Module 18

Energy efficiency in buildings

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Globally the building sector accounts for more electricity use than any other sector, 42 per cent. No wonder considering that we spend more than 90 per cent of our time in buildings. With increasing urbanization, higher in developing countries, the number and size of buildings in urban areas will increase, resulting in an increased demand for electricity and other forms of energy commonly used in buildings. Africa's rate of urbanization of 3.5 per cent per year is the highest in the world, resulting in more urban areas with bigger populations, as well as the expansion of existing urban areas. There are currently 40 cities in Africa with populations of more than a million and it is expected that by 2015 seventy cities will have populations of one million or more.

In many developing countries there is normally very little margin between existing power supply and electricity demand. With increasing electricity demand, new generation needs to be brought in. Although renewable sources of electricity such as hydro, geothermal or wind provide electricity at a much lower cost, their capital outlay is large, they are complex and take much longer to implement. Diesel-based generation is usually brought in the short term to meet this demand, which results in increased cost of electricity.

Investments in energy efficiency in a building can be compared with the cost of capital investments necessary on the supply side of the energy system to produce a similar amount of peak capacity or annual energy production. Usually, the capital costs of efficiency are lower than comparable investments in increased supply and there are no additional operating costs of efficiency compared to substantial operating costs for supply-side options. In addition, energy efficiency investments generally have much shorter lead times than energy supply investments, a particularly important consideration in countries where the demand for energy services is growing rapidly.

One consistent quality in the building sector is that it is subject to a high degree of regulation. Building codes often influence material use and appliance standards that have a significant effect on energy efficiency. Regulatory regimes, to the extent that they exist, may therefore provide a pathway to improve efficiency for both building construction and a variety of building appliances.

This module is designed to provide an overview of energy efficiency in buildings; it aims to help policymakers and regulators understand the potential benefits, the opportunities for improving the efficiency of buildings and give them a background on the key issues to be addressed when developing suitable policies and a framework for implementation. In addition, it briefly discusses the methodology used for determining the efficiency of buildings and the mechanisms that can be used to finance energy efficiency measures.

It concludes with a discussion on the process of developing and implementing policy on energy efficiency in buildings and gives a summary on policy tools that can be used to facilitate implementation of energy efficiency in buildings.

1.2. Module aims

The aims of this module are:

- To introduce the concept and benefits of energy efficiency in buildings.
- To give an overview of the methodology used to determine the energy efficiency of buildings.
- To present the different opportunities and measures for reducing energy use in buildings without sacrificing comfort levels.
- To describe the different mechanisms for financing energy efficiency measures in buildings.
- To give a summary of legislative and policy tools that have been successful in promoting energy efficiency in buildings.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To appreciate the significance and benefits of energy efficiency in buildings.
- To have a general understanding of the methodology used to determine the energy efficiency of buildings, the different opportunities for improving the energy efficiency of buildings and the potential savings.
- To have an overview of the different mechanisms for financing energy efficiency measures.
- To have conceptualized an approach to setting out and implementing policies to facilitate energy efficiency in buildings in their country.

2. INTRODUCTION

More than 90 per cent of our time is spent in buildings i.e. either in the office or at home. Energy used in buildings (residential and commercial) accounts for a significant percentage of a country's total energy consumption. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capita, the prevailing climate, as well as national and local policies to promote efficiency. The following are estimated figures for different regions:

- European Union countries > 40 per cent[1]
- Philippines 15-20 per cent[2]
- Brazil 42 per cent[3]
- Florida/USA 47 per cent[3]
- California 66 per cent[4]

In many countries, buildings consume more energy than transport and industry. The International Energy Agency (IEA) statistics estimate that globally, the building sector is responsible for more electricity consumption than any other sector, 42 per cent.[5]

The building sector encompasses a diverse set of end use activities, which have different energy use implications. Space heating, space cooling and lighting, which together account for a majority of building energy use in industrialized countries, depend not only on the energy efficiency of temperature control and lighting systems, but also on the efficiency of the buildings in which they operate. Building designs and materials have a significant effect on the energy consumed for a select set of end uses. On the other hand, building design does not affect the energy use of cooking or appliances, though these end uses are nonetheless attributed to the building sector. Appliance efficiency matters more for some end uses than for others. Water heating and refrigeration each account for significant shares of building energy use since they are in constant use. By contrast, cooking and small appliances (including computers and televisions)

[1]Directive 2002/91/ec of the European Parliament and of the Council on the Energy Performance of Buildings, 2002.

[2]Energy Efficiency Division of the Philippines Department of Energy (DOE), 2002, Philippines Guidelines for Energy Conserving Design of Buildings and Utility Systems.

[3]Michael Laar and Friedrich Wilhelm Grimme, 2002. Sustainable Buildings in the Tropics. Institute of Technology in the Tropics ITT, University of Applied Sciences Cologne: Presented at RIO 02 – World Climate & Energy Event, January 6-11, 2002.

[4]California Energy Commission, 2005, Options for Energy Efficiency in Existing Buildings.

[5]IEA. 2004b. Energy Balances for OECD Countries and Energy Balances for non-OECD Countries; Energy Statistics for OECD Countries and Energy Statistics for non-OECD Countries (2004 editions) Paris.

generally account for only small percentages of building energy consumption, owing to their intermittent use.

In general, building energy consumption is higher in industrialized countries. Thus, development has an important effect on energy demand from the building sector, implying that building efficiency becomes more significant as countries become more prosperous. The importance of energy efficiency in building sector is especially significant in developing countries, owing to rapid new construction with opportunities to employ efficient materials and best practices.

Analysis of the building sector produces mixed conclusions, owing to the diversity of influences and end uses that the sector embodies. International trade and a small number of multinational corporations play a significant role in the production and distribution of most building appliances, including cooking appliances, lighting, heating and cooling systems. However, the opposite is true for building construction, which is dominated by small local firms. Many materials essential to building efficiency, such as cement and timber, are not heavily traded (aluminum and steel are notable exceptions), and building practices and materials vary widely depending on available resources, customs and prevailing climate.

One consistent quality in the building sector is that it is subject to a high degree of regulation. Building codes often influence material use, and appliance standards, both mandatory and voluntary, have a significant effect on energy efficiency. Regulatory regimes, to the extent that they exist, may therefore provide a pathway to improving efficiency for both building construction and a variety of building appliances. Furthermore, government operations in commercial buildings often constitute a significant share of total building use, as government activity at all levels is building-dependent. By choosing energy-efficient designs and materials for their own use, governments can thus exert significant influence over the building sector as a whole.[6]

2.1. What is the energy efficiency of a building?

The energy efficiency of a building is the extent to which the energy consumption per square metre of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions.

Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared.

[6] Kevin A. Baumert, Timothy Herzog and Jonathan Pershing, 2005, Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, World Resources Institute.

The benchmarks are derived by analysing data on different building types within a given country. The typical benchmark is the median level of performance of all the buildings in a given category and good practice represents the top quartile performance. Comparisons with simple benchmarks of annual energy use per square metre of floor area or treated floor area (kWh/m^2/annum) allow the standard of energy efficiency to be assessed and priority areas for action to be identified.

Benchmarks are applied mainly to heating, cooling, air-conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity consumption for external lighting. The benchmarks used vary with the country and type of building.

The measure of heat loss through a material, referred to as the U-Value, is also used as a way of describing the energy performance of a building. The U-value refers to how well an element conducts heat from one side to the other by rating how much the heat the component allows to pass through it. They are the standard used in building codes for specifying the minimum energy efficiency values for windows, doors, walls and other exterior building components. U-values also rate the energy efficiency of the combined materials in a building component or section. A low U-value indicates good energy efficiency. Windows, doors, walls and skylights can gain or lose heat, thereby increasing the energy required for cooling or heating. For this reason most building codes have set minimum standards for the energy efficiency of these components.

2.2. Why is energy efficiency in buildings important?

Governments have a responsibility to ensure that there is secure supply of energy to ensure economic growth. In many developing countries there is normally very little margin between existing power supply and electricity demand. With increasing electricity use from existing consumers and new connections, new generation needs to be brought on line to meet increasing demand. In addition, due to changing climate patterns and the increasing risk of drought, countries that are highly dependent on electricity from hydro as their main source of electricity are losing much of their generation capacity resulting in intensive power rationing.

Although renewable sources of electricity such as hydro, geothermal or wind provide electricity at a much lower cost than electricity generation from petroleum, their capital outlay is large, they are complex and take much longer to implement. Petroleum-based generation is usually brought in in the short term to meet this demand, which results in increased cost of electricity, over dependence on petroleum and subsequently vulnerability to oil price fluctuations.

Investments in energy efficiency in a building can be compared with the cost of capital investments necessary on the supply side of the energy system to produce a similar amount of peak capacity or annual energy production. Usually, the capital costs of efficiency are lower than comparable investments in increased supply and there are no additional operating costs of efficiency compared to substantial operating costs for supply-side options. In addition, energy efficiency investments generally have much shorter lead times than energy supply investments, a particularly important consideration in countries where the demand for energy services is growing rapidly. By setting energy efficiency targets for buildings, governments share the burden and cost of ensuring the security of energy supply with end-users.

The need to increase generation capacity in developing countries is unavoidable. However governments can solve peak demand constraints by finding a balance between reducing demand and increasing supply. To increase supply, governments in developing countries often have to allocate funds to subsidize new generation capacity or subsidize the cost of petroleum-based generation.[7] Reducing demand by setting up a low interest, easy payment energy efficiency revolving fund to incentivize consumers to implement energy efficiency measures would be a more sustainable approach and repayments could be based on energy savings.

The main benefit from measures to improve energy efficiency buildings is lower energy costs but there are usually other benefits to be considered too. Energy efficiency measures are meant to reduce the amount of energy consumed while maintaining or improving the quality of services provided in the building. Among the benefits likely to arise from energy efficiency investments in buildings are:

- Reducing energy use for space heating and/or cooling and water heating;
- Reduced electricity use for lighting, office machinery and domestic type appliances;
- Lower maintenance requirements;
- Improved comfort;
- Enhanced property value.

In developing countries where electricity is intermittent and power rationing is frequent, there is a large demand for diesel or renewable energy-based back-up/stand-by power generation from end-users. Reducing power and energy requirements in buildings reduces the capital outlay required and the running costs of these stand-by systems.

---

[7]Independent power producer tariffs are a function of the capacity charge as well as volume of energy generated and the prevailing fuel prices. Whereas the cost of energy generated and fuel price are transferred to the customer, the capacity charge is usually borne by the government.

In industrialized countries, policy, incentives, climate change targets and corporate image drive more efficient approaches to energy use in buildings. Codes and practice on energy regulations for buildings in developed countries include obligations for energy audits, requirements for building certification with ratings based on energy efficiency, carbon reduction targets for buildings, levies on energy consumption—charged per unit consumed to discourage high consumption, incentives such as exemption from building tax for good energy efficiency ratings, access to interest free/low-interest loans and grants for undertaking energy efficiency measures in buildings and, as part of their corporate social responsibility, some companies would like to be seen as a green company that promotes energy efficiency.

Box 1. **The success of California's energy efficiency buildings policy**

Reducing energy consumption and peak demand through greater energy efficiency is the cornerstone of the State of California's energy policy. Homes and commercial buildings consume 66 per cent of the State's electricity.

California's homes and buildings are relatively energy-efficient today, compared to those in other states and many countries of the world. Since the passage of the Warren-Alquist Act in 1975, homes and buildings in California have been made increasingly efficient, due to periodically updated efficiency requirements in Building and Appliance Standards. In this same 30-year period, the California Public Utility Commission has directed the investor-owned utilities to commit over $US 5 billion to energy efficiency information, technical assistance and incentive programmes, an estimated 85 per cent of which has been targeted at retrofit energy efficiency investments in existing buildings.

There are over 13 million existing buildings in California, compared to the approximately 200,000 constructed each year. More than half of the existing buildings were built before the first Energy Efficiency Standards were established in 1978. While many have been upgraded over time, these older buildings represent a large reserve of potential energy and peak demand savings.

Over half of the energy savings attributed to the Appliance Standards are from the installation of new appliances in existing buildings. Over time, as existing homes and buildings replace their energy-using equipment, the Appliance Standards increase the efficiency of energy use in those homes and buildings.

While the Building Standards are usually seen as improving energy efficiency in newly constructed buildings, they also apply to all additions and many alterations made to existing buildings and have affected many vintages of existing buildings constructed since they were first enacted in the late 1970s. Figure I shows the energy savings achieved by the California Building Standards within the existing building stock.

California has held electricity consumption per capita steady for the past 30 years, while the rest of the United States experienced a 50 per cent growth in electricity consumption (and slower economic growth than in California). Figure II shows that while average per capita electricity sales have continued to increase significantly for the nation as a whole, the per capita figure for California began leveling off in the mid to late-1970s and has remained basically constant since.

Figure I. Savings achieved within California's existing building stock

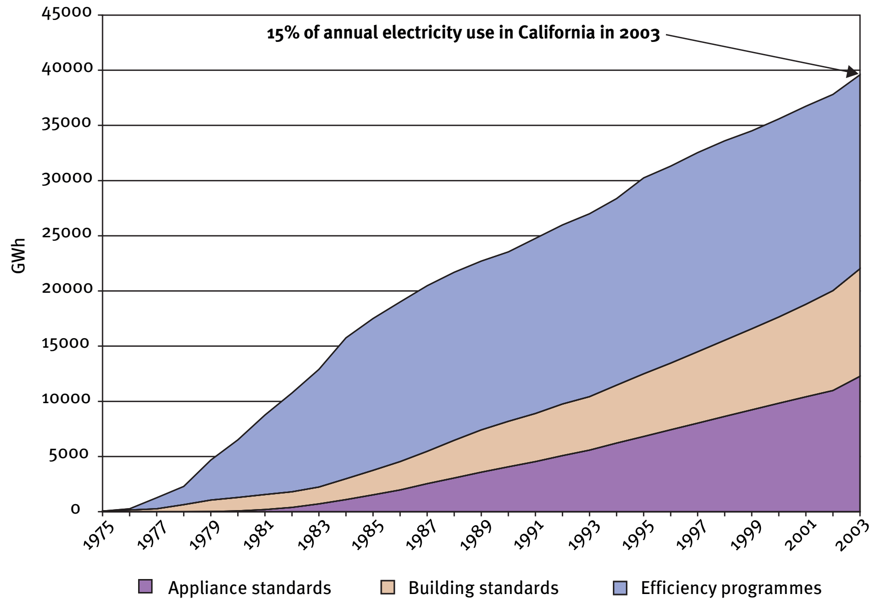
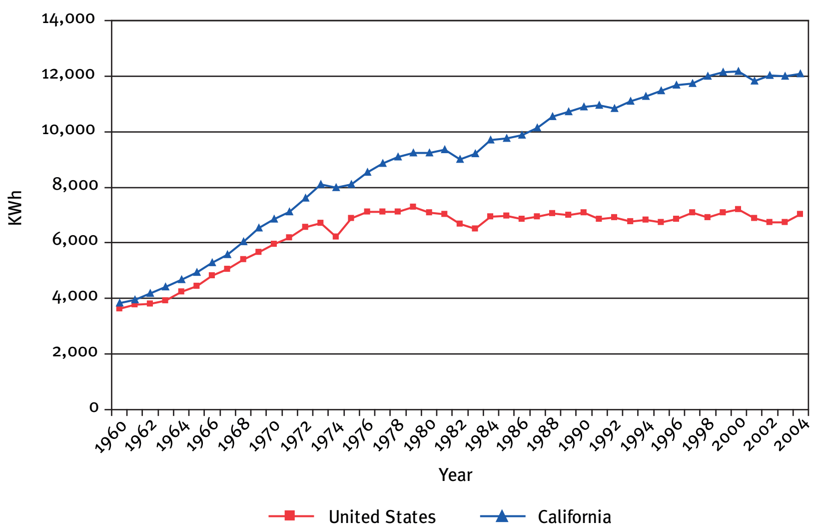


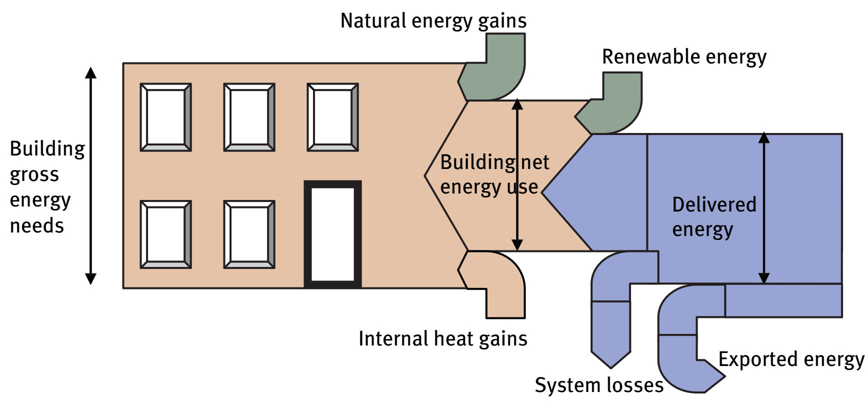
Figure II. Total electricity sales, per capita, in the United States and California between 1960 and 2001



3. ENERGY EFFICIENCY IN BUILDINGS METHODOLOGY

3.1. Typical energy flow in buildings

Figure III. How energy flows are linked in buildings[a]



[a]EU Energy Performance in Buildings – Directive Implementation Advisory Group, Explanation of the General Relationship between various standards from the European Committee for Standardization and the Energy Performance of Buildings Directive (EPBD).

