water for washing, and contributions from renewable energy systems. See SBEM Technical Manual for more information.

**Heating and cooling**

Of the global options in EN ISO 13790 (seasonal, monthly or hourly), SBEM uses the monthly average calculation. This balances reasonable modelling of energy use in different months (which may not readily map onto 'seasons' in the UK climate) against the effort required to acquire input data. The main structure of the CEN calculation procedures in PG-N37 (which are followed by SBEM) is summarised in Table 2. Further options are available, but their documentation is outside the scope of this paper.

**Table 2: Procedure for CEN standard calculations for heating and cooling**

| | |
|---|---|
| 1 | Define the boundaries of the conditioned and unconditioned spaces, and partition them into zones according to the activities in them and the conditions required |
| 2 | Calculate, for each period and zone, the energy needed to heat or cool them to maintain the required set point conditions |
| 3 | Combine the results for different periods and zones served by the same systems, and calculate the delivered energy use for heating and cooling, taking into account the heat dissipated by the heating and cooling systems through distribution within the building or inefficiencies of heat and cooling production. |
| 4 | Combine the results for all zones and systems, to give building delivered energy totals. |

SBEM looks at the energy requirements of each zone – which may have different temperatures, operating periods, gains from lighting etc – and considers energy transfers between the monthly average weather conditions outside the building and each zone. The energy input to the zone from a heating or cooling system to overcome the net heat gain or loss is then deduced and, from information about system efficiency, the delivered energy can be calculated for the whole building.

**Lighting**

Lighting energy is calculated according to EN 15193-1, modified to account for rooflighting, occupancy and the contribution of daylight under different control regimes. The calculation takes account of:

- lamp and luminaire types
- whether a lighting design evaluation has been carried out, or assumptions made about the layout and type of luminaires
- building type and usage
- display lighting

- daylight penetration, which depends on window configuration
- automatic controls including daylight sensing/dimming or switching
- parasitic power for control systems.

**Hot water**

The energy use calculation for hot water service in SBEM follows the principles in EN 15316-3 with some simplifications. The basic calculation scheme is straightforward:

- Hot water service demand is taken from the activity database for areas whose occupants use the hot water. It is expressed per unit of floor area, which reflects occupancy density and nominal consumption per person for the activity.
- Heat losses from storage and secondary circulation are added (if present).
- Heat losses associated with residual hot water in distribution pipes longer than 3 m are added.
- Energy consumption is calculated using the heat generation efficiency.
- If there is a secondary circulation system, auxiliary energy for the secondary circulation pump is calculated.

The calculation does not take account of detailed draw-off patterns or adequacy of service. Energy use by any secondary pump and heat losses from secondary pipework reflect the longest hours of operation defined in the activity database for zones served by each hot water system.

The user can define values for the parameters below. Pessimistic default assumptions are provided, so it is desirable to find the actual values:

- storage volume
- storage vessel insulation type and thickness
- length of secondary pipework
- heat loss per metre of pipework
- secondary pump power
- heat generation efficiency.

More than one system can be specified, so, for instance, point-of-use hot water can be allocated to zones remote from the core of a building with a circulatory system. It is important to assign every zone where there are occupants or processes to one of the hot water systems, because information about the occupied zones from the activity database is needed to tell the calculation how much hot water is needed.
See *A guide to the Simplified Building Energy Model (SBEM)* for more information.

**Solar thermal systems**

Energy yield of solar energy systems is calculated on a monthly basis according to

- panel orientation and inclination between horizontal and vertical
- collector efficiency or type, and loop parameters
- storage water system characteristics.

To calculate the radiation on the collector, the hourly radiation data has been processed on a monthly basis for the different orientations and inclinations.

*Figure 3: The contributions of solar thermal collectors and photovoltaic panels can be evaluated by SBEM*

**Photovoltaic electricity**

Energy yield from photovoltaic (PV) systems is currently calculated on a monthly basis according to:

- panel orientation and inclination
- module technology
- system losses (assumed to be fixed values).

