Module 14

Demand-side management

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Demand-side management (DSM) has been traditionally seen as a means of reducing peak electricity demand so that utilities can delay building further capacity. In fact, by reducing the overall load on an electricity network, DSM has various beneficial effects, including mitigating electrical system emergencies, reducing the number of blackouts and increasing system reliability. Possible benefits can also include reducing dependency on expensive imports of fuel, reducing energy prices, and reducing harmful emissions to the environment. Finally, DSM has a major role to play in deferring high investments in generation, transmission and distribution networks. Thus DSM applied to electricity systems provides significant economic, reliability and environmental benefits.

When DSM is applied to the consumption of energy in general—not just electricity but fuels of all types—it can also bring significant cost benefits to energy users (and corresponding reductions in emissions). Opportunities for reducing energy demand are numerous in all sectors and many are low-cost, or even no-cost, items that most enterprises or individuals could adopt in the short term, if good energy management is practised.

This module examines the types of DSM measures that can reduce energy demand for the end-user, that can manage and control loads from the utility side, and that can convert unsustainable energy practices into more efficient and sustainable energy use. The module includes a review of housekeeping and preventative maintenance, two of the simplest and most effective ways of reducing demand, and discusses marketing of DSM programmes. Some of the challenges that face the implementation of DSM programmes are also examined.

1.2. Module aims

The aims of the module are:

- To introduce the concept of demand-side management for residential, commercial and industrial energy users.
- To give an overview of the different types of demand-side measures.
- To show how housekeeping and preventative maintenance in commerce and industry can be used to reduce energy demand.

- To describe energy auditing and routine data collection and monitoring, and to indicate their benefits.
- To outline information dissemination on demand-side management.
- To provide an overview of the major implementation challenges for DSM programmes.

1.3. Module learning outcomes

The module attempts to achieve the following learning outcomes:

- To be able to define demand-side management.
- To understand the different types of demand-side management measures and their suitability to various energy users.
- To be aware of the benefits of good reliable data collection for regular performance analysis, and as an essential part of energy auditing.
- To appreciate the need for effective information dissemination.
- To understand the challenges facing the implementation of demand-side management.

2. INTRODUCTION

This module covers "demand-side management" or DSM, as applied to energy efficiency measures that modify or reduce end-users' energy demand. This has traditionally been applied to electricity loads but is also used for changes that can be made to demands for all types of energy. The benefits for the energy user are reduced energy costs for a given output (production level or other measure of activity). For the energy provider, the benefit is a better use of its supply capacity.

From a utility point of view it would seem that a sensible business approach would be the promotion of consumption thereby increasing sales. This would be true if there were an excess of capacity and revenues were the only important factor in an energy supply system. However, increased revenues does not translate necessarily in higher profits and in some situations a least-cost planning approach would/could prove the implementation of DSM measures to be more profitable than investing in new generating capacity. Utilities might therefore be better advised to promote DSM and energy saving. From an environmental perspective, a decrease in energy demand due to improved efficiency reduces the environmental impact of energy consumption associated with a particular level of production or other activity. In this respect, promoting DSM can thus enhance the public image of a utility company.

Most of the literature and case studies relating to DSM are linked to electrical demand as a result of programmes set up by utilities and governments and thus this module concentrates on electrical DSM programmes. However, in Africa, where a modest percentage of the population have access to utility generated electricity, it is also necessary to consider DSM in relation to other energy resources—on perhaps a local level. Here an important resource is biomass in the form of wood for space heating and cooking. In this scenario, the supply and demand is often met by the same person and hence self-regulating—the one bearing the load of wood searching and collection will certainly manage the demand and use the supply of wood efficiently as far as their energy use methods/technologies allow e.g. stove types.