Figure III above illustrates the typical energy flows in a building. The building gross energy needs represent the anticipated buildings requirements for heating, lighting, cooling, ventilation, air conditioning and humidification. The indoor climate requirements,[8] outdoor climatic conditions and the building properties (surface/transmission heat transfer and heat transfer due to air leakage) are the parameters used for determining what the gross energy needs of the building will be.

As illustrated in the diagram above, delivered energy, natural energy gains and internal heat gains all contribute to providing the energy needs of a building.

Natural energy gains

These include passive solar heating, passive cooling, natural ventilation flow, and daylight. Intelligent maximization of natural energy gains can result in significant

[8]The indoor climate is a term that summarizes the thermal environment, the air quality and the acoustic and light environment of a building. Indoor climate regulations and guidelines are usually part of the building code.

reduction of delivered energy required to meet a building's energy needs. Environmentally smart buildings make intelligent use of energy resources, while minimizing waste.

Natural energy gains can be maximized by exploiting the potential contribution to a building's performance offered by the site and its surroundings through:

- A building plan which places functions in locations that minimize the need for applied energy;
- A shape which encourages the use of daylight and natural ventilation, and reduces heat losses;
- An orientation that takes account of the potential benefits from solar gains while reducing the risk of glare and overheating;
- Effective use of natural daylight combined with the avoidance of glare and unwanted solar gains;
- Natural ventilation wherever practical and appropriate, with mechanical ventilation and/or air conditioning used only to the extent they are actually required;
- Good levels of thermal insulation and prevention of unwanted air infiltration through the building envelope;
- Intrinsically efficient and well-controlled building services, well-matched to the building fabric and to the expected use.

This is best achieved at the building's design stage but can also be done during refurbishment.

Internal heat gain

Internal heat is the thermal energy from people, lighting and appliances that give off heat to the indoor environment. Whereas this is desirable in cold weather as it reduces the energy requirements for heating, in hot weather it increases the energy required for cooling. In office buildings, commercial stores, shopping centres, entertainment halls etc., much of the overheating problem during the summer can be caused by heat produced by equipment or by a high level of artificial lighting. When there are a large number of occupants or clients their metabolic heat can also add to the problem.

Delivered energy

This is the amount of energy supplied to meet a building's net energy demand i.e. to provide energy for heating, cooling, ventilation, hot water and lighting. It is usually expressed in kilowatt hours (kWh) and the main energy carriers are electricity and fuel, i.e. gas, oil or biomass for boilers. As seen from figure III, the delivered energy could be supplemented by on-site renewable energy, this could be in the form of solar PV, solar water heaters or wind.

Exported energy

This is the fraction of delivered energy that, where applicable, is sold to external users.

System losses

System losses result from the inefficiencies in transporting and converting the delivered energy, i.e. of the 100 per cent delivered energy, only 90 per cent may be used to provide the actual services, e.g. lighting, cooling or ventilation, due to the inefficiency of the equipment used.

When addressing the energy efficiency issue in buildings the main focus is on the energy used to attain the required indoor climate standards. The amount of energy a building will be required to purchase to attain this is dependant on:

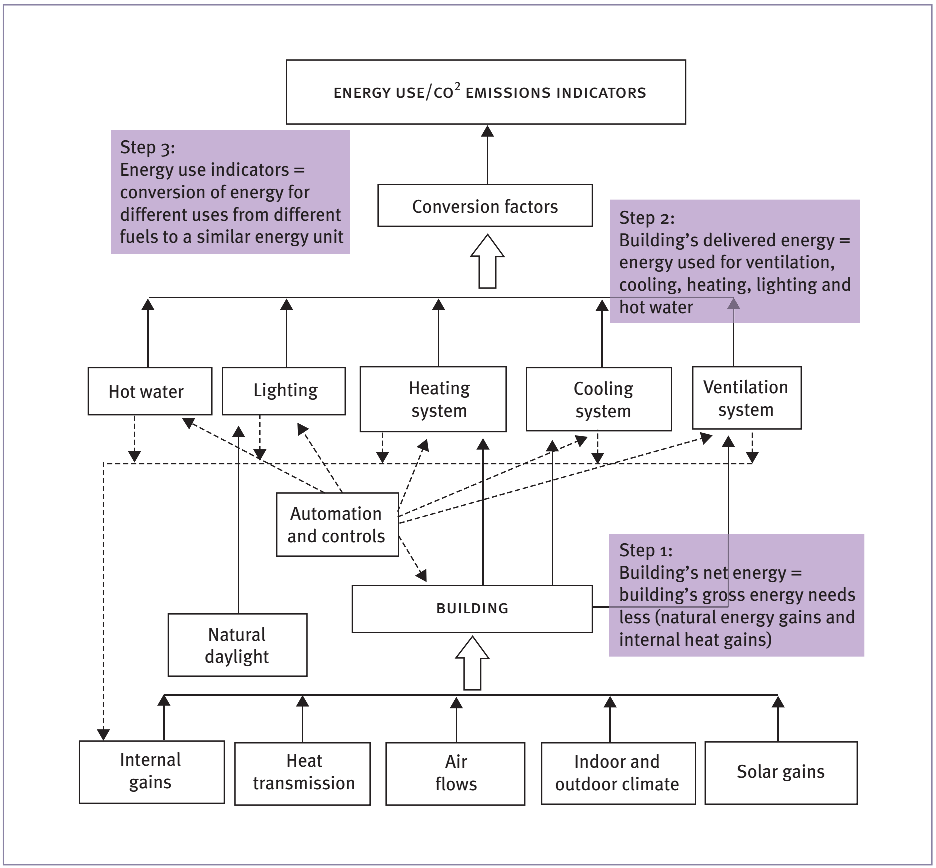
- The properties of the building:
  - The level of heat transfer: the lower the heat transfer the lower the heat loss during cold weather and heat gain during warm weather. This will reduce the energy requirements for heating or cooling;
  - Whether the building is designed to minimize the need for applied energy depending on the outdoor climatic conditions.
- How efficiently the delivered energy is used to meet the building's net energy demand i.e. the efficiency of the equipment and appliances used;
- How efficiently energy is used by people in the building;
- The percentage of the building's energy requirement that is supplied by renewable energy.

3.2. Determining a building's energy performance

Energy use indicators

The calculation of energy use in buildings is based on the characteristics of the building and its installed equipment. It is structured in three levels as illustrated below and the calculation is performed from the bottom up.

Figure IV. Overview of the calculation process of energy use indicators for buildings[a]



[a]EU Energy Performance in Buildings – Directive Implementation Advisory Group, explanation of the general relationship between various standards from the European Committee for Standardization and the Energy Performance of Buildings Directive (EPBD).

1. Step One is the calculation of the building's net energy requirements, i.e. the amount of energy required to provide the indoor climate requirements[9] as specified by the building code. The calculation is used to determine the net energy required based on the outdoor climate and indoor climate requirements while considering the contributions from internal gains, solar gains and natural lighting and losses due to building properties, i.e. heat transmission and airflows (air infiltration and exfiltration). This calculation is used to determine the intrinsic energy performance of the building.
2. Step Two is the determination of the building's delivered energy, i.e. the energy performance of the building in actual use. This is the amount of energy used for heating, cooling, hot water, lighting, ventilation systems, inclusive of controls and building automation, and includes the auxiliary energy needed for fans, pumps, etc. Energy used for different purposes and by different fuels is recorded.

3. Step Three is the determination of the overall energy performance indicators: It combines the results from Step 2 above for different purposes and from different fuels to obtain the overall energy use and associated performance indicators. Since a building can use more than one fuel (e.g. gas and electricity), the different energy sources have to be converted and combined in terms of primary energy to provide the optional end result of the calculation of energy performance. Commonly used energy indicators for buildings are kWh/m^2 (energy consumption in kilowatt hours per metre square of floor area) or CO_2 emissions

For purposes of this calculation, buildings are classified into categories depending on whether they are residential or non-residential, the type of building design and the building size and use. In addition to calculating the performance of existing buildings, energy performance calculations are also undertaken at the design stage for new buildings and refurbished buildings to simulate their energy performance.

It is the government's responsibility to provide, at national or local level, calculation guidelines and methodologies for determining energy performance. In most instances, software is developed for these calculations.

3.3. Benchmarks

Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared. The two main purposes of benchmarks are:

- To identify if a building's energy performance is good, average or poor with respect to other buildings of its type;
- To identify potential savings, shown by the variance between the actual data and the benchmarks: the worse the performance against a benchmark, the greater the opportunity for improving performance, and making cost savings.

Benchmarks can be categorized into two types—modeled benchmarks and empirical benchmarks.[9]

Modeled benchmarks are obtained by using a simulation model to determine the performance of a building, usually at the design or refurbishment stage. The model calculates the delivered energy needed based on the use of the building, the indoor environment, the external climate and the properties of the building.

[9]EU Energy Performance in Buildings – Directive Implementation Advisory Group: Methodologies in support of the Energy Performance of Buildings Directive: The UK approach to implementation for buildings other than dwellings.

Empirical benchmarks are obtained from statistical data from detailed studies of 20-100 buildings per sector. The minimum information required for benchmarking is how much energy has been used over the last year, which is best obtained from meter readings and energy bills and the floor area. Ideally the studies involve energy audits and in some cases sub-metering (metering the different energy end uses individually), but in most cases only bulk data on the building's energy use is collected. This data sets the good practice and typical standards for each energy use in the building.

3.4. Certifying energy efficiency

An energy efficiency certificate is a summary of the building energy audit. It is meant to give information on the building's energy consumption and its energy efficiency rating.

The purpose of energy efficiency certificates is to:

- Inform tenants and prospective buyers of the expected running costs;
- Create public awareness;
- Act as a prerequisite of measures to improve its energy efficiency;
- To effect incentives, penalties or legal proceedings.

Inform tenants and prospective buyers of the expected running costs – With buyers and prospective tenants better informed, builders and landlords will have greater incentive to incorporate energy-efficient technologies and designs into their buildings, in return for lower running costs.

Create public awareness – In large buildings, regularly visited by the public, display of energy performance certificates will raise awareness among citizens of the issue of energy efficiency in their local community.

Act as a prerequisite of measures to improve its energy efficiency – In the final analysis, knowledge of a building's energy efficiency is also the prerequisite of measures to improve its energy efficiency. The energy efficiency certificate is therefore essentially accompanied by modernization recommendations for low-cost improvement of the building's energy efficiency.

To affect incentives, penalties or legal proceedings – Any effects of these certificates in terms of incentives, penalties or any form of legal proceedings are subject to national legislation. Some countries, e.g. Bulgaria, offer 5-10 year exemptions on building tax to buildings that have high-energy efficiency ratings.

In addition to information on the building's energy performance, a range of recommended and current indoor temperatures and, when appropriate, other relevant climatic factors may also be displayed on the certificates.

What information should be displayed on energy performance certificates, and how that information should be interpreted is a key issue. In order to facilitate comparisons between buildings, the energy performance certificate should include reference values such as current legal standards and benchmarks and recommendations for cost effective investments which can be undertaken in the building to improve its energy performance.

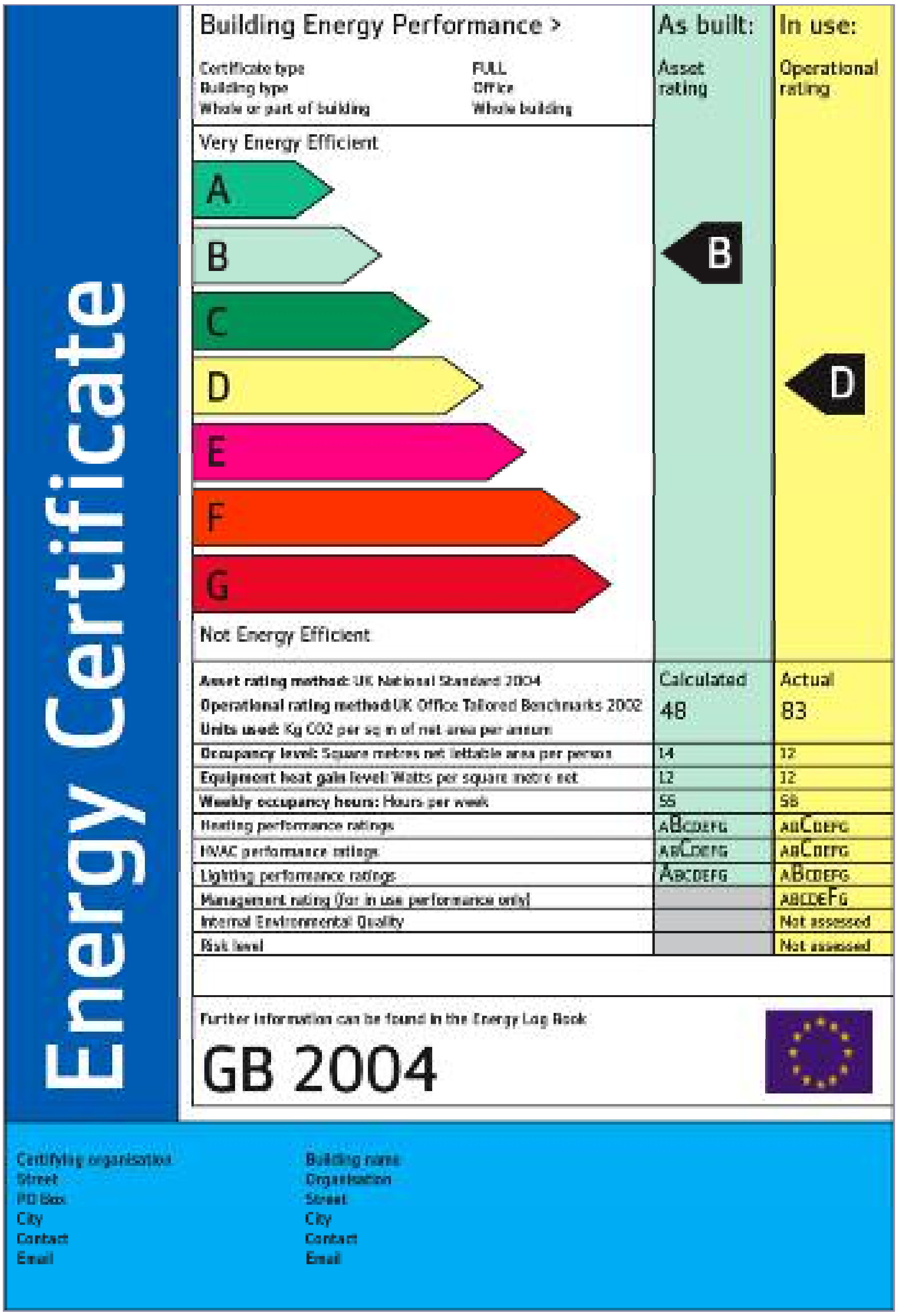
The empirical and modeled benchmarks mentioned above are used to indicate how a particular building compares to the rest of the stock. These benchmarks are used for two ratings normally displayed on the energy performance certificates—the asset rating and the operational rating.

Modeled benchmarks are typically used to rate the intrinsic performance potential of the building and contribute to the building's **asset rating**. This is a rating of the standard of the building fabric and building services equipment and is based on theoretical values.