It is planned to modify this module to deal more specifically with peak installed power, shading and system performance factors.

To calculate the radiation on the PV surface, the hourly radiation data has been processed on a monthly basis for the different orientations and inclinations.

**Wind turbines**

The methodology is based on the average wind power density method. Hourly wind speed data for each location are used to produce an average value of the power in the wind for each month. An average for the wind turbine efficiency is then used to produce the monthly energy output. Corrections for turbine height, power rating and terrain type are made, based on input by the user.

**Combined heat and power**

The energy contributed and used by a combined heat and power (CHP) system is calculated in accordance with *Non-domestic building services compliance guide.* The user provides information:

- fuel type

- heat and electrical seasonal efficiencies
- proportions of space and water heating requirements provided by CHP.

If there is tri-generation (where the generator provides space cooling, space heating and water heating), the user also inputs:

- proportion of space cooling requirement provided by CHP
- seasonal efficiency of the heat fired chiller (typically an absorption chiller).

*Equipment gains*

Although the heat gains from non-HVAC equipment in each activity area are taken into account (to establish typical cooling needs and contribution to offset heating), the electricity for running them is not. This energy is outside the scope of the Building Regulations, and thus it is not part of the Part L or EPC calculation. From 2010, however, it is expected to be reported explicitly.

### Other issues covered by SBEM

SBEM deals with issues more fully than many calculation tools, including:

- duct leakage
- air handling unit leakage
- thermal bridging.

BRE has added these aspects to ensure that SBEM addresses all the requirements of Building Regulations and energy rating schemes.

### Results

The delivered energy consumptions from different fuel and energy sources for the above end uses are totalled and converted into equivalent $CO_2$ emissions, using standard conversion factors. This is not part of EN ISO 13790 but allows decision makers to check the carbon impact of changes and to compare buildings and systems with different fuel/energy mixes.

## USING SBEM

### Relationship between SBEM and iSBEM

SBEM is the engine that calculates the energy requirements and building-related and system-related carbon emissions for a building. However, data must be presented in a standard format through an input interface. iSBEM (‘interface to SBEM’) is the default interface, though others have been approved by DCLG.

The iSBEM input module is the interface between the user and the SBEM calculation. The user is guided towards the appropriate databases, and the input is formatted so data is presented correctly to the calculation, compliance checking and EPC generation modules.

**Logic behind iSBEM structure**

iSBEM is structured as a series of forms in Microsoft Access®. BRE maintains a comprehensive user guide, informed by extensive experience with operating and explaining the software to users from all backgrounds.

**How data collection for SBEM is structured by iSBEM**

The information gathering is arranged in a structured way – forms, tabs and sub-tabs – which is fully detailed in the iSBEM User Guide and follows this framework:

- General
  - project and assessor details
  - type of analysis required
  - file handling

- Project database – the constructions used in the building
  - walls
  - roofs
  - floors
  - doors
  - glazing

- Geometry – definition of zones, activities within them and building elements surrounding each zone:
  - global parameters that affect every zone unless overridden
  - zone area
  - activities
  - air permeability
  - element size, orientation, construction
  - glazing and shading
  - thermal bridges
  - links between elements

- Building services
  - HVAC systems
  - hot water generators including solar hot water
  - photovoltaic systems
  - wind generators
  - combined heat and power
  - lighting and its control
  - general issues relating to ventilation, power factor correction, etc
  - allocation of systems to each zone.

A fifth form deals with the ratings for the building, while a sixth simplifies navigation through and checking of the input data.

Data should be entered on the forms in the order presented on the screen. The user can enter data in any order but may not be able to complete some forms until earlier ones are finished. Some parameter questions and defaults change depending on responses to earlier questions, particularly on the 'purpose of analysis' when this switches between compliance checking and EPCs, for new and existing buildings, respectively.

Each data item is described as a 'building object', some of which need to be linked (eg a window to the wall in which it is placed, and the wall to the zone which it partly encloses – see Figure 4). iSBEM checks whether these links have been made, although it helps if the recommended nomenclature is adopted for each object so as to identify the links that should be in place.