There are technologies that assist with the efficiency of wood fuel cooking, such as improved cook stoves. However, in the United Republic of Tanzania, as in many other sub-Saharan countries, the majority of rural people are poor and since they can collect firewood for free, they cannot be easily motivated to purchase improved stoves. Improved stoves for rural applications must therefore utilize cheap and innovative clay stove technologies to keep costs as low as possible

(Lugano Wilson, 2006) and information needs to be made available to end-users to explain how using an improved cook stove can save them time (collecting firewood) and/or money (if they buy their wood).

Having said this, this module focuses principally on the opportunities for applying DSM principles to industrial and commercial enterprises. Improved energy management can reduce fuel consumption for little or no investment in many cases, and this may contribute to lower imports of fuels that are costly and in short supply, therefore increasing the cost-effectiveness and competitiveness of industries and businesses.

Box 1. **DSM facts in the United States**

- In 1999 in the United States, 459 large electricity utilities had DSM programmes. These programmes saved the large utilities 50.6 billion kilowatt hours (kWh) of energy generation. This represented 1.5 per cent of the annual electricity sales of that year.
- New York has the potential to reduce demand by 1,300 MW (2002) through DSM—enough to supply power to 1.3 million homes.

Source: www.cogeneration.net/Demand_Side_Management.htm (accessed 06July06)

3. WHY PROMOTE DSM?

Various reasons are put forward for promoting or undertaking DSM. For example, DSM may be aimed at addressing the following issues (University of Warwick, REEEP, 2005):

- Cost reduction—many DSM and energy efficiency efforts have been introduced in the context of integrated resource planning and aimed at reducing total costs of meeting energy demand;
- Environmental and social improvement—energy efficiency and DSM may be pursued to achieve environmental and/or social goals by reducing energy use, leading to reduced greenhouse gas emissions;
- Reliability and network issues—ameliorating and/or averting problems in the electricity network through reducing demand in ways which maintain system reliability in the immediate term and over the longer term defer the need for network augmentation;
- Improved markets—short-term responses to electricity market conditions ("demand response"), particularly by reducing load during periods of high market prices caused by reduced generation or network capacity.

An energy customer may have many reasons for selecting a certain DSM activity. Generally these would be economic, environmental, marketing or regulatory. The above points are expressed in a slightly different way (Satish Saini, 2004), where it is argued that the benefits of DSM to consumers, enterprises, utilities and society can be realized through:

- Reductions in customer energy bills;
- Reductions in the need for new power plant, transmission and distribution networks;
- Stimulation of economic development;
- Creation of long-term jobs due to new innovations and technologies;
- Increases in the competitiveness of local enterprises;
- Reduction in air pollution;
- Reduced dependency on foreign energy sources;
- Reductions in peak power prices for electricity.

An additional aspect (Satish Saini, 2004) is that of enhanced energy security through a diminished dependency on foreign energy sources. While the vulnerability to the volatility of international energy markets may not be the concern of an individual utility, industry or commercial company, at the national level, decreased dependency on energy imports can have important security of energy supply implications. For example, the dependency of many countries on oil, which as a primary resource is concentrated in only a relatively few countries, is creating geo-political tensions.

In a survey conducted by the International Energy Agency (IEA) between governments and utilities of 14 OECD countries[1] (*INDEEP Analysis Report*, 2004), the top four reasons given for implementing DSM programme were:

- Wanting reductions in global warming-related emissions of GHGs (environmental);
- Public image (marketing);
- Quality of service (marketing);
- Regulatory incentives (regulatory).

Where economic reasons were quoted for programme implementation—such as reducing cost of services—actual implementations were relatively few. However, this survey focused on the motivation of government and utilities; industrial plants, commercial companies and individuals are likely to have different priorities.

Box 2. **Environmental benefits of DSM**

As part of the City of Cape Town's initiative to improve energy efficiency in government buildings, an energy audit was carried out to determine potential energy saving opportunities. As a result of the audit, certain measures were implemented to reduce energy consumption including timers on electric geysers so that water is only heated when needed, replacement of inefficient urns with insulated electric water heating systems, installation of energy efficient lighting and installation of solar water heaters. Resulting from these measures, 20 per cent savings in electricity were achieved per month (equal to 24 476 kWh/month) equivalent to a reduction in greenhouse gas emissions of about 323 tons of CO_2 per year. The next step will be to introduce measures to influence behavioural changes in staff energy use to reduce consumption further.