Empirical benchmarks are typically used to rate the in-use performance of the building—the **operational rating**. This will be influenced by the quality of the building (as measured by the asset rating), but also by the way the building is maintained and operated. The operational rating is based on actual metered energy consumption, normalized in some way to account for the effects of building size, pattern of use, weather, etc.

To supplement certification, in some European countries regular inspection of heating and air-conditioning systems to assess their efficiency and sizing compared to the heating and cooling requirements is carried out.

Figure V. Illustration of a possible format for a non-domestic building energy certificate, proposed by the Europrosper project[a]



[a]European Programme for Occupant Satisfaction, Productivity and Environmental Rating of Buildings 2004: Certification of Existing Building Energy Performance—The Energy Performance Label.

Box 2. **Building energy performance certification and labelling**

The Europrosper project produced a proof-of-concept methodology for determining an "operational rating" for office buildings, and was successfully tested by 79 users across 13 of the EU-15 countries (pre EU-expansion). The method has the following main steps:

- Calculate the building's energy intensity;
- Calculate energy benchmarks appropriate to the specific building and its use;
- Compare energy intensity with benchmarks to determine energy efficiency grade;
- Determine how the energy supplied is broken down by end use;
- Analyse and prioritize potential energy efficiency measures for their cost effectiveness and calculate the potential improvement in the energy efficiency grade;
- Produce an energy certificate that reports all of the above.

Review question

What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

4. ENERGY EFFICIENCY MEASURES FOR BUILDINGS

Energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. They can typically be categorized into:

- Reducing heating demand;
- Reducing cooling demand;
- Reducing the energy requirements for ventilation;
- Reducing energy use for lighting;
- Reducing energy used for heating water;
- Reducing electricity consumption of office equipment and appliances;
- Good housekeeping and people solutions.

Reducing heating demand

Heating demand can be reduced by:

- Limiting the exposed surface area of the building;
- Improving the insulation of the building's fabric;
- Reducing ventilation losses;
- By selecting efficient heating systems with effective controls.

Limiting the exposed surface area of the building

The shape of a building determines how much area is exposed to the outdoors through exterior walls and ceilings. To save energy, try to keep this exposed area to a minimum. The most economical house to build and heat is one with a simple square or rectangular floor plan. Complex shapes increase the exposed surface area as well as the construction and energy costs when a house has a complex shape.

Improving air tightness

Air leaks reduce a building's energy efficiency. Air can leak through cracks or holes in walls, ceilings, floors and around doors and windows. A typical building can lose about one-third of its heat through this infiltration (outside air coming in) and exfiltration (inside air escaping). An airtight house will reduce heat and air movement and be quieter and cleaner. Infiltration and exfiltration losses can be reduced by:

- Installing continuous vapor retarders on walls and ceilings;
- Caulking any holes or cracks on the inside surfaces of walls and ceilings;
- Caulking around windows and door trim on the outside;
- Sealing around window and door trim, and electrical outlets on the inside;
- Sealing around any pipes or ducts that penetrate the exterior walls;
- Weather-stripping windows and doors.

Improving the insulation of the building's fabric

The other two-thirds of heat loss occurs by conduction through foundations, floors, walls, ceilings, roofs, windows and doors. Heat flow in and out of the building from conduction can be reduced with high levels of insulation in the attic, sidewalls, basement walls and doors. Windows should have a low U-value.

Effectively using controls

The main controls used in a heating system are time, temperature and boiler controls and ensuring these are set correctly is the best place to start when looking for savings in a heating system. Time controls turn the heating on and off at predetermined times; advanced time controls monitor internal and/or external temperatures and switch the heating on at the right time to ensure the building reaches the correct temperature by the time it is occupied.

Temperature controls are essential to avoid space overheating and should be used to ensure minimum comfort conditions for employees. The more active the employees, the lower the temperature can be to provide comfort. Temperature controls can be used to pre-cool small office buildings so that they take less power to cool during peak demand and to reduce heat and cooling temperature during unoccupied periods in offices or when occupants are sleeping (in the case of homes or hotels).

By turning the thermostat back 10° to 15° for eight hours, savings of about 5 per cent to 15 per cent a year on heating bills are achievable—a saving of as much as 1 per cent for each degree if the setback period is eight hours long. The percentage of savings from setback is greater for buildings in milder climates than for those in more severe climates. In the summer, similar savings can be achieved by keeping the indoor temperature higher when there are no occupants.[10]

Studies have also shown that significant cooling energy use savings can be achieved if ceiling fans are used in conjunction with higher thermostat set points.[11]

Identifying a suitable heating system

The most appropriate and efficient form of heating for a building will vary depending on the use to which the building is to be put. For buildings which are used intermittently (such as churches) or which have large air volumes (such as industrial units) radiant heating may be an effective form of heating. For buildings which are used more regularly and with smaller air volumes, conventional central hot water systems will be more effective. For non-domestic buildings with varying loads, modular boilers should be used to prevent boilers operating at part load. Condensing boilers should be used in place of conventional boiler plant due to their higher seasonal efficiency; they can be up to 30 per cent more efficient than standard boilers if operating correctly. Where condensing boilers are installed, the use of weather compensation controllers and under-floor heating systems, will improve their efficiency by reducing water flow temperatures.

Reducing cooling demand

Energy use in typical air-conditioned office buildings is approximately double that of naturally ventilated office buildings. The need for air-conditioning or the size of the systems installed can be reduced by:

- Controlling solar gains through glazing;
- Reducing internal heat gains;
- Making use of thermal mass and night ventilation to reduce peak temperatures;
- Providing effective natural ventilation;
- Reducing lighting loads and installing effective lighting controls.

Avoiding excessive glazing

Windows should be sized to provide effective day light while avoiding excessive solar gains. Large areas of glazing will increase solar heat gains in summer and

---

[10] Programmable Thermostats – U.S. DOE, Energy Efficiency and Renewable Energy Network, Consumer Energy Information, www.energyguide.com/library/EnergyLibraryHome.asp?bid=austin&prd=10.

[11] P. W. James, et al., “Are Energy Savings Due to Ceiling Fans Just Hot Air?” Florida Solar Energy Center (FSEC), www.fsec.ucf.edu/en/publications/html/FSEC-PF-306-96/index.htm.

heat losses in winter making it more difficult to provide a comfortable internal environment.

Use of shading

Solar gains can be reduced by the use of external shading, mid pane blinds (where blinds are integrated between the panes of the double or triple glazing unit) or by internal blinds. Internal blinds are the least effective method of controlling solar gains as the heat will already have entered the space. External blinds are the most effective but may be difficult to maintain and are less easily adjusted for controlling glare. Mid pane blinds often provide an effective compromise. They can be raised when solar gains and glare is not an issue or lowered when required. High angle summer sun can be controlled on south facing elevations by the use of overhangs and fixed shading devices. Solar gains to east and west glazing are more difficult to control and will require adjustable shading devices.

Solar control glass

Glazing is available with a range of selective coatings that alter the properties of the glass; ideally glazing should be selected with the highest light transmittance and the lowest solar heat gain factor. This will help provide daylight while reducing solar gains. All major glass manufacturers provide data on the properties of their products, including those with coatings as described here.

Selecting equipment with reduced heat output

Selecting office equipment with a reduced heat output can reduce cooling demands and by ensuring equipment has effective controls that automatically switch it off when not in use. The use of flat screen monitors can significantly reduce heat gains, while at the same time reducing energy use for the equipment and using office space more effectively. These benefits usually compensate for the higher cost of flat screen monitors.

Separating high heat load processes from general accommodation

Where a building includes energy intensive equipment such as mainframe computers, these are best located in a separate air-conditioned space, avoiding the need to provide cooling to the whole building.

Making use of thermal mass and night ventilation to reduce peak temperatures

Thermal mass is the ability of a material to absorb heat energy. A lot of heat energy is required to change the temperature of high-density materials such as concrete, bricks and tiles. They are therefore said to have high thermal mass. Lightweight materials such as timber have low thermal mass.

Thermal mass is particularly beneficial where there is a big difference between day and night outdoor temperature. Correct use of thermal mass can delay heat flow through the building envelope by as much as 10 to 12 hours, producing a warmer house at night in winter and a cooler house during the day in summer. A high mass building needs to gain or lose a large amount of energy to change its internal temperature, whereas a lightweight building requires only a small energy gain or loss. Allowing cool night breezes and/or convection currents to pass over the thermal mass, draws out all the stored energy.

Reducing heat gains from lighting

Heat gains from lighting can be reduced by making best use of day lighting and by providing energy-efficient lighting installations with good controls.

Predicting the impact of passive cooling strategies

Computer simulation tools can be used to predict the likely comfort conditions in buildings and optimize glazing and shading arrangements.

Reducing the energy requirements for ventilation

When the cooling demand is sufficiently reduced by implementing the above measures, it may be possible to reduce heat gains so that air-conditioning is unnecessary and comfort conditions can be maintained through the use of natural ventilation. The energy required for ventilation can be minimized by:

- A building design that maximizes natural ventilation;
- Effective window design;
- Use of mixed mode ventilation;
- Using efficient mechanical ventilation systems.

Building design

The most effective form of natural ventilation is cross ventilation, where air is able to pass from one side of a building to the other. For this to work effectively it typically dictates that buildings are no more than 12-15 m in depth. However, in deeper plan spaces, natural ventilation can be achieved by introducing central atria and making use of the "stack effect" to draw air from the outer perimeter and up through the centre of the building.

Figure VI. Cross ventilation[a]

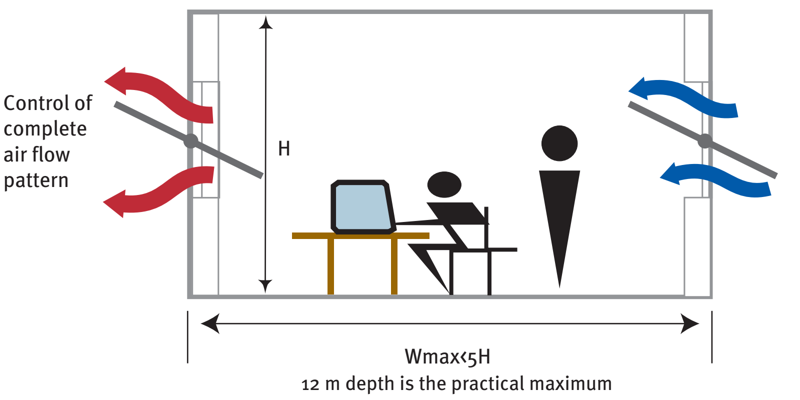
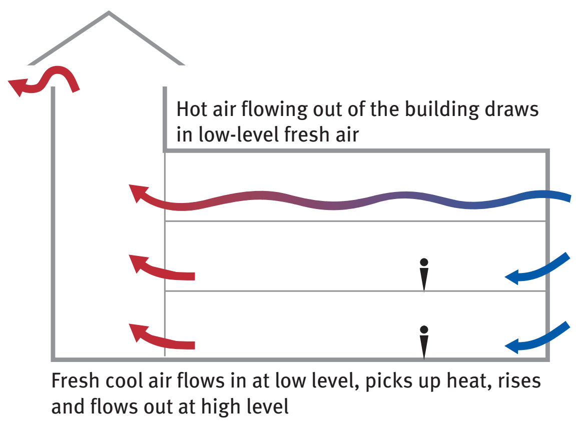


Figure VII. Stack effect[a]



[a]Building Research Energy Conservation Support Unit for the Energy Efficiency Best Practice programme Good Practice Guide 290 Ventilation and cooling option appraisal—a client's guide.

Effective window design

Windows should allow ease of control by building occupants and controlled ventilation that will not blow papers off desks, or cause draughts.

Night ventilation can be an effective method of maintaining comfort conditions in summer. Where night ventilation is used, it is important that building occupants understand how the building is intended to be operated, or that effective control measures are introduced, as it is counter intuitive to open windows before leaving a building at night. Other factors to consider include maintaining security, and controlling wind and rain. In some cases, high ambient noise levels or air pollution may prohibit the use of natural ventilation.

Mixed mode ventilation

Mixed mode ventilation strategies allow natural ventilation to be used for most of the year or to serve parts of a building. Mechanical cooling is used to deal only with peak design conditions in summer or to serve areas of the building that experience a higher build up of heat.

Reducing energy use for mechanical ventilation

The main use of energy for both mechanical cooling and for air conditioning is the fans needed to circulate the air. Fan energy use for mechanical ventilation can be reduced by:

- Designing the system to reduce pressure drops;
- Selecting efficient fans;
- Utilizing variable speed fans to respond to varying load requirements;
- Avoiding excessive air supply volumes.

Reducing energy use for lighting

This can be accomplished through:

- Making maximum use of daylight while avoiding excessive solar heat gain;
- Using task lighting to avoid excessive background luminance levels;
- Installing energy-efficient luminaires with a high light output to energy ratio;
- Selecting lamps with a high luminous efficacy;
- Providing effective controls that prevent lights being left on unnecessarily.

Maximizing the use of daylight

Introducing natural light into buildings both saves energy but also creates an attractive environment that improves the well-being of building occupants. The provision of effective daylight in buildings can be assessed using average daylight factors and by ensuring that occupants have a view of the sky.

The average daylight factor will be influenced by the size and area of windows in relation to the room, the light transmittance of the glass, how bright internal surfaces and finishes are, the depth of reveals, and presence of overhangs and other external obstructions which may restrict the amount of day lighting entering the room.

Window design has a key impact on day lighting. As a rough rule of thumb, a window will introduce effective daylight into a room to a distance twice the head height of the opening. The use of high ceilings and clerestory windows can be effective in providing good daylight. Sunpipes and skylights can be used to introduce daylight to windowless areas.

Energy-efficient lighting system

An efficient lighting installation should be able to provide the required illuminance level for a particular use with minimum energy consumption. Efficient lights should be able to provide illuminance levels of 500 lux[12] on a working plane for less than $12W/m^2$ of installed power.

Lighting controls

Lighting controls should be designed so that small groups of lights can be controlled individually with the controls provided adjacent to the work area. Perimeter lighting should be controlled separately to core lighting so that perimeter lights can be switched off when there is adequate daylight. Absence detection should be provided to rooms that are used intermittently. This should switch lights off automatically after a room or space has been unoccupied for a set period of time. Daylight sensors and timed switches should be used to prevent external lighting being left on unnecessarily. Daylight sensors can also be used to switch off internal lighting when daylight levels are sufficient.

[12]The lux is the SI unit of illuminance. It is used in photometry as a measure of the intensity of light per square metre. Achieving an illuminance of 500 lux might be possible in a home kitchen with a single fluorescent light fixture with an output of 12,000 lumens. To light a factory floor with dozens of times the area of the kitchen would require dozens of such fixtures.

Reducing energy used for heating water

This can be achieved by:

- Installing time controls, and setting them to correctly reflect the hours of hot water requirement;
- Setting sanitary hot water thermostats to the appropriate temperature—no more than 60°C for normal requirements (but ensure the water does not drop below 56°C);
- Switching off electric heating elements (immersion) when hot water from the boiler is available;
- Switching off any associated pumps when hot water is not required;
- Replacing any damaged or missing insulation from all hot water pipe work and cylinders, except where the pipes are providing useful heat into the space;
- Identifying a suitable hot water system.

Hot water provision is either provided via a central generation plant, with a distribution network to provide hot water to the required areas within a building, or by localized provision at the point it is required. Combined heating and hot water systems and separate heating and hot water systems are the two types of centralized hot water systems. In the case of localized hot water systems, water is heated and stored locally or is provided on demand. The most significant reduction in energy use for hot water can be achieved by providing solar water heating.

Reducing consumption of office equipment and appliances

Most businesses rely on a range of office equipment in order to function. From the basic essentials such as computers, monitors, printers, fax machines and photocopiers to projectors, scanners and teleconference facilities, it is widely recognized that these items have become integral to daily activity.

Office equipment is the fastest growing energy user in the business world, consuming 15 per cent of the total electricity used in offices. This is expected to rise to 30 per cent by 2020. There are also associated costs that are often overlooked, specifically those of increasing cooling requirements to overcome the additional heat this equipment produces. As ventilation and air conditioning are major energy consumers themselves, it makes good business sense to ensure they are only used when absolutely necessary.

Typical measures to reduce consumption which also apply to household appliances are:

- Switching off – switching off or enabling power down mode reduces the energy consumption and heat produced by equipment, which in turn lowers cooling costs;
- Upgrading existing equipment – some energy-efficient appliances may cost more to buy but will recoup savings over the lifetime of the equipment;
- Matching the equipment to the task – bearing in mind current and predicted requirements and purchase equipment that meet these;
- Taking advantage of energy labelling schemes – some well know energy labelling schemes are Energy Star, European Ecolabel Scheme, Energy Saving Recommended and The Market Transformation Program.