A large part of the data is input by transferring information from drawings and schedules in the geometry form. This could be laborious if the user had to identify each element and links with its sub-elements such as doors, windows and thermal bridges, but input is simplified by using a table under the sub-tab 'quick envelopes'; this enables areas, construction type, adjacency and glazing on each orientation to be input without navigating between screens. This also helps in keeping track of which elements have been entered.

Tables of data for each zone are presented by iSBEM for the user to check that input information is complete.

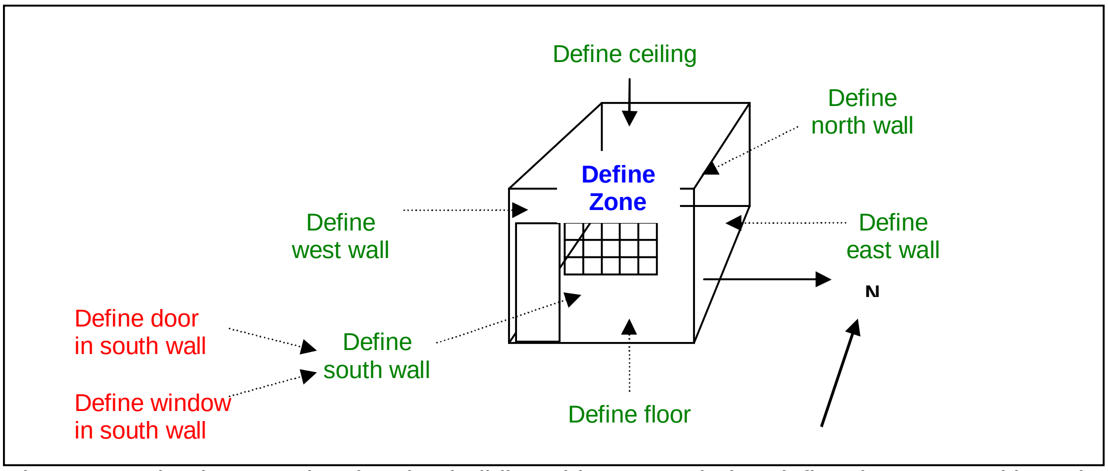



*Figure 4: A simple zone showing the 'building objects' needed to define the zone and how they need to be linked*

**iSBEM outputs**

The SBEM calculation is initiated from the ratings form in iSBEM. Clicking one of the buttons on the form tells iSBEM to create a text file to be fed to SBEM for calculation.

Various calculations are available, depending on the 'purpose of analysis' selected, and described below.

The core results are expressed as $kgCO_2/m^2$ per year, with additional information (such as breakdown by end use) as $kWh/m^2$ (see Figure 6).

Intermediate results are available for diagnostic checks on the proposed building:

- data reflection (to confirm entry associated with results)
- monthly energy use profiles
- total and system electricity use and use of each fuel, and resulting carbon emissions.

Having obtained a result, the user can return to earlier forms and tabs in iSBEM to see the impact of changing some parameters. Such iterations show how the building can be improved, and allow an analysis of the sensitivity of the building emissions to variations.

However, some input parameters to SBEM are determined by fixed databases to allow comparisons between options for a building or between buildings on a consistent basis. It should therefore not be used to design a building as it is not possible to input the actual operating patterns, occupation densities and heat gains. This is the role of other software.