Source: Energy Management News, Vol 10, number 4, Dec 2004. www.erc.uct.ac.za

[1]Austria, Brazil, Canada, Denmark, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom and United States.

4. WHAT DRIVES DSM?

The motivation behind the implementation of DSM is obviously different for the various parties involved. Thus for utility companies, the reduction or shift of a customer's energy demand could mean avoiding or delaying building additional generating capacity. In some situations, this would avoid or defer energy price increases that would otherwise be imposed on customers to help finance new investments in system capacity. For customers, DSM offers the opportunity to reduce their energy bill through efficiency and conservation measures. In the case of industrial customers, this would translate to lower production costs and a more competitive product. For domestic customers it means that they would save money that could be spent on other household commodities.

Utilities (and thus governments, where utilities are nationalized enterprises) can therefore be one of the key driving forces behind DSM implementation but energy customers should also be motivated in using energy more efficiently, subsequently reducing their energy demand and thus their energy costs. Consumers may also be able to take advantage of any special incentives offered by utility companies, and may participate in programmes offered by the utilities (and possibly supported by government).

Organizations with energy-dependent activities such as industrial manufacturers and owners/operators of buildings are often strongly interested in DSM, primarily to reduce their own energy consumption and costs, and partly perhaps to assist their local utility to maintain a reliable energy supply. The latter is of course directly in the interests of the energy user.

Industrial plants are often able to reduce overall demand by adopting various kinds of energy efficiency measures. Depending on the processes used, many have the flexibility to reschedule their periods of highest demand to cut peak loads and to even out their demand over a longer or different time period, thus helping the utility itself to run at higher efficiency.

The investment needed for these actions may be quite low if a simple retiming of operations proves possible. Other measures, such as replacing electric motors with high efficiency versions or installing variable speed drives, will require investments. A financial evaluation of any proposed measure is needed to see where and when the benefits of DSM can be accrued to the industrial enterprise. Provided a reasonable return on investment can be assured, the enterprise management should take prompt action, in some cases with the technical advice of the utility company experts.

For building owners or operators, there may be a variety of cost effective measures available. For example, light fixtures can be modified, and heating and cooling systems can be altered from constant-volume to variable-volume drive applications (or indeed replaced entirely by new equipment). Equipment changes and new controls and other instruments, e.g. meters or timers, should also be considered.

In conclusion, based on the discussion above on “Why promote DSM?” and taking into account the driving forces for DSM, it is possible to trace the rationale of the various DMS efforts back to two main categories:

- Cost reduction and environmental motives;
- Reliability and network motives.

4.1. Cost reduction and environmental motives

DSM was started with the focus strongly on electricity systems. There was a first wave of DSM activity in California in the late 1970s as part of the response to rising oil prices (cost motivation) and increasing public hostility to new power stations (environmental motivation). However, the initiative began to develop in earnest in the United States in the early 1980s, in the context of integrated resource planning where the emphasis was on reducing total costs (financial and environmental) of meeting energy demand (University of Warwick, REEEP, 2005).

California set up the California Energy Commission (CEC) which worked with the California Public Utilities Commission (CPUC) to set spending targets for energy conservation and load management for the state's four investor-owned utilities. During the 1980s and early 1990s, cost reduction and environmentally-driven DSM programmes were implemented in many United States states, Canada and a number of European countries. Essentially, DSM was made attractive for utilities, through changes to the incentives set by regulators.