Box 3. **Energy Star energy efficiency equipment and appliance labelling**

Energy Star labeled products are the same or better than standard products, only they use less energy. To earn the Energy Star, they must meet strict energy efficiency criteria. Energy Star is a US programme for office equipment, appliances, commercial foodservice products, home electronics, home envelope products, lighting, residential heating, cooling and ventilation equipment, new homes and other products. It is widely used and accepted across the commercial sector.

Energy Star models have the following benefits:

- Computers – use 70 per cent less electricity than computers without enabled power management;
- Monitors – use up to 60 per cent less electricity than standard models;
- Printers – use at least 60 per cent less electricity and must automatically enter a lower power setting after a period of inactivity;
- Fax machines – use almost 40 per cent less electricity and may have the capability to scan double-sided pages, reducing both copying and paper costs;
- Refrigerators are at least 15 per cent more efficient than standard models;
- TVs – consume 3 watts or less when switched off, compared to a standard TV, which consumes almost 6 watts on average;
- Light bulbs (CFLs) – use two-thirds less energy than a standard incandescent bulb and must meet additional operating and reliability guidelines;
- Furnaces – are 15 per cent more efficient than the standard.

Figure VIII. The Energy Star label

Good housekeeping and people solutions

The level of achievable energy savings from office equipment is down to the everyday management by staff. A simple energy conservation programme for an organization would consider:

- Setting up an energy policy for the organization;
- Appointing an energy champion;
- Involving staff;
- Setting targets;
- Using notices and reminders;
- Conducting walk-rounds;
- Taking meter readings.

Setting up an energy policy

Commitment to energy efficiency has to come from the top and should be backed up by a personalized mission statement and energy policy. It is also important to appoint an energy champion. In very small businesses, this may be the owner or manager but in larger companies, an appointed staff member will often improve involvement and awareness across the whole organization. Show management commitment by developing a procurement policy whereby energy-efficient products are specified when purchasing.

Involving staff

All staff are important in saving energy, so they must be made aware of wastage areas and be trained to operate equipment and controls correctly. Motivate staff—ask for opinions and encourage people to review their own working practices to increase energy savings. The best ideas usually come from those that use the equipment on a daily basis. Competitions, campaigns and team projects are great ways to get buy-in. Reinforce the benefits of improving the working area and give staff a sense of ownership of energy management.

Setting targets

Tell staff how much energy is currently being a consumed and set a realistic savings target. As the energy-saving programme gathers momentum, it will be possible to track progress and highlight energy savings.

Using notices and reminders

Use notices and reminders on turning off equipment. They can also be used to highlight how this makes the working environment more pleasant.

Conducting walk-rounds

Carrying out regular good housekeeping walk-rounds in your building to find out where energy is being used. Note down when equipment is being used and act on any wastage or maintenance measures needed. As patterns of energy use vary throughout the day, it is advisable to carry out a series of walk-rounds at different times to get a better idea of where and when energy is being wasted. Walking round your office after everyone has left, before everyone comes in and when offices are empty during the day, gives an idea of what equipment tends to be left on out of office hours.

Take meter readings

Meter readings can give a picture of the energy usage in the office. Meter readings can be used to determine electricity use during and after office hours. These figures give an idea of the energy used every hour the office is empty and to find out how much energy is used when no one is in the building. In most offices, the overnight energy consumption should only be a small percentage of the overall energy use.

Exercise

From the measures mentioned above, list:

1. Those easiest to implement in your country.
2. Those with the highest potential savings.

5. FINANCING ENERGY EFFICIENCY IN BUILDINGS

There is a tendency in many businesses and public sector enterprises to undervalue cost reduction where this itself requires investment. This happens when the organization fails to see the connection between the investment and the benefits derived from it. Conventional financial management information systems do not make visible the benefit the business derives from energy saving investments.

Financial appraisal involves finding and evaluating the best projects to invest in whatever they are and wherever they arise. It gives energy savings the priority they merit when compared with other aspects of cost reduction or business expansion. The six key steps in financial appraisal of energy efficiency investment in buildings are:

- Locating the buildings which have the potential;
- Identifying the area in each of these buildings where a saving can be made and identifying the measures required to release these savings;
- Establishing the costs and the savings for each measure and calculating the key financial indicators, such as payback period and net present value;
- Optimizing the financial return measured by these indicators for each project, and the portfolio of projects;
- Establishing how much investment capital is available and identifying new sources of capital;
- Deciding which projects make best use of the organization's available capital.

The most common reason for the failure of financial appraisals is that they are too optimistic and in most cases do not give a true financial picture of a project, either through overstating the benefits or understating the costs. Costs for energy saving projects in buildings are usually easier to establish than savings. A good energy monitoring system will make it easier to predict the effect of a proposed project on energy use and cost.

5.1. Energy efficiency financing mechanisms

After appraising the required energy efficiency measures, the next challenge is sourcing the necessary capital to implement them. Listed below are several options for financing energy efficiency measures for buildings.

Internal funds

Energy efficiency improvements are financed by direct allocations from an organization's own internal capital or operating budget. The most direct way to pay for energy efficiency improvements is to allocate funds from the internal capital or operating budget. Financing internally has two clear advantages over the other options: it retains internally all the savings from increased energy efficiency, and it is usually the simplest option administratively. All or some of the resulting savings may be used to decrease overall operating expenses in future years or retained within a revolving fund and used to support additional efficiency investments. Many public and private organizations regularly finance some or all of their energy efficiency improvements from internal funds.

Debt financing

Energy efficiency improvements are financed with capital borrowed directly by an organization from private lenders and include municipal bonds. Direct borrowing of capital from private lenders can be an attractive alternative to internal funding for energy efficiency investments. For both public and private organizations, this approach avoids tapping internal funding, and financing costs can be repaid by the savings from increased energy efficiency. Additionally, municipal governments often issue bonds or other long-term debt instruments at substantially lower interest rates than private corporate entities. As in the case of internal funding, savings from efficiency improvements, less only the cost of financing, are retained internally. Debt financing is administratively more complex than internal funding.

In general, debt financing should be considered for large projects that involve multiple buildings and pose relatively little risk in achieving their energy savings targets. When considering debt financing, organizations weigh the cost and complexity of the type of financing against the size and risk of the proposed projects.

Lease or lease-purchase agreements

Energy-efficient equipment is acquired through an operating or financing lease of 5-10 years with no up-front costs. Leasing and lease-purchase agreements provide a means to reduce or avoid the high, up-front capital costs of new, energy-efficient equipment. These agreements may be offered by commercial leasing corporations, management and financing companies, banks, investment brokers, or equipment manufacturers. As with direct borrowing, the lease should be designed so that the energy savings are sufficient to pay for the financing charges.

Financing leases are agreements in which the lessee essentially pays for the equipment in monthly installments. Although payments are generally higher than for an operating lease, the lessee may purchase the equipment at the end of the lease for a nominal amount.

Guaranteed savings leases are the same as financing or operating leases, but with an additional guaranteed savings clause. Under this type of lease, the lessee is guaranteed that the annual payments for leasing the energy efficiency improvements will not exceed the energy savings generated by them. The building owner pays the contractor a fixed payment per month. However, if the actual energy savings are less than the fixed payment, the owner pays only the amount saved and receives a credit for the difference.

Energy performance contracts

Energy efficiency measures are financed, installed and maintained by a third party that guarantees savings and payments based on those savings. Energy performance contracts are generally financing or operating leases provided by an energy service company (ESCO) or equipment manufacturer. What distinguishes these contracts is that they provide a guarantee on energy savings from the installed retrofit measures, and they usually also offer a range of associated design, installation and maintenance services.

Under an energy performance contract, the ESCO provides a service package that typically includes the design and engineering, financing, installation and maintenance of retrofit measures to improve energy efficiency. The scope of the improvements can range from work that affects a single part of a building's energy-using infrastructure (such as lighting) to a complete package of improvements for multiple buildings and facilities. Generally, the service provider will guarantee savings as a result of improvements in both energy and maintenance efficiencies.

An energy performance contract must define the methodology for establishing the baseline costs and cost savings and for the distribution of the savings to the parties. The contract must also specify how the savings will be determined and address contingencies such as utility rate changes and variations in the use and occupancy of a building.

Utility incentives

Rebates, grants, or other financial assistance offered by an energy utility for the design and purchase of certain energy-efficient systems and equipment usually as a result of the implementation of a policy to promote energy efficiency. Some utilities offer financial incentives for the installation of energy-efficient systems and equipment. These incentives are available for a variety of energy-efficient products including lighting, heating, ventilation and air-conditioning systems, energy management controls and others. The most common incentives are equipment rebates, design assistance and low-interest loans (see box 4). In general, the primary purpose of utility incentives is to lower peak demand. Overall energy efficiency is an important but secondary consideration. Incentives can be in several forms:

Equipment rebates

Offering rebates on the initial purchase price of selected energy-efficient equipment. An electricity consumer for instance who switches from incandescent lights to efficient compact fluorescent lights could get a refund on the tax they paid through the electricity utility company for the lights through a reduction on their electricity bill by a similar amount.

Box 4. **Energy efficiency commitment of the United Kingdom**

The Energy Efficiency Commitment (EEC) was introduced in April 2002, by the Department of Environment, Food and Rural Affairs (Defra), and set a three-year energy savings target for domestic energy suppliers to help reduce carbon emissions by improving energy efficiency in households. The EEC is administered by Ofgem, the Office of Gas and Electricity Markets.

This energy-saving target is met through measures such as offering cavity wall and loft insulation, using energy-efficient boilers, appliances and light bulbs. At least half of these savings are aimed at low-income consumers in order to alleviate fuel poverty.

As a result of the EEC, the U.K.'s fuel utility companies set up an energy efficiency commitment fund. The money contributed by the fuel companies is used to fund various energy efficiency schemes for homeowners and tenants. Some schemes are UK-wide, whilst others are run locally. Some are run directly by the fuel companies, whilst others are carried out in partnership with local councils, housing associations and other relevant agencies.

The first EEC period from 2002 to April 2005, saw energy suppliers set an overall three-year target of 62 TWh total energy savings. The total was exceeded, reaching 86.8 TWh savings. The current EEC period began in April 2005 and has a three-year energy savings target of 130 TWh. It is estimated energy suppliers will have to invest approximately £1.2 billion in order to meet the challenge.

Design assistance

Provision of direct grants or financial assistance to architects and engineers for incorporating energy efficiency improvements in their designs. This subsidy can be based on the square footage of a building, and/or the type of energy efficiency measures being considered. Generally, a partial payment is made when the design process is begun, with the balance paid once the design has been completed and installation has commenced.

Low-interest loans

Provision of loans with below-market rates for the purchase of energy-efficient equipment and systems. The source of funding could be through loans from development banks accessed through government for this aim or from an energy efficiency fund levied from utilities.

Local authority and national assistance

Matching grants, loans or other forms of financial assistance may be available from the local or state governments. In countries with energy efficiency policies, a variety of state-administered programmes for building efficiency improvements are often available, some of which are funded through grants and programmes and national energy programme funds.

Box 5. **Salix: working with the public sector to reduce carbon emissions through investment in energy efficiency measures and technologies in the United Kingdom**

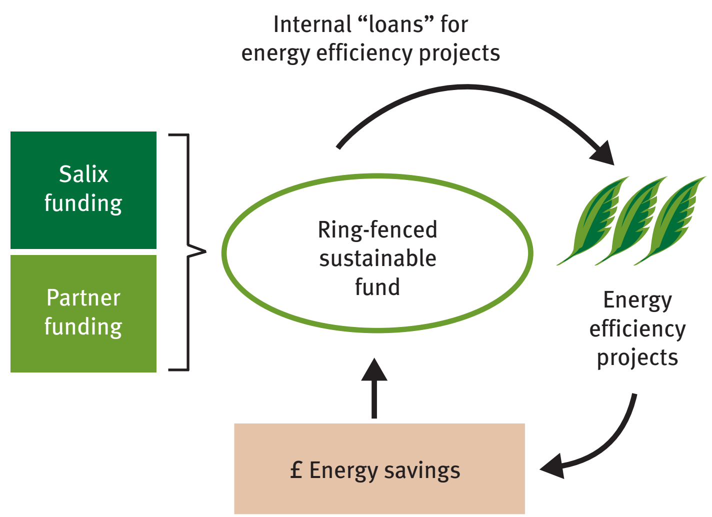
Escalating energy prices and the urgency attached to climate change has increased the need to significantly scale up the implementation rate of energy saving measures and technologies in the United Kingdom. Salix is an independent company set up by The Carbon Trust—a government-funded company—which helps the United Kingdom's business and the public sectors cut carbon emissions. Salix was established in 2004 to work with the public sector to reduce carbon emissions through investment in energy efficiency measures and technologies. Due to the success of its pilot, the Local Authority Energy Finance Scheme, Salix is extending the range and scale of its operations by increasing the number of local authorities that it currently works with as well as opening the scheme to a larger number of qualifying public sector bodies.

By combining grant funding and its expertise, Salix gives organizations an opportunity to both improve energy efficiency and reduce energy costs while taking a leadership role in tackling climate change. Salix will provide a grant of typically £200,000 to kick-start an energy efficiency drive affecting all components of the partner's estate. The partner organization will be required to supplement this grant to make up the total "invest to save" ring-fenced fund.

Monies dedicated to implementing energy saving projects will be provided by this fund through interest-free internal "loans". Loans are repaid using a minimum of 75 per cent of annual savings. Once the project loan has been repaid to the fund the project recipient will continue to benefit from the ongoing energy savings. As repayments are recycled into the fund they become available for re-investment, hence creating a self-sustaining fund.

The United Kingdom's Carbon Trust also offers interest-free energy efficiency loans to small or medium-sized enterprises (SMEs) that have been trading for at least 12 months. SMEs can borrow from £5,000 to £100,000 unsecured, interest free and repayable over a period of up to four years.

Figure IX. The Salix funding mechanism



Review question

List and describe four mechanisms for financing energy efficiency in buildings.

Discussion question

Outline how at least two of the finance mechanisms outlined here would be applied in your country highlighting how they would be affected and which organizations would be involved.

6. DEVELOPING AND IMPLEMENTING POLICY ON ENERGY EFFICIENCY IN BUILDINGS

To ensure effective implementation of energy efficiency in buildings involves the development and formulation of an energy efficiency policy and the enactment of a legal and institutional framework.

The formulation of an energy efficiency policy should be developed by the relevant ministry[13] in partnership with relevant stakeholders. The policy is owned by the ministry and guides the ministry on what it would like to achieve, how long it will take and what it should do to achieve it. The energy efficiency policy does not have to be exclusive to buildings and can cover energy efficiency in buildings, industry as well as supply and demand-side management if policies for these do not already exist. The drafting of a law to implement and enact the policy is the only guaranteed means to ensure its application. An "Energy Efficiency for Buildings Act" will:

- Establish an energy efficiency agency or bureau and define its functions and powers;
- Establish or identify a body to facilitate and enforce efficient use of energy in buildings;
- Establish penalties for failure to comply to the energy efficiency building standards[14] and set up a body or office with powers to adjudge compliance;
- Establish an appellate tribunal and appeal framework to hear appeals of those who have been adjudged and penalized.

6.1. The formulation of an energy efficiency policy

Policy is formulated on a need basis, and therefore policymakers require a clear picture of the contribution of buildings to the country's total energy consumption, the future impact of urbanization and increase in the number of new buildings vis-à-vis energy demand and the potential for energy savings from large-scale implementation of energy efficiency measures in existing and future buildings.

---

[13] Ministry of Energy, but requires participation from the Ministry Public Buildings of Works (responsible for monitoring the building industry).

[14] Penalties for failure to comply with standards can be established during the formulation of the policy or by the regulator. Under India's Energy Conservation Act, those who fail to comply with the energy efficiency provisions are liable to a penalty of up to $US 230 for each failure and an additional $US 23 per day in the case of continuing failures. In Bulgaria, the penalty is $US 330-2000.

Policymakers also need to understand the potential benefits of more energy-efficient buildings, these benefits being:

- Improving the security of supply and reducing the need for imported energy;
- Reducing the needs for new investments in energy generation;
- Having a favourable social effect, bringing down energy bills and needs for subsidies;
- Reducing the adverse impact of energy production and energy use on the environment.