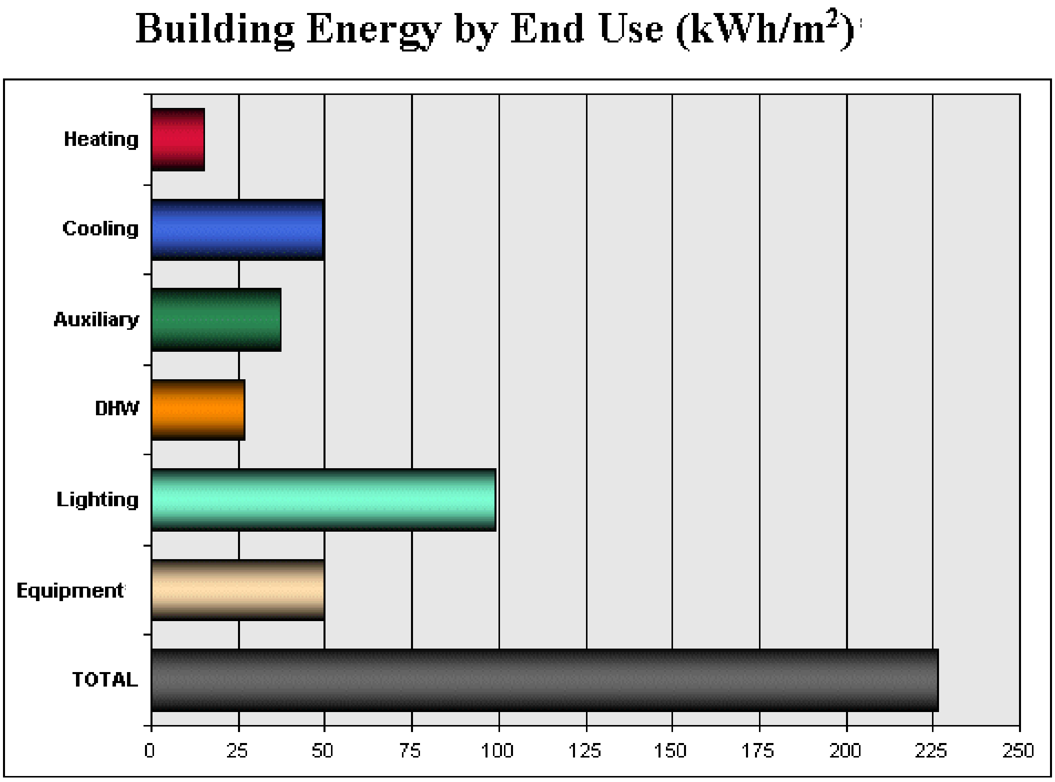



*Figure 5: Annual energy consumption by end use, from the SBEM outputs. This building is dominated by lighting and cooling energy: this indicates where improvements can best be made to improve performance.*

**Familiarisation with iSBEM**

As with any software, users need to become familiar with the interface:

- appearance
- structure
- functionality
- data demands
- flexibility of output.

Most of this familiarity comes through using the software repeatedly and resolving problems by reviewing the FAQ section on the NCM website *www.ncm.bre.co.uk*. However, many users will want to use the software in revenue-earning work as soon as possible; training will help. Courses are available explaining the layout of the software, data acquisition and input, and the format of the results. A number of training providers offer such courses, including BRE. Courses including hands-on exercises are recommended to speed familiarisation.

**Adaptation of calculation for energy audit**

There are two types of rating:

a. Asset - derived from the intrinsic properties of the building, if operated in a standard way. Indicates how good the building is, and can be used to show the impact if improvements are made.

b. Operational – derived from meter readings compared with standard benchmarks. Reflects how well the building's energy systems are managed. Cannot forecast benefit of improvements, but can report them if repeated for similar periods (eg annually).

Both should be undertaken on each building (where data are available) to establish whether improvements can best be made to the building, its operation, or both.

For consistency between auditors, all buildings should be compared using the same calculation method for either asset or operational rating.

The basis for comparison should exclude, as far as possible, parameters that are based on an individual's opinion or judgement that could be favourable to the building.

Where possible, inputs to the calculations should be drawn from standard databases to ensure consistency and reduce interpretation or error by auditors.

Wherever defaults are used they should be pessimistic so that

- The rating is not better than it would have been if actual information had been collected
- Auditors are motivated to seek out the actual (hopefully better) information.

Asset ratings are based on standardised operational parameters for each building occupancy type, which need to be decided upon and then fixed as far as the assessments are concerned.