Before these changes were made, the utilities would lose income if they sold fewer kWh and DSM programmes offered risk but no reward for shareholders, as such investment would not be added to the asset base on which the regulators calculated the allowed rate of return. The solution was to make utility profits less dependent upon the numbers of units sold and to enable the utilities to earn profits on DSM activities. DSM became a major activity in the United States with utilities spending $US 2.8 billion on it by 1993 (Hadley & Hirst, 1995). The main activity undertaken under DSM programmes was energy efficiency for customers. Typically, utilities would subsidize the cost of energy saving measures such as efficient heating systems, appliances, lighting and insulation.

DSM as operated in the 1980s and early 1990s worked in the context of vertically integrated monopoly electricity utilities. It is more complicated to use it where companies are not vertically integrated and/or where competition has been introduced. As electricity market reform was introduced in the United States from the mid-1990s, spending on DSM fell by 50 per cent from 1994 to 1997 (Crossley, 2005). Nevertheless it is possible to use it where electricity reforms have taken place, particularly in the natural monopoly distribution side (see case study of New South Wales below) where network-driven DSM can be particularly useful.

The fate of DSM programmes in the face of power sector reform has varied widely across the globe. In some jurisdictions, DSM programmes are now coordinated by governmental or other agencies, rather than utilities, and funded with taxes or general revenues, rather than by ratepayers. However, in most countries where DSM is used it is funded through electricity bills and the electric utilities are actively involved in programme design and delivery. Policies that support the continuation of DSM programmes include the following, often in combination:

- An agreed-upon or mandated quantified target for energy savings;
- A funding mechanism that strengthens, or does not harm, the competitive position of the energy companies practicing DSM;
- A standardized and mandatory scheme for cost-benefit evaluation of the DSM activities;
- Price regulation of the remaining monopoly segments (transmission and distribution network and retail supply to non-eligible customers) in a manner that removes artificial incentives to increase sales and disincentives to save energy (e.g. Denmark, Italy, NSW in Australia, Norway and the United Kingdom).

DSM measures can certainly reduce consumer energy costs. Many measures require little or no implementation costs, as suggested in “Energy Saving Tips” later in this module. The implementation of different DSM mechanisms would incur different costs that need to be carried by government, utilities or consumers. Often any implementation cost is passed on to the consumer, for example, by the utility in the form of higher tariffs or by the manufacturer of an energy efficient appliance in the price tag of that appliance. However, government in the form of subsidies or loan assistance may often share these costs.

The advent of competitive electricity wholesale (generation) markets in which prices can be highly volatile is encouraging the development of market-driven DSM, particularly to provide short-term responses to energy market conditions (“demand response”). Market-driven DSM is a growth area in the United States and this is likely to be replicated in other developed countries that have competitive electricity markets. Such market-driven DSM will be primarily motivated to achieve cost savings. It may also reduce energy demand although it may mainly shift demand to times when prices are lower. Market-driven DSM may have positive or negative environmental impacts. This will depend upon the nature of the marginal generating plants that may be displaced (e.g. coal or gas) and the demand-side response (e.g. energy efficiency measures or different forms of distributed generation such as solar or diesel).

A study conducted by the Government of New Zealand estimated in about 22 per cent of current consumption, the economically efficient savings that New Zealand could achieve through electricity DSM over a five-year period (Treasury, New Zealand, 2005). More realistic estimates have set between 6.5 per cent and 11 per cent the amount of savings that could be practically achieved.

DSM effectiveness needs to be quantified and this can be achieved using measurement and verification (M&V). M&V has the advantage of being an impartial, credible and transparent process that can be used to quantify and assess the impacts and sustainability of DSM and energy efficiency projects (Eskom, 2006). It provides customers and utilities with information on the impact of the DSM programme so that future planning can take into account the results. In South Africa the following DSM results were quantified by M&V and published by Eskom *(Eskom—Energy Audits, Quarterly Report,* Period: April to June 2006*)*:

- 2004 calendar year — 42.71 MW saved, of which 31.09 MW was saved by two separate lighting projects applying compact fluorescent lamps (CFL);
- January 2005 to March 2005 — 44.57 MW saved (CFL lighting projects);
- 2005/6 Eskom financial year — 81.80 MW saved (of this, 9.78 MW was saved by three separate CFL lighting projects);
- 2006/7 Eskom financial year — pro-rata first quarter savings are 38 MW.