In most developing countries there is little or no information on the energy consumption of buildings or the potential energy savings. There are methodologies that have been developed to collect this data, but they have to be adapted to the local situation. This information gap is a major barrier to making a convincing argument towards the formulation of an effective policy. Therefore an initial data collection and information-sharing phase is required to kick-start the process.

During the policy formulation phase, the relevant ministry should involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers. The policy should:

- Outline the need for and benefits of energy efficiency in buildings;
- Estimate potential savings both in terms of energy use and reduction of capacity;
- Set achievable targets and timelines;
- Outline an approach to achieve the targets and monitor them;
- Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;

Consider the financial support instruments for undertaking energy efficiency measures.

6.2. Implementing policy on energy efficiency in buildings

To implement policy, certain bodies need to be set up to operationalize it. These would consist of an agency whose role is to develop and recommend a framework for the policy, a regulator to facilitate and enforce the policy, an adjudicating body to mete out penalties and an appellate tribunal to hear appeals against the orders of the adjudicating body. These bodies are set up by an act of parliament, through which their functions and powers are defined.

The energy efficiency agency

The role of the agency would be to develop and recommend a framework for application of the policy, create awareness, provide guidance and information to stakeholders, and actively promote energy efficiency in buildings.

The functions of the agency would be to:

- Recommend the application and exemption i.e. which buildings based on application, size, and/or energy consumption the policy will target or exempt;
- Develop standard methodology for assessing the energy requirements of existing or proposed buildings and specify the manner and intervals of time in which energy audits shall be conducted;
- Develop energy efficiency benchmarks to gauge the level of efficiency of a building and to set energy efficiency targets/requirements for buildings;
- Develop a certification and labelling criteria for buildings and appliances to prescribe guidelines for energy conservation building codes;
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy in buildings;
- Promote research and development in the field;
- Strengthen consultancy services in this field;
- Formulate and facilitate implementation of pilot projects and demonstration projects for promotion of efficient use of energy in buildings;
- Promote use of energy-efficient processes, equipment, devices and systems;
- Promote innovative financing of energy efficiency projects;
- Give financial assistance to institutions for promoting efficient use of energy and its conservation;
- Levy fee, as may be determined by regulations, for services provided for promoting efficient use of energy in buildings;
- Specify, by regulations, qualifications for accredited building energy auditors;
- Register and maintain a list of accredited building energy auditors;
- 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;
- Implement international cooperation programmes;
- Create awareness and disseminate information for efficient use of energy in buildings.

The energy efficiency agency will require advisory committees to guide it in performing these functions as it builds its own internal capacity. The committees also ensure contributions and participation from experts and key stakeholders. The energy efficiency agency is also best placed to make recommendations of suitable penalties and incentives.

The energy efficiency regulator

The energy efficiency agency could also double up as the regulator, but it has to be structured so that both arms are complementary. In some developing countries, a regulatory body for electricity or energy already exists and could be mandated to be the energy efficiency regulator as well instead of establishing a new body. The regulatory body would have authority to:

- Specify and prescribe the energy efficiency norms and standards for buildings and appliances;
- Specify the application and exemption i.e. which buildings based on application, size, and/or energy consumption the policy will target or exempt;
- Specify equipment or appliance or class of equipments or appliances, for which the law/act applies;
- Prohibit manufacture, sale, purchase or import of equipment or appliances specified unless such equipment or appliances conforms to energy consumption standards;
- Specify certification and labelling of buildings and appliances;
- Direct any designated consumer to get an energy audit conducted by an accredited energy auditor;
- Direct any designated consumer to furnish to the designated agency, information with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor;
- Direct any designated consumer to designate or appoint an energy manger in charge of activities for efficient use of energy and its conservation and submit a report, in the form and manner as may be prescribed, on the status of energy consumption at the end of the every financial year to the designated agency;
- Direct every designated consumer to comply with energy consumption norms and standards;
- Prescribe energy conservation building codes for efficient use of energy;
- Amend the energy conservation building codes to suit the regional and local climatic conditions;
- Direct every owner or occupier of the building or building complex, being a designated consumer to comply with the provisions of energy conservation building codes for efficient use of energy and its conservation.

The regulator could also be required to:

- Make available all compliance material for buildings and create awareness and disseminate information on this material;
- Appoint inspecting officers for the purpose of ensuring compliance with energy consumption standards specified;
- Arrange and organize training of personnel and specialists;
- Encourage preferential treatment for application of energy-efficient measures and use of energy-efficient equipment or appliances;
- Constitute a fund for the purpose of promotion of efficient use of energy and its conservation to be credited all grants and loans that may be made by the government or any other organization or individual for the purposes of this Act.

The energy efficiency adjudicating body

The functions of this office would be to:

- Set penalties (fine or jail) and how they would be applied in case of failure to comply to energy efficiency standards;
- Holding inquiries, establishing and meting out penalties.

The appellate tribunal

The tribunal would be responsible for:

- Developing an appeal framework to hear appeals of those who have been adjudged and penalized:
- Hearing and judging on appeals against the orders of the adjudicating officer/body.

? Review question

List five functions of the energy efficiency agency.

Discussion questions

1. What would be the most suitable model in your country with regard to the bodies required to operationalize an "Energy Efficiency in Buildings Policy" and their functions?
2. How would you set up an energy efficiency fund in your country? Where would the funds be sourced from and what criteria would you use to allocate the funds?

7. POLICY TOOLS TO PROMOTE BUILDING EFFICIENCY

The most effective programmes are designed not only to ensure that a particular target level of energy efficiency improvement is realized but also to assure that the market is prepared continually to introduce better and better technologies for energy efficiency.

This process of continuous improvement in energy efficiency should be anticipated in the developmental process for energy efficiency codes by requiring that the codes be reviewed periodically—such as every three or four years—and updated to include requirements for the use of newer technologies that are cost-effective and feasible.

Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:

- Codes and standards for new construction and performance-based economic incentives to go beyond the standards;
- Long-term incentives with ambitious energy efficiency targets;
- Normative labels to distinguish the most energy-efficient buildings and equipment;
- Informative labels that provide the information necessary to measure energy efficiency and annual energy costs for operation;
- Education and outreach to promote market acceptance of energy efficiency technologies and energy-efficient designs, most notably efficiency demonstration centres;
- Government-funded research and development on energy efficiency in buildings.

7.1. Codes and standards

Codes refer to mandatory energy efficiency requirements for new construction in buildings. New construction refers either to an entirely new building being erected, or the construction of a new energy-using system (such as a lighting system or an air conditioning system) in an existing building. Standards refer to minimum mandatory requirements for equipment used in buildings, such as air conditioning units, furnaces or boilers, water heaters, office equipment, appliances, etc.

Before adopting codes and standards, the regulator must first develop testing protocols and methodologies to determine how much energy the whole building uses, how much each of the energy-using components contribute to the total energy use and benchmarks for new and existing buildings. Ideally, compliance with these protocols will yield databases listing the performance of each product or building offered for sale, and labels publicizing the tested performance.

Residential and non-residential buildings

All of the major energy-related choices—the thermal conductivity of insulation, the thermal transmission qualities of windows, the heat capacity of building materials, the solar heat transmission qualities of windows, the visible light transmission of windows, the air and water movement output of fans and pumps, the efficiency of motors, heat transfer efficiencies of heaters for air and water, etc.—must be determined by standardized measurements. Before advanced energy-efficient equipment requirements can be determined for either a mandatory or a voluntary programme, test protocols and labelling rules must be established and enforced.

For building energy efficiency, the most effective codes offer two options of compliance, called prescriptive and performance-based.

Prescriptive standards set requirements for the components of a building, for example, the thermal conductivity of insulation or the efficiency of a heating or cooling device. They do not offer the designer the flexibility to vary from many of these minimum specifications.

Performance-based standards, on the other hand, set maximums on the energy consumption or annual predicted energy cost of a building taken as a whole. They allow the designer to specify less energy efficiency in some components in return for more efficiency in others. They are more economically efficient because they allow the designer or builder to optimize the selection of efficiency measures to minimize first costs. They also tend to lead to innovations in which the efficiency measures actually used are better than the ones that were required in the prescriptive standards.

In addition to establishing protocols for testing buildings and components and regulating minimum acceptable levels of performance, the regulator must develop plans for implementation and enforcement of the standards. These can be more difficult to establish at first, since the goal is to establish a positive feedback cycle in which companies and individuals that comply receive positive reinforcement in the marketplace, where those that are out of compliance face potential penalties. Once it is established that a code will be enforced, it is not difficult to maintain these positive expectations, but a jurisdiction must plan to make significant initial efforts to enforce the code with credibility.

Certain categories of buildings may be exempted from these standards, e.g. buildings and monuments designated officially as protected, places of worship, temporary buildings with a planned time of use of two years or less, non-residential agricultural buildings with low energy demand, buildings whose useful floor area is below a certain range (e.g. less than 1,000 square metres)

New constructions

Standards for new construction can be adopted legislatively or administratively. Where legislative adoption has been used, the legislative body has often adopted the local requirements of a national or international model, rather than having the details worked through the legislative process.

Authority is often delegated to an administrative agency which is provided with general instructions or criteria that code revisions must meet. These typically require that the code incorporate all energy efficiency measures that are technologically feasible and cost effective to the consumer over the lifetime of the building.

A second general process is for the agency to allow public comment on draft standards and require the agency to respond to this commentary. Public comment identifies areas with problems for implementation in advance and can create a more positive attitude among the design and construction community towards eventual compliance. The authorizing legislation usually specifies what agencies are responsible for implementing the energy standard. It may or may not be the same agency that adopts it.

Implementation will require a programme of outreach and education to enforcement officials, building designers and the construction industry. At a minimum, this includes a means for disseminating current and updated versions of these standards and a process for compiling and publicizing interpretations of the standards as they are made.

Implementation should also include the development and dissemination of design manuals that show how to construct buildings or details such that they comply. The design manuals should almost motivate the designer to meet or do better than the energy code.

There also needs to be an agency to provide fast-response telephone and e-mail answers to questions concerning the meaning of the code. Frequent training of code enforcement officials as well as building industry officials has proven necessary. Government as part of the legislation authorizing the standards can provide funding for training. But usually other funding sources have been used. Some form of third-party inspection by government officials or independent private sector inspectors is necessary to assure quality control.

In many countries, building inspectors at the local level already certify building compliance with construction codes with respect to fire safety, electrical safety, etc. These officials can also enforce energy codes. But they will require frequent training as well as motivation to get them to do so. Some jurisdictions, instead of relying on building code inspectors, allow or require the use of independent third-party private sector inspectors. In this case, the energy agency must establish standards for technical expertise, professional conduct and financial independence of the inspector from the builder in order to assure that the private sector inspectors are doing their job.

Refurbishing and renovations

There are two ways to affect energy efficiency in existing buildings. The first is to require that energy efficiency measures be installed when a major renovation or reconstruction is taking place. This could include something as minor as a new tenant moving into an existing commercial building and installing a replacement lighting system; in this case, the codes require that the new lighting system comply with the same energy efficiency standards as if it were an entirely new building. Similarly, when a component in a building is replaced in a fashion that requires a building permit, the component can be required to have the same energy efficiency as it would for a new building (or even a somewhat different level of efficiency).

A second way of addressing the problem of existing buildings is to require retrofits at a particular time, typically, point of sale. In this case, the code requires the owner to undertake construction projects that would not have been undertaken at all but for the energy code, in contrast to requiring that upgrades already being undertaken be done in an energy-efficient manner. However, mandatory energy efficiency standards for retrofit buildings are relatively rare.

7.2. Incentives

Economic incentives complement codes and standards. They depend on the prior existence of these standards both to establish the criteria by which superior performance can be measured and to establish levels of efficiency at which economic incentives are justified. In turn, incentives can complement standards by providing for differentiation in the marketplace between low efficiency, typical and high efficiency buildings or products. Incentives can also encourage the widespread use of new technologies that may later be appropriate for standards, but which it is impossible to require at a given time due to questions of availability or universality of application.

Although incentives are often more effective than regulation, they must be balanced against the need to provide a financial revenue source for the incentives. Standards require a dramatically smaller investment by the government in producing a given level of energy efficiency. They also guarantee that at least a basic level of efficiency will be met in all cases covered by them.

Legislation establishing programmes for energy efficiency incentives must provide a funding mechanism for the incentive as well as an administrative mechanism for spending the money in the most effective way.

7.3. Certification and labelling

Labels can typically be distinguished as normative or informative.

Normative labels

Normative labels mark products or buildings that achieve an “exemplary” or recommended level of energy efficiency higher than the typical level of efficiency. Normative labels can be established as a freestanding government programme, or as private sector programmes.

Government policy can make use of normative labels by requiring that products purchased by the government directly or on government contracts qualify for the appropriate label.

Informative labels

Information labelling as a policy tool can be a meaningful part of energy efficiency policy. It could encompass new and existing buildings or could be limited to new buildings only. The European Union, for example, has recently required that all buildings be rated for energy efficiency over the next several years. However, the EU is yet to implement a standardized test protocol with which to do such ratings. These ratings would apply to all buildings, both existing and new.

Box 6. **Energy benchmark pool for commercial buildings in Frankfurt**

The energy agency of Frankfurt organized an energy benchmark pool for commercial buildings. Users, owners and investors of buildings are invited to analyse and optimize the energy use of their buildings in small groups of up to 10 participants and the results are published anonymously. The aim is to enforce competition of energy-efficient buildings in Frankfurt and to give owners and investors clear figures to describe energy efficiency for their planners.

Facilitation of a benchmark process with the owners, users or investors of a commercial building:

- Step 1: Introduction workshop (questionnaire and determination of the benchmark process);
- Step 2: Data collection through the participants;
- Step 3: Data analysis through the energy agency;
- Step 4: Discussion of the analysis, experience and information exchange and best practice presentation in up to three workshops;
- Step 5: Collection and public presentation of the (anonymous) results;
- Step 6: Continuous experience exchanges twice a year.

The results from the process were:

- On average, 25 per cent of the total energy demand of the buildings was identified as a saving potential with a payback time of less than five years.
- Typically 10-15 per cent of the total demand could be saved only by optimizing the running time of the equipment without any investment
- For the first time, the electricity demand in 10 big office buildings in Frankfurt was analyzsed in great detail (parts of lighting, HVAC, office equipment, etc.) showing large deviations in specific demands as well as high saving potentials.

The implementation of the defined potential energy saving initiatives is still in process.

Lessons learned

A huge improvement in the energy efficiency awareness of the responsible manager is one of the positive aspects of project implementation. It is necessary to hold a process that is attractive to both the technical and financial departments.

8. CONCLUSION

With the current rate of urbanization and the subsequent increase in energy demand, energy efficiency in buildings has a significant role to play in contributing to energy security in developing countries. With the increasing cost of complexity of new energy sources and the escalating cost of energy, governments should share the burden and cost of ensuring security of supply with end-users through energy efficiency.

Technological improvements in building design and appliances offer new opportunities for energy savings. Furthermore, many of these technologies are yet to be adapted to African environments and other developing countries suggesting a huge potential for savings. Resistance to change and the cost of implementing energy savings means that unless a policy and regulatory framework is set up, there is unlikely to be any change.

The lack of information on energy consumption trends in buildings and the opportunities and potential for energy savings is a significant barrier. These numbers are imperative to develop effective policies and set realistic and achievable targets.

Policy formulation should be consultative and involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers. An effective policy for energy efficiency in buildings should:

- Outline the need for and benefits of energy efficiency in buildings;
- Estimate potential savings both in terms of energy use and reduction of capacity;
- Set achievable targets and timelines;
- Outline an approach to achieve the targets and monitor them;
- Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;
- Consider the financial support instruments for undertaking energy efficiency measures.

An appropriate institutional framework is necessary to implement policy. These institutions would have the functions of developing and recommending a framework for the policy, facilitating and enforcing the policy, meting out penalties and hearing appeals against penalties. These institutions are set up by an act of parliament, through which their functions and powers are defined.