Operational ratings involve comparison with standard energy benchmarks, which need to be established for each building type.

Communication of the ratings to decision makers (eg building owners, tenants and/or operators) would be enhanced if a simple format could be devised to express them in a non-technical way that nevertheless motivates the decision makers to take action for improvements.

It should be recognised that neither SBEM nor any other tool can produce reliable absolute differences of energy (hence cost or carbon) that can be validated against the actual building performance, because building use data cannot be found reliably. We recommend that the audit tool be used to produce a ranking of measures in bands with savings with wide confidence limits. These would feed into the application process for the contingent support mechanism.

**Energy audit in the absence of statistically derived benchmarks**

1. Ideally a benchmark is needed, against which the metered consumption can be compared. This is needed to determine which buildings are worse than others in the stock, and thus have a higher priority for attention and potentially for funding. If this cannot be derived statistically from validated records for a population of similar buildings (indications are that this is unlikely for Mauritius), then it could be calculated specifically for each building.
2. This benchmark should not be the lowest possible energy consumption (eg the asset energy calculation) but should allow for typical
    a. Construction standards
    b. Equipment choice and efficiency

   c. Maintenance standards

Values for these parameters should be sought from the experience of local practitioners. Operating periods for building services, equipment energy and internal heat gains (eg from people, equipment) would be typical values for Mauritius incorporated into the activity database.

3. However the typical benchmark should not allow for
   a. poorly set temperatures
   b. very inefficient plant
   c. lazy operating period management
      i. when the building is unoccupied
      ii. when individual zones are unoccupied, where the service can respond instantaneously
      iii. poor control of “unregulated” equipment

   These could be incorporated into the definition of a “poorly managed building”

4. An asset-based methodology such as SBEM can be extended to predict energy consumption under these different circumstances, to enable comparison against metered consumption, and allow differentiation of the causes of deviation from the computed benchmark, if
   a. The calculation includes equipment energy in the total, since the metered readings would include it
   b. A Mauritian version of the activity database allows variation of
      i. Equipment energy
      ii. People-related loads (metabolic, ventilation)
      iii. Operating periods
      iv. Plant efficiencies where these degrade under normal maintenance
   c. These variations should be applied via the activity database rather than allowing auditors to enter them directly; thus the effects of variation would be consistent and the changes would not be prone to excessive adjustment by users to distort their buildings’ performance for any reason.

5. Propose multiple calculations with outputs in absolute kWh (or appropriate units) for each fuel:
   a. normal actual asset energy calculation (with equipment included in total)
   b. same but with “typically maintained” adjustments (as listed in 2 above) applied automatically
   c. same but with “poorly managed” adjustments (as listed in 3 above) applied automatically

   d. same but with improvements suggested by software in a, and confirmed by auditor; this calculation would be the result of changes to the inputs undertaken by the auditor

6. The auditor would also be asked to fill in a questionnaire that would objectively score the quality of management of the building, to place it on a scale from well to poorly managed.

7. The relative positions of these buildings on the actual and calculated scales, together with the position on the scale from well to poorly managed will determine the relative proportions of savings that would be due to asset and operational characteristics, and the priority for attention that the building deserves compared with others in the stock.

8. This approach is weak if the asset performance of buildings varies for reasons other than listed in 2 above, eg if building standards have changed radically over time. We need to check whether this is the case, although since there have been no previous energy standards, this is unlikely.

## Appendix C - Auditor and trainer entry requirements

### TRAINEE ENERGY AUDITOR

- At least an Honours Degree or equivalent in a building related discipline or Science/Engineering.

- A *minimum of 2 years* working experience in at least *one or a combination* of the following domains :

  - building surveying,
  - building services,
  - facilities management,
  - building energy modeling,
  - building automation,
  - building engineering physics,
  - energy management, or
  - other agreed equivalent.