Whilst there will be environmental benefits from not constructing new infrastructure, these need to be considered alongside actions taken to avoid infrastructure development. Most (e.g. energy efficiency, distributed co-generation using gas, solar power) will bring environmental benefits but some (e.g. some forms of stand-by generators) may create some environmental problems such as localized noise and pollution from diesel generators and risk of pollution from careless disposal of batteries or other equipment.

4.2. Reliability and network motives

Network constraints are becoming a problem in both developed and developing countries where electricity demand is increasing and network infrastructure is becoming inadequate. For example, air conditioning is a major growth area in many countries. In many situations, network-driven DSM can delay the need for network expansion and augmentation. Sometimes network-driven DSM may even be able to eliminate cost-effectively the requirement to build a large-scale distribution network: this may be particularly useful in many developing countries where extensive distribution networks do not exist. Although experience to date with this type of DSM is limited, network-driven DSM may offer the scope for significant savings in costs in the future (University of Warwick, REEEP, 2005).

Box 3. **Katoomba demand management project, New South Wales, Australia**

In late 1990s, the electricity network infrastructure in the Katoomba area of the Blue Mountains west of Sydney had limited capacity and, due to load growth, required a new transmission substation at Katoomba North, which was constructed in 1996/97. In 1998, Integral Energy launched a demand management programme, focusing on energy efficiency in the residential sector in an attempt to defer further augmentation of the network.

The programme used one full-time advocate of energy efficiency measures to provide advice to homebuilders and developers. It created a register of energy efficiency service providers that could sell and/or install items such as insulation, double glazed windows, alternative fuel appliances, high efficiency light fittings and heat pumps. Integral Energy also ensured that the registered vendors offered their products and services at reasonable prices. However, Integral Energy did not arrange for the installation of energy efficiency measures or provide subsidies for the installation cost. The programme ran from 1998 for about five years. It was successful in achieving reductions in winter peak period loads, particularly space heating loads. However, the summer load continued to grow. The programme successfully deferred additional capital works in the area—including the construction of a second feeder and second transformer—until 2006/07. The programme cost $AUS 70,000 per annum (administrative costs).

5. TYPES OF DSM MEASURES

Most DSM measures are put in place by utilities or by the energy end-users themselves—typically industrial enterprises. Utilities try to encourage energy users to alter their demand profile, and this is generally accomplished through positive tariff incentives allowing customers to schedule demand activities at a time that will reduce their energy costs. This in turn helps the utilities by moving the demand away from the peak period. In some cases, negative incentives (penalties) are charged for the continued operation of inefficient equipment with unnecessarily high loads: this is intended to encourage customers to upgrade equipment and thereby reduce electrical demand.

Industrial enterprises will normally consider a wide range of possible actions to reduce the consumption of all types of energy. A straightforward reduction in energy consumption will normally reduce costs, and a shift of demand to a different time might reduce costs if an appropriate tariff is available.

The main types of DSM activities may be classified in three categories:

- Energy reduction programmes—reducing demand through more efficient processes, buildings or equipment;
- Load management programmes—changing the load pattern and encouraging less demand at peak times and peak rates;
- Load growth and conservation programmes.

5.1. Energy reduction programmes

This category covers a large number of measures in all sectors. As examples of typical energy reduction measures, a series of "energy saving tips" are presented below. Many are so-called housekeeping items that can be implemented for little or no investment, while others may require significant capital investment. A discussion of widely applicable measures follows, as well as examples of particular relevance to industrial and commercial enterprises.