LEARNING RESOURCES

Key points covered

The module covers the following key points:

- The building sector is an important contributor to any country's total energy consumption. Globally, the building sector is responsible for more electricity usage than any other sector—42 per cent. While building sector energy consumption is generally greater in developed countries than in developing countries, it is still an issue (and a growing issue) for developing countries, particularly for those with restricted generating capacity.
- While the building sector is a major energy consumer, including residential, commercial and industrial buildings, very considerable energy savings are possible—with many being achievable at a relatively low cost.
- There are many different energy flows within any given building—into and out of the building. Methodologies are available to measure a building's energy performance.
- Energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. They can typically be categorized into:
  - Reducing heating demand;
  - Reducing cooling demand;
  - Reducing energy requirements for ventilation;
  - Reducing energy used for lighting;
  - Reducing energy used for heating water;
  - Reducing electricity consumption of office equipment and appliances;
  - Good housekeeping and people solutions.
- To ensure effective implementation of energy efficiency in buildings involves the development and formulation of an energy efficiency policy and the enactment of a legal and institutional framework. To implement policy, certain bodies need to be set up to operationalize it. These would consist of an agency whose role is to develop and recommend a framework for the policy, a regulator to facilitate and enforce the policy, an adjudicating body to mete out penalties and an appellate tribunal to hear appeals against the orders of the adjudicating body. These bodies are set up by an act of parliament, through which their functions and powers are defined.
- There is a tendency in many businesses and public sector enterprises to undervalue cost reduction where this itself requires investment. This happens

when the organization fails to see the connection between the investment and the benefits derived from it. Conventional financial management information systems do not make visible the benefit the business derives from energy saving investments. However, as the different real-life experiences presented in the module and case studies show, energy efficiency in buildings can yield significant financial benefits. Financial appraisals need to be conducted (and in the right way) to demonstrate a project's potential to save energy and hence save money for the building's owner/operator.

Answers to review questions

Question: What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

Answer:

Energy efficiency benchmarks are representative values of energy consumption for common building types against which a building's actual performance can be compared.

To determine how efficient or inefficient a building is, its energy consumption is compared with the benchmark for a building of its type, use and performance in a similar climatic zone

Question: List and describe four mechanisms for financing energy efficiency in buildings

Answer:

1. Internal funds: Direct allocations from an organization's own internal capital or operating budget. All or some of the resulting savings may be used to decrease overall operating expenses in future years or retained within a revolving fund and used to support additional efficiency investments.

2. Debt financing: Capital borrowed directly by an organization from private lenders. As in the case of internal funding, savings from efficiency improvements, minus only the cost of financing, are retained internally.

3. Lease or lease-purchase agreements: Energy-efficient equipment is acquired through an operating or financing lease with no up-front costs. Leasing and lease-purchase agreements provide a means to reduce or avoid the high, up-front capital costs of new, energy-efficient equipment.

4. Energy performance contracts: Energy efficiency measures are financed, installed and maintained by a third party that guarantees savings and payments based on those savings. Energy performance contracts are generally financing or operating leases provided by an energy service company (ESCO) or equipment manufacturers. They provide a guarantee on energy savings from the installed retrofit measures, and they usually also offer a range of associated design, installation and maintenance services.

5. Utility incentives: Rebates, grants or other financial assistance offered by an energy utility for the design and purchase of certain energy-efficient systems and equipment usually as a result of implementation of a policy to promote energy efficiency.

Question: List five functions of the energy efficiency agency

Answer:

- Recommend the application and exemption i.e. which buildings based on application, size and/or energy consumption the policy will target or exempt.
- Develop a standard methodology for assessing the energy requirements of existing or proposed buildings and specify the manner and intervals of time in which energy audits shall be conducted.
- Develop energy efficiency benchmarks to gauge the level of energy efficiency of a building and to set energy efficiency targets/requirements for buildings.
- Develop certification and labelling criteria for buildings and appliances to prescribe guidelines for energy conservation building codes.
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy in buildings.
- Promote research and development in the field.
- Formulate and facilitate implementation of pilot projects and demonstration projects for promotion of efficient use of energy in buildings.
- Promote use of energy-efficient processes, equipment, devices and systems.
- Promote innovative financing of energy efficiency projects.
- Give financial assistance to institutions for promoting the efficient use of energy and its conservation.
- Levy fee, as may be determined by regulations, for services provided for promoting efficient use of energy in buildings.
- Specify, by regulations, qualifications for accredited building energy auditors.
- Register and maintain a list of accredited building energy auditors.
- Implement international cooperation programmes.
- Create awareness and disseminate information for efficient use of energy in buildings.

Presentation/suggested discussion topic

Presentation:

ENERGY EFFICIENCY – Module 18: Energy efficiency in buildings

Suggested discussion topic:

1. What incentives would you recommend to facilitate energy efficiency measures in buildings in your country and how would you implement them?

Relevant case studies

1. Sustainable energy authority in Australia.
2. Improving energy efficiency in Ekurhuleni Metropolitan Municipal (EMM) Buildings, South Africa.
3. Efficient lighting in Latvian Academy of Sport Education (LASE), Latvia.
4. Passive design in local government offices in Ireland

REFERENCES

Directive 2002/91/ec of the European Parliament and of the Council on the Energy Performance of Buildings, 2002.
eurlex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=2002&nu_doc=91

Energy Efficiency Division of the Philippines Department of Energy (DOE), 2002, Philippines Guidelines for Energy Conserving Design of Buildings and Utility Systems.
www.doe.gov.ph/downloads/default.htm

Michael Laar and Friedrich Wilhelm Grimme, 2002. Sustainable Buildings in the Tropics. Institute of Technology in the Tropics ITT, University of Applied Sciences Cologne: Presented at RIO 02 – World Climate & Energy Event, January 6-11, 2002.
www.rio02.de/proceedings/pdf/159_Grimme.pdf

California Energy Commission, 2005, Options for Energy Efficiency in Existing Buildings.
www.energy.ca.gov/ab549/index.html

IEA. 2004b. Energy Balances for OECD Countries and Energy Balances for non-OECD Countries; Energy Statistics for OECD Countries and Energy Statistics for non-OECD Countries (2004 editions) Paris

Kevin A. Baumert, Timothy Herzog and Jonathan Pershing, 2005, Navigating the Numbers Greenhouse Gas Data and International Climate Policy, World Resources Institute
www.wri.org/climate/pubs_description.cfm?pid=4093

EU Energy Performance in Buildings - Directive Implementation Advisory Group, Explanation of the General Relationship between various standards from the European Committee for Standardization and the Energy Performance of Buildings Directive (EPBD).
www.diag.org.uk/documents.jsp

EU Energy Performance in Buildings - Directive Implementation Advisory Group: Methodologies in support of the Energy Performance of Buildings Directive: The UK approach to implementation for buildings other than dwellings.
www.diag.org.uk/documents.jsp

European Programme for Occupant Satisfaction, Productivity and Environmental Rating of Buildings 2004: Certification of Existing Building Energy Performance—The Energy Performance Label.
www.eplabel.org

Robert Cohen, Energy for Sustainable Development 2004: Display and Disclosure.
www.eplabel.org/Links/DandDArticleBSJ.pdf

Building Research Energy Conservation Support Unit for the Energy Efficiency Best Practice program Good Practice Guide 290 Ventilation and cooling option appraisal—a client's guide.

Department of Trade and Industry New and Renewable Energy Program: 2000. Extended Renewable Eergy Case Study: Channelling Light To Dark Places. www.leicester.gov.uk/housing/PDFs/DTI25.pdf

www.salixfinance.co.uk

INTERNET RESOURCES

www.carbontrust.co.uk

Carbon Trust is a government-funded company which helps UK business and the public sector cut carbon emissions. The Carbon Trust website was developed to demonstrate best practice and make businesses aware of the cost of carbon emissions and climate change.

The website houses a large online collection of free independent energy efficiency publications. Below are links to some useful publications.

> www.carbontrust.co.uk/publications/publicationdetail?productid=CTV007
>
> Maximizing energy savings in an office environment—an overview for office-based companies introducing the main energy saving opportunities for businesses and demonstrating how simple actions save energy, cut costs and increase productivity.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=ECG019
>
> Energy use in offices—a guide to raise awareness of the potential to improve the energy and environmental performance of offices and encourage positive management action. It outlines technical and management measures to help reduce energy consumption and costs and provide additional detail to assist diagnosis, analysis, technical and managerial improvements.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GIL124&metaNoCache=1
>
> Heating fact sheet—an introductory guide to heating systems and their components, simple energy saving tips covering heating systems and controls commonly found in commercial and industrial buildings.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GIL126&metaNoCache=1
>
> Lighting fact sheet—information on energy saving measures for lighting.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GPG290&metaNoCache=1
>
> Ventilation and cooling options appraisal—the focus of the guide is cooling and ventilation strategies that give value for money while ensuring good quality internal environments, simple systems which can be readily understood, managed and maintained and run in an energy-efficient manner.

www.greenhouse.gov.au/yourhome/technical/fs00.htm

Australia's guide to environmentally sustainable homes—a technical manual showing how to design and build comfortable homes that have less impact on the environment.

www.energy.ca.gov/title24/2005standards/index.html

2005 Building Energy Efficiency Standards for California—manual designed to help owners, designers, builders, inspectors, examiners and energy consultants comply with and enforce California's energy efficiency standards for residential and non-residential buildings. The manual is written as both a reference and an instructional guide.

www.cibse.org/pdfs/GPG075.pdf

Financial aspects of energy management in buildings—a guide outlining the key steps in the financial appraisal of energy efficiency investment in buildings.

www.diag.org.uk/pdf/CIBSE_Briefing.pdf

The Energy Performance of Buildings Directive—a summary of the objectives and contents of Directive 2002/91/EC of the European Parliament and Council, on the energy performance of buildings. It came into force on 4 January 2003 to increase awareness of energy use in buildings, and will lead to substantial increases in investments in energy efficiency measures within domestic and non-domestic buildings.

The complete directive is available at: www.diag.org.uk/pdf/EPD_Final.pdf

www.keralaenergy.gov.in/ecact/ecact_main.htm

India's Energy Conservation Act of 2001—the Act provides for efficient use of energy and its conservation. It establishes and incorporates a Bureau of Energy Efficiency, gives power to the Central Government to enforce efficient use of energy and power of State Government to enforce certain provisions for efficient use of energy and its conservation, establishes a State Energy Conservation Fund for the purposes of promotion of efficient use of energy and its conservation within the State and gives authority to the designated agency to appoint inspecting officers for the purpose of ensuring compliance with energy consumption standards specified.

www.doe.gov.ph/downloads/default.htm

Philippines guidelines for energy conserving design of buildings and utility systems

www.mi.government.bg/eng/norm/rdocs/mdoc.html?id=190688

Bulgaria's Energy Efficiency Act

www.seea.government.bg/index_en.php?mid_val=39

Policy documents for energy efficiency in buildings from Bulgaria's Energy Efficiency Agency

GLOSSARY/DEFINITION OF KEY CONCEPTS

Blinds — A blind is a covering for a window, usually attached to the interior side of a window. Exterior blinds (for the outer side of the window) and mid pane blinds (located in the cavity of the double glazing), are also available. Blinds hide from sight an external view from the window or reduce sunlight. Blinds have varying thermal effects: they can block unwanted heat in summer and keep heat inside during cold weather. But in both these applications, they also reduce light to varying degrees, depending on the design. Many kinds of blinds attempt varying balances of blinding external views and allowing sunlight.

Caulking — Refers to the activity of closing up joints and gaps in buildings. The function of caulking is to provide thermal insulation and noise mitigation. This is mostly done with ready-mix construction chemicals sold as caulk.

Climate change levy — This is a tax on energy levied on users in the United Kingdom. Its aim is to provide an incentive to increase energy efficiency and to reduce carbon emissions. The levy applies to most energy users, with the notable exceptions of those in the domestic and transport sectors. Electricity generated from new renewables and approved cogeneration schemes is not taxed. From when it was introduced, the levy was frozen at 0.43p/kWh on electricity, 0.15p/kWh on coal and 0.15p/kWh on gas. A reduced levy applies to energy-intensive users provided they sign a climate change agreement. Revenue from the levy was offset by a 0.3 per cent employers' rate reduction in National Insurance. However, the 2002 Finance Act subsequently increased that rate by 1 per cent, reversing the reduction. Part of the revenue is used to fund a number of energy efficiency initiatives, including the Carbon Trust.

Condensing boilers — A condensing boiler one that achieves enhanced efficiency by incorporating an additional heat exchanger that uses the heat in the exhaust gases from the boiler to preheat water as it enters the boiler, and so recapturing energy that would otherwise be lost. When a condensing boiler is working at peak efficiency the water vapour produced by the consumption of gas or oil in the boiler condenses back into liquid water. The condensation of exhaust gases releases the latent heat of vaporization of the water, a more significant source of energy than the transfer of heat by cooling the vapour. The design has its greatest advantages with gas-fired boilers, because less water is produced in burning oil or solid fuel, but it is still practicable with oil.

Floor area — The floor area of buildings is the sum of the area of each floor of the building measured to the outer surface of the outer walls including the area of lobbies, cellars, elevator shafts and in multi-dwelling buildings all the common spaces. Areas of balconies are excluded.

Glazing — Glazing is a transparent part of a wall, usually made of glass or plastic. Common types of glazing used in architectural applications include clear and tinted float glass, tempered glass and laminated glass, as well as a variety of coated glasses, all of which can be single, double or even triple-glazed units.

Hydroboils — The hydroboil is an instant boiling water heater. It is up to three times more energy efficient than the traditional electric kettle (urn) and just as efficient as a well-managed kettle. It uses less power on stand-by than a 60-watt light bulb and when connected to the cold water and power supply, boiling water is continuously available, around the clock, at a touch of the tap. It is available in models delivering from 12 to 300 cups of boiling water at one time. The hydroboil fully contains all the steam within the system, condensing it, thus preheating the incoming cold water.

Indoor climate — The indoor climate is a term that summarizes the thermal environment, the air quality and the acoustic and light environment of a building. Indoor climate regulations and guidelines are usually part of the building code.

Passive cooling — Passive cooling refers to technologies or design features used to cool houses naturally. In building design, the two principles of passive cooling are: *(a)* to prevent heat from entering a building in the first place; in domestic buildings this usually means shading from the sun and *(b)* to purge unwanted heat from a building, usually by natural ventilation.

Passive solar heating — Passive solar heating makes use of the building components to collect, store and distribute solar heat gains to reduce the demand for space heating. It does not require the use of mechanical equipment because the heat flow is by natural means (radiation, convection and conductance) and the thermal storage is in the structure itself.

Retrofit — The modification of a building to incorporate new functions not included in the original building design.

Skylight	A flat or sloped window built into a roof structure for day lighting
Solar gains	Solar gain refers to the increase in temperature in a space, object or structure that results from solar radiation. The amount of solar gain increases with the strength of the sun, and with the ability of any intervening material to transmit or resist the radiation.
Useful floor area	This is the total area of all enclosed spaces measured to the inside face of the external walls, including sloping surfaces such as staircases but excluding areas that are not enclosed such as open floors, covered ways and balconies.
Vapour retarder	Is any material, usually a plastic or foil sheet, that resists the passage of both air and moisture through walls, ceilings and floors. It helps prevent interior moisture from penetrating into and condensing in unheated attics, basements, crawlspaces and wall cavities. This is especially important in well-insulated homes, where there is often a great difference in temperature between the air in conditioned space and the air in unconditioned space. The vapour barrier is placed in between the insulation and the conditioned space.

Case study 1.

SUSTAINABLE ENERGY AUTHORITY IN AUSTRALIA

CONTENTS

1. BACKGROUND

In order to implement a greenhouse gas reduction strategy, the Government of Victoria has developed the Sustainable Energy Authority, an agency established to promote energy efficiency and support and facilitate the development and use of renewable energy. Its aim is to achieve environmental and economic benefits for the Victorian community. These initiatives will also act as a significant stimulus for the development of a sustainable energy industry.

The Sustainable Energy Authority of Victoria (SEAV) has established six Energy Smart Advisory Centers that provide a range of information products to assist all sectors of the community to select energy smart appliances; design and construct energy smart buildings; reduce energy costs through energy saving practices; and utilize renewable energy. They also distribute independent advice and information, media campaigns, seminars and targeted promotions.

SEAV has introduced a range of “Energy Smart” programmes:

- Energy Smart Appliances (Reach for the Stars programme);
- Energy Smart Housing;
- Energy Smart Business;
- Energy Smart Government;
- Renewable energy.

2. ENERGY SMART APPLIANCES

The Reach for the Stars programme is a joint Commonwealth and state government initiative to increase the purchase of energy-efficient, energy smart appliances, which reduce energy bills and help the environment. In October 2000, the Australian Government introduced the Energy Label for Appliances initiative. It rates appliances on a scale of five stars, the more stars the appliance has, the more environmentally friendly it is.