- Undergo a training program which covers the following competencies:

  - Using the Mauritius Energy Audit tool based on Simplified Building Energy Model (SBEM).
  - Commercial building construction, zoning and surveying.
  - Building Services.

- Pass an examination set by the certification body that includes the theory behind and the practical application of the audit tools including that based on iSBEM.

### SCHEME TRAINER

- At least an Honours Degree or equivalent in a building related discipline or Science/Engineering.

- A *minimum of 5 years* working experience in at least *two or a combination* of the following domains :

  - building surveying,
  - building services,
  - facilities management,
  - building energy modeling,
  - building automation,
  - building engineering physics,
  - energy auditing,
  - energy management, or
  - other agreed equivalent.

- Undergo a training program which covers the following competencies:

  - Using the Mauritius Energy Audit tool based on Simplified Building Energy Model (SBEM).
  - Commercial building construction, zoning and surveying.
  - Building Services.

- The certification body lays down the auditor’s competencies but not the training and trainer requirements and does not certify the trainer or the course.

## Appendix D - Scheme Quality Plan

**Scheme Quality Plan will detail the general scheme architecture and supporting procedures and processes, including:**

- Accreditation team structure
- Application, membership and renewals procedures and requirements
- Application process
- Membership renewal process
- Quality Assurance Procedures
- Scheduling of Random Audits
- Scheduling of Targeted Audits
- Additional QA checks for high lodgement rates
- Types of audit – overview of requirements
- Quality Assurance escalation procedure for failed audits
- Appeals process for audit result
- Quality Assurance Procedures – Process Maps
- Continuous Professional Development (CPD)
- Handling of complaints procedure
- Disciplinary procedure
- Energy Auditor Code of Conduct
- Energy Auditor Code of Conduct - violation procedure
- Appeals procedure
- Technical – Software
- Measurement, analysis and improvement
- Customer satisfaction procedure

## Appendix E – Alternative fiscal and funding mechanisms

A contingent support mechanism can be in the form of one or more of the following fiscal instruments:

- Grants;
- Interest free or low cost loans;
- Tax breaks.

**Grants**

From our experience these are popular because they are perceived as “free money”. Such schemes need a good application procedure that passes forward only the cost effective projects based on qualification criteria that need to be simple (but not just payback) to ensure savings are sustainable. The sustainability of the measures implemented can be encouraged by having a mixed portfolio of projects, for example where paybacks are 2-3yrs (short term), 3-5yrs (medium term) and some 5-10+yrs (long term). The scheme would need to be linked to the survey/audit and there would have to be a mechanism that shows evidence that the grant-aided measures have been implemented. A clearly understood recovery mechanism, to come into play when the measures are incorrectly implemented, is needed. A down side is that such schemes are expensive to run in terms of administration and marketing, up to 25% of the cost. Such a scheme could be supported by a list of “approved contractors” to ensure the works carried out are up to standard and which could be checked by site visits.

**Interest free or low cost loans**

These are normally interest free and from our experience not the determining factor in an organisation’s decision making process. They are viewed as a “nice to have” and as a result good marketing is essential. The application process, administration and choice of projects are identical to those of the grant schemes described above. An additional requirement is that loan schemes are normally run on a revolving fund basis where the savings generated by the applicant are used to pay the loan off, thus generating funds for future applications. However, there has to be a lead time between when the loan is given and the measure is put in, and when the savings start to be generated. This means the pot has to be of sufficient size to be able to give out loans for a long enough period, until repayments start to come back to bolster the fund. For these schemes credit checks are essential and a debt recovery mechanism needs to be in place.

**Tax breaks**

These are not so popular and require good marketing to ensure that the both financial advisors and organisations are made aware of the benefits. They do however normally have the benefit of “piggy backing” on existing legislation and as a result are cheaper to run.

All of these mechanisms could be underpinned with a labelling scheme (eg of products which qualify for a technology list) to ensure any measures installed are to best practice standards. This could be supported by standard specifications aligned with best practice, which have to be followed in order to get the fiscal support. This has been shown to drive up standards in the supply chain and gives the manufacturer an incentive in terms of a label for marketing purposes beyond the scope of the fiscal support scheme. An application process would have to be put in place for such a technology list. This would require the suppliers to provide third party evidence of compliance to the best practice criteria.