Energy saving tips

Industrial and commercial sectors

Boilers
Production of steam and hot water is a major activity for most enterprises and uses well known technology. However, poor boiler operation represents a significant source of energy losses. Therefore, boiler performance improvement is often a practical and low cost option. The actions that can be taken to improve performance include:

- Monitoring combustion conditions routinely and keeping efficiency as high as possible at all times;
- Ensuring there are adequate controls to adjust the quantity of combustion air;
- Ensuring insulation (on the outside of the boiler) and refractory (inside) are in good condition and that thicknesses are appropriate for good modern practice;
- The water treatment system should be in good working order at all times, and boiler feed water quality should be monitored regularly;
- Equipment should be checked frequently for steam and water leaks;
- Capacity utilization should be checked—one boiler operating at high load is much more efficient that two boilers each at low load.

Steam systems
These represent an important operating cost for many companies and good performance can be achieved by good management. Substantial losses are incurred through poor maintenance as well as poor original design. The following actions should be considered:

- Insulate steam and condensate return lines, vessels and fittings;
- Repair steam leaks and maintain steam traps;
- Use condensate return systems to the maximum;
- Consider heat recovery from contaminated condensate that cannot be returned;
- Consider using flash steam in the plant;
- Fit automatic temperature controls to equipment wherever possible, to minimize waste of steam to overheat equipment or processes.

Lighting

Often consuming 10 per cent or more of industrial plant electricity and 50 per cent or more in commercial buildings, lighting normally offers good opportunities for savings. Some of the items listed below will also apply to a greater or lesser extent to the domestic sector.

- Use energy efficient fluorescent tubes, CFLs and other low energy light sources;
- Consider using energy efficient electronic ballasts;
- Clean luminaries regularly;
- Use appropriate lighting levels for different parts of the work area;
- Install lights at working level where possible, not necessarily on a high ceiling;
- Use natural light where possible, e.g. fit translucent roof panels or skylights;
- Paint walls and ceilings white or bright colours (also floors if possible) to improve light reflection.

Motors and drive systems

In all sectors, motors are significant energy consumers. In many industrial plants, motors and drive systems may consume over 50 per cent of the total electricity used. Poor motor performance is typically a major source of energy losses. The following actions should be considered to improve motor performance:

- Use properly sized motors and only run when needed;
- Use high efficiency motors;
- Use electronic variable speed controls where motor loads are variable in normal operation;
- Use cogged belts or improved gears: smooth belts often slip and are not efficient;
- Install improved bearings and lubricate regularly;
- Check power factor regularly and improve with capacitor banks, preferably installed close to the running equipment;
- Maintain all equipment regularly.

Compressed air systems

Often a significant user of electricity in an industrial plant, compressed air systems frequently lack meters and suffer poor maintenance. Operating practices may be poor too. The following actions should be considered:

- Eliminate inappropriate use of compressed air (e.g. do not use for clearing away dust or metal shreds from lathes and similar machines);
- Listen for leaks during shift changes or lunch breaks, when workshops are typically quiet and not supposed to be using air;
- Regular maintenance of all parts of the system, including valves and joints, which are often subject to leaks. Check air filters as these may be blocked by dust or grease;
- Reduce air intake temperature e.g. consider relocating the intake;
- Improve overall system efficiency by checking compressor running times e.g. running when there is little or no demand;
- Optimize system pressure: do not generate at high pressure for tools etc. that do not need this;
- Install heat recovery systems.

Household

No-cost or low-cost measures

If no action has previously been taken on simple energy savings measures, there may be large savings opportunities available for very low cost. Although the items below are classed as "household", most of them apply just as well to buildings of any kind.

- Sealing and insulation—look for air infiltration or hot air escapes, and inadequate or failed insulation in:
  - Floors, walls, ceilings;
  - Doors and windows;
  - Fans and vents;
  - Heating, cooling and ventilating ducts, and fireplaces;
  - Electric outlets;
  - Plumbing penetrations through walls.
- Hot water cylinders—set the thermostat to 50°C, use insulating blankets, and insulate pipes;
- Washing machines, dryers and dish washers—only run with a full load;
- Space heating/cooling temperatures—use curtains to insulate at night and as a sun blind: to cool if hot, or open to let sun in if cold;
- Replace incandescent lighting with CFLs.