3. ENERGY SMART HOUSING

The Energy Smart Housing programme aims to facilitate house energy ratings as the energy efficiency benchmark for housing and the introduction of energy performance standards. Activities include development of the First Rate house energy rating software, provision of user training and accreditation of third party rating providers. It includes Energy Smart Builders and Energy Smart Commercial Buildings, which use Building Greenhouse Rating scheme.

4. ENERGY SMART BUSINESS

The Energy Smart Business programme helps small, medium and large enterprises to adopt and integrate sustainable energy solutions by providing expert technical advice, best practice information, free seminars, networking opportunities and case studies.

5. ENERGY SMART GOVERNMENT

The Energy Smart Government programme provides support services to government departments and agencies to undertake energy management programmes. It includes Energy Smart Local Government, Energy Smart Schools, Travel to Work programmes. The Energy Smart Local Government programme is helping Victorian municipalities to reduce energy consumption, recurrent energy costs and greenhouse gas emissions within their own operations. It builds upon the results of earlier benchmarking studies and provides services to develop energy management activities. The Energy Smart Schools programme establishes partnerships with both state and private schools to introduce improved energy management in the operation of school facilities. Travel for Work is a programme designed to help businesses help themselves reduce the costs and environmental impacts of work-related travel. It also improves employee health through promoting walking and cycling.

6. ENERGY SMART LOCAL GOVERNMENT

SEAV provides lot of help to local authorities to develop sound energy management and to achieve reductions in recurrent energy costs. Firstly it provides help in developing an energy management programme. The only effective way to manage energy consumption and costs is by assigning responsibility to an internal "energy manager". The size and structure of the energy management team depends on the nature of the local government. SEAV gives advice on appropriate team structure. SEAV also helps with creation of the energy management programme especially in defining aims, specific targets, priorities, time frames, responsibilities and budget allocation of resources.

SEAV also provides a series of workshops called the Municipal Energy Management Support Programme to train municipal staff. It was designed to help local governments gain an understanding of basic energy management principles. They also developed an easy to use Municipal Energy Management Tool, a software package to assist councils track and report their energy consumption and greenhouse performance. The software is capable of delivering comparisons with other councils because it contains benchmarking data.

Case study 2.

IMPROVING ENERGY EFFICIENCY IN EKURHULENI METROPOLITAN MUNICPAL (EMM) BUILDINGS, SOUTH AFRICA

CONTENTS

1. BACKGROUND

The project of improving energy efficiency in EMM buildings started in June 2005 with the call on all suitably-qualified entities to submit quotations to carry out all the necessary work to achieve the set objective of saving energy and reducing GHG emissions.

The first proposal included the supply, delivery and installation of solar water heaters, compressors and 10 KW solar photovoltaic panels. A preliminary analysis of a building's infrastructure, design and plumbing systems determined that the installation of solar energy would add more complexity and time to the work. The retrofitting project was to be completed before the end of the municipal financial year.

The second proposal was the use of different mechanisms to reduce energy consumption in lighting and heating/boiling water. The mechanisms included the replacement of conventional incandescent lights with compact fluorescent light bulbs (CFLs), the replacement of cool-beam down lighters with light-emitting diodes (LED) lights, the replacement of urns and kettles with hydroboils, and the installation of geyser and lighting timers. These measures were determined to be more cost effective and could be implemented within the set time frames and allow significant reductions.

The CFLs are very efficient and inexpensive over their lifetime with high return on savings after the initial investment. They have been designed to screw into standard light sockets, which allow them to be used very easily instead of incandescent light. LEDs are small, solid light bulbs, which are extremely energy-efficient. The zip hydroboil is a wall mounted, instant-boiling water heater, which means that boiling water is available instantly. It cuts down on water bills, as there is no evaporation due to escaping steam. It also saves electricity/energy because it consumes less compared to urns and all the water that is boiled is used. Geyser timers regulate when the water can be heated by connecting electricity to the geyser at specified times. This saves energy because water is not heated throughout the day.

Summary of equipment:

- 23 zip hydroboils;
- 2,003 CFLs;
- 90 LED lights;
- Two lighting timers;
- 15 geyser timers;

- Replacement of 96, eight-foot double fluorescent light fittings with open channel, five-foot double fluorescent lights with electronic ballasts.

2. COSTS AND IMPLEMENTATION

The work started in December 2005. The total cost of the project, including labour and equipment, was R249,120 ($US 41,063). ICLEI (Local Governments for Sustainability) secured a grant totaling R242,761 ($US 40,000) from the United States Agency for International Development (USAID) to fund this project. The unit price of equipment as quoted by the service providers is shown in the following section.

3. RESULTS

A small-scale retrofit project, such as the EMM's buildings project, results in 328,988 kWh of energy saved in one year, representing economic savings in the order of $US 50,664 per year (using the value of $US 0.157/kWh for Ekurhuleni Municipal Buildings). A simple payback period, taking into account the total investment, will be 0.8 years.

Table 1. Equipment costs per unit

Equipment	Cost in South Africa Rand (ZAR)	Cost in $US*
Hydroboils	4,775.00	786.64
75 W (low wattage) CFLs	15.00	2.47
LED lamps	15.00	2.47
Lights timer	450.00	74.21
Geyser timer	450.00	74.21
5-foot double fluorescent lights	104.50	17.23

*The exchange rate used is for 02/02/2006: $US 1 = 6.06375 ZAR.

Table 2. Results on energy savings

Equipment	Pre retrofit energy use (kWh/year)	Post retrofit energy use (kWh/year)	Energy savings (kWh/year)	Percentage of savings
Lighting (CFLs and LEDs)	366,694	91,673	275,020	75
Lighting (5-foot double fluorescent lights with electronic ballast)	21,024	18,221	2,803	13
Water heating (Ums replaced with zip hydroboil)	214,072	171,256	42,814	20
Geyser timer	20,878	12,527	8,351	40
TOTAL	622,668	293,679	328,988	53

4. KEY REPLICATION ASPECTS

The creation of the policy on Energy Efficiency in Council Buildings and on Council Premises, the State of Energy Report, draft Energy Efficiency Strategy of Ekurhuleni, and the subsequently implemented retrofitting project are all part of an easily-replicable strategy that can be used in other South African cities interested in reducing energy costs and minimizing the negative environmental impacts of their municipal operations.

Case study 3.

EFFICIENT LIGHTING IN THE LATVIAN ACADEMY OF SPORT EDUCATION (LASE), LATVIA

CONTENTS

1. BACKGROUND

The project was carried out in the framework of the Efficient Lighting Initiative (ELI) programme, implemented in Latvia between 2000 and 2003 and was designed to accelerate the penetration of energy-efficient lighting technologies and to develop and encourage the use of energy service companies (ESCOs). An energy audit in LASE was carried out in October 2001 in order to estimate and evaluate the possibilities for lighting system improvement in one of the sport halls on the campus.

The existing lighting system in this sport hall consisted of 33 spotlights mainly mounting 1000 W halogen bulbs and an additional six light points using high-pressure bulbs with capacity of 750 W each. In the balcony of the sport hall there were 10 separate luminaries, each with 500 W incandescent bulbs. The lighting system was used seven months a year for 12-15 hours a day—a total of 4100 hours per year.

2. THE ENERGY AUDIT

The energy audit pointed out several problems, of which the main were:

- Eight per cent of the luminaries were not in working condition;
- Lighting quality did not correspond to existing local and European quality standards;
- The existing control system did not contribute to efficient use of the lighting system;
- There was no evacuation lighting;
- The shock protection bars over the luminaries reduced the quality of light;
- Low cleaning and maintenance of the system, causing dust settlement reducing the quality of light;
- Some of the bulbs were replaced with inappropriate bulbs causing bad interconnection and as result some of the wires were burned;
- The yearly electricity consumption in the sport hall was 173,120 kWh/year representing costs of €8,900/year;
- Total installed capacity of the lighting system was 42.5 kW.

3. FINANCING

Based on the results of the energy audit, which showed project feasibility and profitability, the administration of LASE agreed to refurbish the lighting system and announced a call for tender addressed to energy service companies. LASE was convinced to have an ESCO mainly for three reasons: the possibility to attract third-party financing, the possibility to have the operation and maintenance of the system included in the contract, and in particular the idea of a guarantee on energy savings.

The project was fully financed through the ESCO. Total project costs were €28,500. The ESCO has taken a loan of €14,250 from a Latvian commercial bank and the rest was covered from its own resources.

4. IMPLEMENTATION

The ESCO has replaced lamp units in the academy sport hall. The new units have a greater optical efficiency and the new casings have a much longer lifespan than their predecessors. They are vibration resistant and keep out dirt. They are also easier to service, which means lower maintenance costs. Lighting design and computer simulations work has been done to calculate the right number and wattage of the units and to make sure that new units are positioned correctly in terms of their positions and angle. In particular the project included the following parts:

- Replacement of old light points with 66 new luminaries with 250 W capacity for a total capacity of 16.5 kW;
- Automatic lighting control system;
- Electricity consumption control meter with possibility to read the data on PC from the technical department of LASE;
- Eight motion sensors and one outside lighting sensor;
- Emergency exit lighting;
- Electrical wires have also been changed, which will ensure the system runs smoothly for years to come.

5. RESULTS

The project has achieved its main objective, which was to reduce energy consumption and stop the physical degradation of the lighting system in the sport hall. By using better technology, the network's energy use has been cut by 83,720 kWh per year. The system now has a much better control system—including the possibility of having different light levels in the hall in function of different applications and sports played. The project can be judged a success and also the objective of using third-party financing was achieved, in spite of the difficulty in involving ESCOs in small-scale projects.

The table below shows a comparison of the situation before and after project implementation.

Table 1. Comparison of old and new lighting system in LASE

	Old system	New system
Operating time	4,064 hours/year	4,064 hours/year
Installed capacity	42.5 kW	16.5 kW
Electricity consumption	173,120 kWh/year	89,400 kWh/year
Energy savings		83,720 kWh/year

Case study 4.

PASSIVE DESIGN IN LOCAL GOVERNMENT OFFICES OF IRELAND

CONTENTS

1. SUMMARY

The design of Fingal County Hall, completed in 2000, incorporates passive design principles including daylighting, passive heating, passive cooling and natural ventilation as well as ground source heat pump technology. A building of this type would generally rely on mechanical ventilation and air conditioning but by using passive techniques the need for mechanical ventilation and air conditioning has been minimized. The capital costs of such services were reduced from the typical figure of 30 per cent of total building cost to 17 per cent. In addition, operational costs (lighting, heating and air conditioning) have been reduced.

The design of the building was taken from the winning entry in a competition held amongst interested architects and so even before construction the process of promoting sustainable design had begun.

This is an example of an initiative where a local authority, as building owner and occupier, has lead by example to promote and develop passive design in local architectural practices and reduce energy consumption in its own buildings.

The local authority has also benefited from the public relations which tend to follow these projects and the work of environmental officers has been made easier by sustainability issues having been placed more visibly within the authority's agenda.

2. THE SCHEME

Fingal County Council, as a new local authority anxious to assert a clean green image, decided from the outset in 1995 to put sustainable design into practice in its own new headquarters in Swords, Co. Dublin, Ireland. As an owner-occupier, Fingal County Council was interested in both the initial cost of the building and its operating costs. Completed in 2000, the design of the building and its services employ passive design principles and ground source heat pump technology.

3. TECHNOLOGY

Incorporating passive design into a building can improve energy performance in three areas: lighting, cooling and building heating.

“Day lighting” involves the use of devices and techniques to capture and direct light into the building, whilst avoiding glare. As electric lighting in a typical office building can account for up to 20 per cent of total energy usage, the use of daylight should be carefully considered. A combination of orientation, shallow building plan, light shelves, the curved profile of the exposed ceiling slab and recessed roof lights serve to reflect day light into the building. The office bars maximize south-facing natural daylight.

Passive cooling involves the use of shading devices, natural ventilation and thermal mass. The shallow plan design lends itself to a natural ventilation strategy and façade elements provide the means for its implementation. Both the stairwell at the end of each office bar and the atrium contain ventilation louvres at the upper level to provide stack-effect ventilation. The thermal mass of the exposed concrete ceiling slab is cooled by night ventilation during the summer and absorbs heat from the room throughout the day. Nighttime pre-cooling of the building is controlled in office areas by motorized office windows and the stairwell stack dampers.

Passive heating involves the collection, retention, storage and distribution of heat, and also avoids overheating. While the south-facing orientation of the office sections will provide a degree of solar gain from low winter sunshine, the thermal mass of the exposed concrete slab absorbs peak afternoon casual gains (heat from people, lighting and office equipment) and retains the heat so reducing the following morning’s pre-heat.

A heat pump is an environmental energy technology that extracts heat from low temperature sources (ground, water, air), upgrades it to a higher temperature and releases it where it is required for space or water heating. A ground source heat pump delivers heat to the atrium’s under-floor heating system. For its heat source, water is drawn from a borehole drilled to a depth of 160 m below ground level.

There are no light switches within the office areas. The lighting above each desk group is controlled by occupants using their telephone. Mechanical ventilation was deemed necessary for the toilet areas, the canteen and lower ground floor. The latter includes a heat recovery system. The council chamber is the only area requiring mechanical cooling. To reduce the energy used, a displacement ventilation system has been installed to take advantage of free cooling when available. Heating is provided by high-efficiency gas-fired condensing boilers with thermostatic radiator valves for local occupant control.

4. PROJECT TEAM

Fingal County Council, as owner occupier of their new building, lead the project with an holistic view of costs since it had an interest in both the initial cost of the building as well as its operating costs.

The project team needed for the construction of a passively designed building does not differ dramatically from that of a conventional building apart from an interest in life-cycle costs on the part of the owner and architects/engineers who are aware of passive design principles. Both these essential factors were present in this project, with the right architects being located through the innovative means of using a design competition.

5. FINANCING

By using passive techniques, the costs of mechanical ventilation and air conditioning services were reduced from the typical figure of 30 per cent of total building cost to 17 per cent. In addition, operational costs have been reduced. Estimates from the UK DETR suggest that a naturally ventilated building consumes 50 per cent of the energy of an air-conditioned building.

The cost of constructing a passively designed building of this sort need not be more than for a conventional construction. Any additional costs associated with the passive design may be offset by the reduced costs of mechanical services. Lower operational costs are another important factor where the building owner and occupier are the same organization.

6. LOCAL CONDITIONS FOR RENEWABLE ENERGY

Ireland has a relatively low penetration of renewable energy technologies. However, driven by national policy, government buildings are increasingly designed with environmental issues and the minimization of energy requirements in mind.

The real driving force behind this initiative was the desire on the part of Fingal County Council to make a fresh start in a new building and help develop a green image.

Ireland has a relatively mild, temperate climate with large amounts of diffuse sunlight year-round, making it well suited to the use of passive design principles.

7. OVERCOMING BARRIERS

The primary barrier to the increased use of passive design is lack of awareness and experience which means that it is rarely part of a design brief. There is also a reluctance to make investments in unfamiliar technologies.

The fragmented nature of the construction industry also inhibits their use. The client often knows little about building design and may not intend to own the building after its construction. The financial benefits of sustainable design generally accrue to the occupant in terms of lower operating costs, but it is rarely the client who commissions the building.

The financial cost and commercial value of employing passive design is difficult to accurately quantify at design stage and is rarely quantified by post-occupancy evaluation of building performance. Consequently, there is a lack of hard data to promote the widespread application of sustainable design.

These barriers were overcome because the client was a local authority so that:

- The client team included architects and engineers who were aware of passive solar design principles;
- The client was also the owner and occupier of the building and was, therefore, interested in the total life-cycle costs of the building;
- Government strategy was implemented which seeks to promote sustainable design, including leading by example.

By placing sustainable design as a central part of the original design brief, the local authority drove the sustainable design agenda. By using an architectural competition as the means of selecting the architects, the local authority was able to select architects with experience and interest in this area.

8. RESULTS AND IMPACTS

Mechanical ventilation and air conditioning tend to be electrically-driven and operational throughout the building's occupied life, which makes them both expensive to operate and, depending on the combined efficiency of national power generation plant, a significant source of greenhouse gas emissions. Removing them from the building design and replacing them with passive designs will have a significant impact over the life of the building. For instance, it is estimated that air-conditioned office buildings consume approximately 250 kWh/m^2 per annum, while naturally ventilated office buildings consume 120 kWh/m^2 per annum. Similarly, with day lighting reducing the need for artificial lighting, the life-cycle impact will be substantial.