Our initial recommendation is that the energy audit scheme could be supported by interest free loans run a revolving fund basis. This would be administered by the Energy Efficiency Office who then can easily link these to the audits. Any plant and machinery specified would meet best criteria similar to those in the UK's Energy Technology List (ETL).

The ETL gives the criteria for each type of technology, lists those products in each category that meet them and is used as a procurement tool for designers, specifiers and purchasers interested in energy-saving capital equipment. Such a list would include technologies such as:

- Air-to-air energy recovery.
- Automatic monitoring and targeting equipment.
- Compact heat exchangers.
- Compressed air equipment.
- HVAC Equipment.
- Lighting.
- Motors and Drives.
- Pipe insulation.
- Refrigeration equipment.
- Solar thermal systems.
- Uninterruptible Power Supply.

An early task will be to undertake a needs analysis for the selected contingent support mechanism, to be included within the desk study.

**Enhanced Capital allowances**

The Enhanced Capital Allowances (ECAs) scheme was introduced in April 2001 to provide incentives for businesses to incur expenditure on energy efficient plant and machinery. The scheme enables businesses to claim a 100% first year capital allowance on investments in prescribed energy saving equipment, which are of a description specified by Treasury order. This enables businesses to write off the whole cost of their investment against their taxable profits of the period during which they make the investment.

The purpose of the scheme is to encourage investment to assist in achieving the Government targets for carbon emissions. A budget of £100m, paid for by Climate Change Levy revenues, was allocated to finance the scheme.

Since its introduction it has become clear that barriers exist to the uptake and success of the scheme. These range from technical barriers, due to the complex Capital Allowances legislation, through to some of the more practical barriers of the scheme. This report sets out some of the technical and practical barriers to the uptake of the ECA scheme, together with experience with the Inland Revenue, and suggests some possible solutions and enhancements to the scheme.

To qualify for ECAs energy saving equipment included within the product list must also fall within the definition of ‘plant and machinery’. The first part of this report provides an overview of the capital allowances legislation and case law, both of which provide technical barriers to the scheme in respect of qualifying ‘plant’. The second section of part 1 covers the complexities related to the ‘ownership’ of assets that can further complicate the availability of allowances. The final section provides an outline of other barriers that exist.

Comparison of other tax incentive schemes and overseas energy saving schemes are considered in part 2 of the report. Various tax incentives are in use within the UK to encourage investment in specific areas. The benefits and structure of these schemes are considered in the first section of part 2, which also identifies where attributes of the specific incentives could be considered for enhancements to the ECA scheme. In the latter section, environmental schemes in force in overseas countries are considered in comparison to the UK ECAs scheme.

Finally, the third part of the report suggests possible solutions and enhancements to overcome the potential barriers identified. There are a number of barriers that exist, which affect the uptake and success of the scheme. Some of the proposed solutions detailed in the report include:

- Special exclusion of energy efficient plant and machinery from the capital allowances definition of plant and machinery (in particular for lighting).
- Extending the scheme to provide incentives to non-tax payers, developers and loss making companies by offering a form of tax credit.
- Increasing the amount of relief offered from 100% to 150% of the expenditure incurred.
- Withdrawing the First Year Allowances exclusion in respect of energy saving plant and machinery which are considered to be long life assets.
- Extending the technology areas included in the Treasury Order as qualifying for the purposes of CAA 2001 s 180 A (2).
- Reviewing the rules in respect of second hand assets to enable ECAs to be claimed.
- Simplification of identification of qualifying expenditure.
- Continued marketing and publicity of the ECA scheme.

The Enhanced Capital Allowances scheme is generally accepted as an incentive to encourage investment within energy saving plant and machinery. However, with the current barriers that exist it is likely that the original objectives of the scheme will not be achieved.