Measures needing investment

- Replace old outdated appliances (washing machines, refrigerators, air conditioners, etc.) with new more efficient ones;
- Install a solar water heater (but check payback period for the investment needed);
- Install double glazing windows (but check payback period).

Widely applicable measures

Efficient lighting

Energy consumed for industrial, commercial and domestic lighting is a significant component of energy demand for many electricity supply systems, particularly at times of peak demand. Measures to save electricity in lighting will normally require some investment but this need not be excessive and will typically allow paybacks under a year or so to be attained. Measures include changes in light bulbs, fittings and switches. In some cases, increased use of natural light can be achieved but may involve expensive building modifications. Other measures are suggested in the “tips” above.

Regarding light bulbs, traditional incandescent bulbs lose a large proportion of their energy to heat and only 3-6 per cent of the input energy results in light. Depending on the colour acceptable in the specific situation, different lights may be used. For example, fluorescent lamps can allow big reductions to be made in lamp wattage for the same intensity of illumination. Standard fluorescent tubes may be adopted but energy saving tubes operate at even lower wattages (saving around 12 per cent) for almost the same light output. Fluorescent lamps controlled by electronic ballast operating at high frequency (20 kHz) are typically 10 per cent more efficient than those with conventional ballasts. Note too that ballasts of flickering fluorescent tubes continue to consume 15 per cent of the lamp wattage even if the contribution to lighting is zero. Also, although up to 25 times more expensive than conventional starters, electronic starters last longer and start lamps without flicker, thus extending lamp life.

Compact fluorescent lamps (CFL) are now available from various manufacturers as direct replacements for incandescent lamps up to 100W. The lamp, complete with electronic ballast can be fitted in the lamp holder of the incandescent lamp to be replaced with no modifications required. Although more expensive (up to 20 times the cost of the equivalent incandescent bulbs) they consume less than 25 per cent of the energy for the same light output and last up to 10 times as long.

Table 1 below gives a summary of different light source characteristics. For industrial plants or large commercial warehouses and yards where colour rendering is not critical, sodium and mercury-based lamps can offer substantial savings in electricity.

Table 1. Comparison of typical light source characteristics

	LAMP TYPE					
CHARACTERISTIC	Incandescent (tungsten-halogen)	Low pressure discharge		High pressure discharge		
		Fluorescent	LP sodium	Mercury vapour	Metal halogen	HP sodium
Efficacy in terms of initial lumens watt	20 (23)	70	140	50	80	120
Typical rated life in hours	1,000 (2,000)	12,000 to 20,000	18,000	16,000 to 24,000	7,500 to 15,000	20,000 to 24,000
Ballast required	NO (YES)	YES	YES	YES	YES	YES
Colour of light	Warm	Cool/warm	Yellow	Cool/warm	Cool	Warm
Lamp cost	Low	Low	Low	Medium	High	High
Operating cost (comparative)	1.0	0.25	0.15	0.36	0.22	0.2

In summary, the main opportunities for reducing the electricity used for lighting are:

- Lighting retrofitting—the replacement of existing lamps with more efficient light sources, sometimes in conjunction with new lighting fixtures (possibly high initial costs but long-term benefits);
- Fixture delamping—removing selected lamps from existing light fixtures in a uniform pattern throughout specific areas to reduce overall lighting, or to remove selected lights entirely where they do not contribute to task or safety lighting;
- Modifying switches, e.g. to allow selected areas of lighting to be switched off while adjacent areas remain on. Additional switches can be installed in large areas where selected parts are switched on or off by the workers in different parts, rather than keeping the whole area illuminated when few people are present.