Occupants' response to their environment is influenced by the quality of the environment, the perceived level of individual control, the quality of the management of services and response to complaints, and the desire to be close to a window. Buildings that make good use of natural light and ventilation, in which occupants have the opportunity to make local adjustments, often prove to be more acceptable work environments. This building provides occupants with local control of lighting, heating and natural ventilation, and also satisfies the desire to be close to a window.

9. REPLICATION

This building illustrates that comfortable conditions can be achieved within high density, heavily glazed office spaces in the Irish climate without recourse to mechanical ventilation or air conditioning. The well-publicized energy-saving features of the building have served to raise awareness amongst building designers and procurers. The local authority planners who occupy the building are intimately familiar with the features and their effectiveness and are in a position to influence the design of other buildings.[1]

[1]For further information contact: Stephen Dunn, (Stephen.Dunne@fingalcoco.ie), Building Services Manager, Fingal County Hall, Main Street, Swords, Fingal, Co. Dublin, Republic of Ireland, +353 1 890 5000 or Chris Croly (CM-Croly@bdp.ie), Building Design Partnership (BDP), Blackhall Green, Dublin 7, Republic of Ireland, +353 1 474 0600.

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 18:
ENERGY EFFICIENCY IN BUILDINGS

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Overview of energy efficiency in buildings and its benefits
- How to approach EE in buildings
- Different opportunities and measures for improving EE of buildings
- Key aspects of suitable policies to support EE in Buildings
- Financing options and mechanisms
- Discussion on the process of developing and implementing policies on EE in buildings and summary of some policy tools

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Introduce the concept and benefits of energy efficiency (EE) in buildings
- Give an overview of the methodology to determine the EE of buildings
- Present opportunities and measures for reducing energy use in buildings
- Describe mechanisms for financing EE measures
- Summarize legislative and policy tools successful in promoting EE in buildings

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To appreciate the significance and benefits of EE in buildings
- To have a general understanding of the methodology used to determine the EE of buildings and an overview of different measures for improving energy use in buildings
- To have an overview of the different mechanisms for financing EE measures
- To have conceptualized an approach to setting out and implementing policy to support EE in buildings

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Buildings?

- Globally the building sector accounts for more electricity use than any other sector: 42%;
- We spend more than 90% of our time in buildings;
- Africa's rate of urbanization is 3.5%, the highest in the world;
- Currently 40 cities in Africa with populations of more than a million;
- It is expected that by 2015 seventy African cities will have populations of one million or more.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What is the Energy Efficiency (EE) of a Building?

The extent to which the energy consumption per m^2 of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why is EE in Buildings Important for Governments?

- Where the demand for energy services is growing rapidly
  - Capital costs of efficiency are lower than comparable investments in increased supply
  - No additional operating costs of efficiency measures compared to substantial operating costs for supply-side options
  - Energy efficiency investments have shorter lead times than energy supply investments
  - By setting energy efficiency targets for buildings, governments share the burden and cost of ensuring the security of energy supply

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

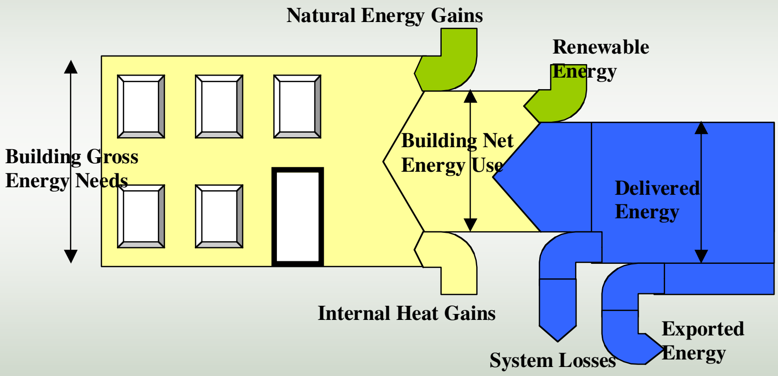
Benefits from EE in Buildings

- Energy efficiency measures are meant to reduce the amount of energy consumed while maintaining or improving the level of comfort in the building;
- Among the benefits arising from energy efficiency investments in buildings are:
  - Reducing energy use for space heating/cooling and water heating;
  - Reduced electricity use for lighting, office machinery and domestic appliance';
  - Lower maintenance requirements;
  - Enhanced property value.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings



Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings (2)

- **Natural Energy Gains:** Passive solar heating, passive cooling, natural ventilation flow, and daylight.
- **Internal Heat Gain:** Thermal energy from people, lighting and appliances that give off heat to the indoor environment.
- **Delivered Energy:** Amount of energy supplied to meet the buildings net energy demand. Could be supplemented by on-site renewable energy
- **Exported Energy:** Fraction of delivered energy that, is sold to external user
- **System Losses:** System losses result from the inefficiencies in transporting and converting the delivered energy

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings (3)

- The amount of energy a building will need to purchase in order to attain the required indoor climate is dependant on:
  - The properties of the building;
  - How efficiently the delivered energy is used to meet the buildings net energy demand;
  - How efficiently energy is used by people in the building;
  - The percentage of the buildings energy requirement that is supplied by renewable energy.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Determining Energy Consumption of Buildings

- The Energy performance of a building is based on the building properties and the energy required to attain the indoor climate standard. It is a factor of the:
  - **Intrinsic energy performance** - The delivered energy needed based on the use of the building, the indoor environment, the external climate, and the buildings properties.
  - **Actual energy performance** - The energy used over the last year, obtained from energy audits, metering and sub-metering.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building Energy Consumption Benchmarks

- Benchmarks are representative values for common building types against which a building's actual performance can be compared;
- The main purposes of benchmarks are:
  - To identify if a buildings energy performance is good, average or poor with respect to other buildings of its type;
  - To identify potential savings, shown by the variance between the actual data and the benchmarks.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

Module 18

Certifying Energy Efficiency

- An Energy Efficiency Certificate is a summary of a building's energy audit. It is meant to give information on the building's energy consumption and its energy efficiency rating.
- The purpose of Energy Efficiency Certificates is to:
  - Inform tenants and prospective buyers on the expected running costs;
  - Create public awareness;
  - Acts as a prerequisite of measures to improve its energy efficiency;
  - To effect incentives, penalties or legal proceedings

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Certifying Energy Efficiency (2)

- Buildings are given two ratings based on the intrinsic and actual energy performance:
  - **Asset Rating**: A rating of the standard of the building fabric and building services equipment and is based on theoretical values.
  - **Operational Rating**. This will be influenced by the quality of the building (as measured by the Asset Rating), but also by the way the building is maintained and operated. It is based on the normalized actual metered energy consumption.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

EE Measures for Buildings

- Approaches through which the energy consumption of a building can reduced. They can be categorized into:
  – Reducing heating demand
  – Reducing cooling demand
  – Reducing the energy requirements for ventilation
  – Reducing energy use for lighting
  – Reducing energy used for heating water
  – Reducing electricity consumption of office equipment and Appliances
  – Good housekeeping and people solutions

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Heating Demand

- Heating demand can be reduced by:
  – Limiting the exposed surface area of the buildings
  – Improving the insulation of the building fabric
  – Reducing ventilation losses
  – By selecting efficient heating systems with effective controls.

Module 18

Reducing Cooling Demand

- Energy use in typical air-conditioned office buildings is approximately double that of naturally ventilated office buildings. The need for air-conditioning or the size of the systems installed can be reduced by:
  - Controlling solar gains through glazing;
  - Reducing internal heat gains;
  - Making use of thermal mass and night ventilation to reduce peak temperatures;
  - By providing effective natural ventilation;
  - Reducing lighting loads and installing effective lighting controls.

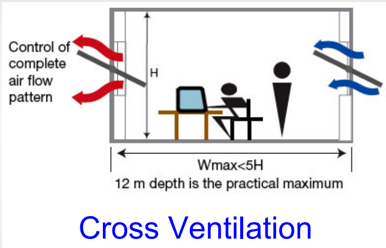
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

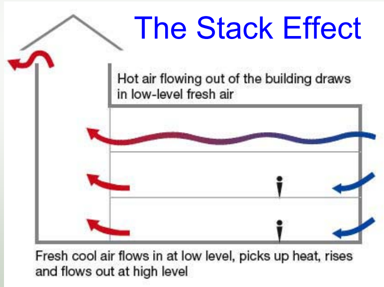
Reducing the Energy Requirements for Ventilation

- The energy required for ventilation can be minimized by:
  - A building design that maximizes natural ventilation;
  - Effective window design;
  - Use of mixed mode ventilation;
  - Using efficient mechanical ventilation systems.

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing the Energy Requirements for Ventilation (2)





Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Energy Use for Lighting

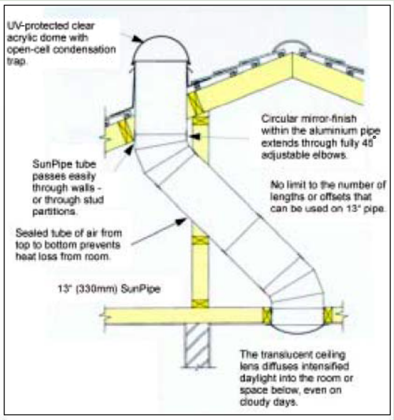
- This can be accomplished through:
  - Making maximum use of daylight while avoiding excessive solar heat gain
  - Using task lighting to avoid excessive background luminance levels
  - Installing energy efficient luminaires with a high light output to energy ratio
  - By providing effective controls which prevent lights being left on unnecessarily

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Energy Use for Lighting (2)

- Natural light provides healthier working conditions than artificial light—and it is free;
- Large modern buildings often have many areas being starved of natural light;
- Therefore the challenge is to channel natural light to areas without windows;
- Sunpipes can be used to introduce daylight to windowless areas.



Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Energy Use for Heating Water

- Installing time controls and setting them to reflect the hours of hot water requirement;
- Setting sanitary hot water thermostats to the appropriate temperature;
- Switching off electric heating elements (immersion) when hot water from the boiler is available;
- Switching off any associated pumps when hot water is not required
- Replacing damaged or missing insulation from hot water pipe work and cylinders;
- Identifying a suitable hot water system.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Consumption of Office Equipment and Appliances

- Office equipment currently consumes 15% of the total electricity used in offices;
- This is expected to rise to 30% by 2020;
- There are also associated costs of increasing cooling and ventilation requirements to overcome the additional heat that office equipment produces.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Consumption of Office Equipment and Appliances (2)

- Typical measures to reduce consumption which also apply to household appliances are:
  – Switching off or enabling power down mode reduces the energy consumption and heat produced by equipment.
  – Upgrading existing equipment. Some energy efficient appliances may cost more but they will recoup savings over their lifetime.
  – Matching the equipment to the task. Bear in mind current and predicted requirements and purchase equipment that meet these.
  – Taking advantage of energy labeling schemes

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Good Housekeeping and People Solutions

- The level of achievable energy savings from office equipment is down to the everyday management by staff. A simple energy conservation program for an organization would consider:
  - Setting up an energy policy for the organization;
  - Appointing an Energy Champion;
  - Involving staff;
  - Setting targets;
  - Using notices and reminders;
  - Conducting walk-rounds;
  - Taking meter readings.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (2)

From the measures mentioned, which are:

1. The easiest to implement in your country.
2. The ones with the highest potential for savings.

Discuss

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings

- Financial appraisal involves finding and evaluating the best projects to invest in whatever they are and wherever they arise. It gives energy savings the priority they merit when compared with other aspects of cost reduction or business expansion.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings (2)

The seven key steps in financial appraisal of energy efficiency investment in buildings are:

- Locating the buildings which have the potential;
- Identifying the areas where savings can be made ;
- Identifying the measures required to release these savings;
- Establishing the costs and the savings for each measure and calculating the key financial indicators;
- Optimizing the financial return measured by these indicators;
- Establishing how much investment capital is available and identifying new sources of capital;
- Deciding which projects make best use of the organization’s available capital.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings (3)

Options and mechanisms include:

- Internal funds;
- Debt financing;
- Lease or lease-purchase agreements;
- Energy performance contracts;
- Utility incentives (equipment rebates, design assistance, and low-interest loans)
- Local authority and national assistance

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (3)

1. List and describe 4 options/mechanisms for financing energy efficiency in buildings.
2. Outline how at least 2 of the financing options/ mechanisms discussed could be applied in your country and highlight how they would be effected and which organizations would be involved.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings

- Policy is formulated on needs basis and therefore policy-makers require a clear picture of:
  - The contribution of buildings to the countries total energy consumption;
  - The future impact of urbanization and increase in the number of new buildings vis-à-vis energy demand;
  - The potential for energy savings from large-scale implementation of energy efficiency measures in existing and future buildings.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings (2)

- Policy formulation phase should involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings (3)

- The policy should:
  - Outline the need for and benefits of EE in buildings;
  - Estimate potential savings both in terms of energy use and power demand;
  - Set achievable targets and timelines;
  - Outline an approach to achieve the targets and monitor them;
  - Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;
  - Consider the financial support instruments for undertaking energy efficiency measures.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Implementing Policies for EE in Buildings

- To implement a policy certain bodies need to be set up. These would consist of:
  - An agency to develop and recommend a framework for the policy;
  - A regulator to facilitate and enforce the policy;
  - An adjudicating body to meet out the penalties;
  - An appellate tribunal to hear appeals against the orders of the adjudicating body.
- These bodies are set up by an act of the parliament which defines their functions and powers.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (4)

1. List 5 functions of an Energy Efficiency Agency
2. What would be the most suitable model in your country with regard to the bodies required to implement a policy for EE in buildings?
3. What would their functions be?
4. How would you set up an EE fund in your country? Where would the funds be sourced from and what criteria would you use to allocate the funds?

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings

- The most effective programmes are designed:
  - To ensure that a particular target level of energy efficiency improvement is realized;
  - To assure that the market is prepared continually to introduce better technologies for energy efficiency.
- This process of continuous improvement in energy efficiency should be anticipated in the developmental process for energy efficiency codes.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings (2)

- Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:
  - Codes and standards for new construction and performance-based economic incentives to go beyond the standards.
  - Long-term incentives with ambitious energy efficiency targets;
  - Normative labels to distinguish the most energy efficient buildings and equipment:
  - Informative labels that provide the information necessary to measure energy efficiency and annual energy costs for operation.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings (3)

- Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:
  - Education and outreach to promote market acceptance of energy efficiency technologies and energy efficient designs, most notably efficiency demonstration centers;
  - Government-funded research and development on energy efficiency in buildings.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (5)

What incentives would you recommend to facilitate Energy Efficiency measures in buildings in your country and how would you implement them?

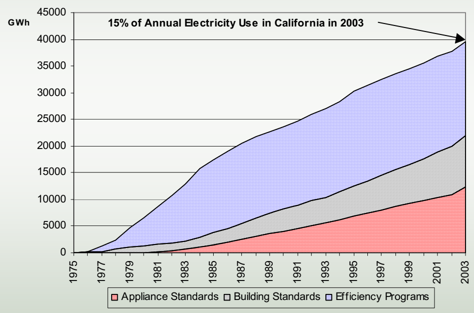
Discuss

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Potential of EE Savings

- Energy Efficiency in buildings has considerable potential for energy savings as evidenced by the California experience



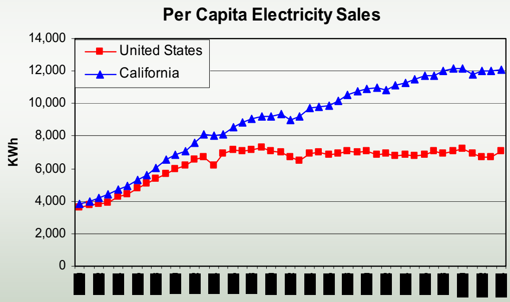
Savings achieved within California's existing building stock.

Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Potential of EE Savings (2)

- California has held per capita electricity sales steady for the past 30 years while the rest of the US experienced a 50% growth and slower economic growth.



Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Technological improvements in buildings design and appliances offer new opportunities for energy savings;
- Many of these technologies are yet to be adapted in Africa and other developing countries, suggesting a huge potential for savings;
- Resistance to change and the cost of implementing energy savings means that unless a policy and regulatory framework is set up, it is unlikely there will be any change.

Module 18