Box 4. **Efficient lighting initiative in South Africa**

In South Africa 69 per cent (2001 Census) of households that have access to electricity use electricity for lighting. Vast potential exists for reducing load demand relatively quickly and cheaply. The Global Environment Facility (GEF) has provided $US 225 000 in funding to assist with an Efficient Lighting Initiative (ELI). The aim of ELI is to penetrate the South African Market with 18 million compact fluorescent lamps (CFLs) over the next 15 years.

With coal-fired power stations accounting for 90 per cent of South Africa's generation capacity, any reduction in electricity demand due to demand-side measures benefits the environment by reducing associated emissions and water use. If the target of 18 million lamps is met, then on an annual basis, it could reduce power consumption in South Africa by over 4,000 GWh compared with the power consumed by standard incandescent lamps.

Source: Future Planning (Eskom CER 1999), Corporate Environmental Affairs, Eskom www.eskom.co.za/enviroreport99/future.htm Accessed 06July06

Energy efficient motors

Electric motors are extensively used in all sectors. In many industrial plants, they may represent over 50 per cent of the total electrical load. In manufacturing plants and the mining industry, there can be large ventilation requirements to dilute dust and gases, and to remove heat in buildings or deep mines. In buildings—commercial, institutional and domestic—a major source of power usage is in air conditioning for air circulation and compressor motors.

An opportunity therefore exists in many situations to reduce electrical loads by the types of measure listed above in the “energy saving tips”. In particular, for locations where motors are run continuously for long periods of time, it can often be cost effective to replace conventional motors by high efficiency types. This may be carried out at any time—provided it is cost effective to do so—but companies may typically find that the shortest paybacks are obtained when replacing a conventional motor that has failed in service. Rather than replacing it with an identical motor, serious consideration should be given to installing a high efficiency motor instead.

For the ventilation of mines, for example, the use of energy efficient motors and high power impellers can allow demand to be reduced without changing the main equipment frames. The payback time is often quite short and reliability can be improved (C.D. Pitis, 2004).

In Ghana in 1999, feasibility studies were conducted for the establishment of one-stop motor repair and sales centres, which could serve as outlets for energy efficient motors and drives in various parts of the country. The study established that repeated motor rewinding and refurbishment (common practice in Ghana and many other countries) leads to significant efficiency losses.

The study found that it was feasible to establish private motor centres that would sell energy efficient motors to industry and provide motor advisory and repair services.

The study also recommended the development and implementation of motor testing procedures, minimum efficiency standards and labels as well as the establishment of a facility in Ghana to manufacture small electric fan and pump motors (Alfred K. Ofosu Ahenkorah, 2006).

Box 5. **Assessment of energy utilization at the University of Zambia**

1. Background

Since energy costs have risen in the past few years and since energy is essential for operating a big learning institution, the University of Zambia (UZ) undertook an energy audit to identify ways of reducing energy expenses. At the beginning of the study, UZ owed the supply company about $US 1.0 million in unpaid electricity bills. Electricity consumption had to be reduced to sustainable levels. The advantages of energy efficiency to UZ are very significant as the financial savings can be channelled to more needy sections in the university.

2. Audit objectives

The objectives were to identify ways of reducing energy costs, and evaluate possibilities for energy substitution to reduce electricity bills.

3. Description of the project

The key tasks of the audit were identifying the main energy using units, estimating energy consumed by each, and identifying energy saving opportunities. Specifically the study undertook the following:

- Energy consumption estimates were made for student hostels and water pumping systems by measuring currents and voltages with a clamp-on-meter because these units are fed by sub-stations with faulty energy meters. There are 52 hostels and about 124 students live in each. Students do not pay for electricity since this is paid in bulk by the University authorities. There are five borehole pumping systems to supplement water supply from municipal sources.

- Power factor measurements were carried out from a sample of about 14 hostels for a continuous period of three months.
- A questionnaire was also administered to study energy consumption patterns.

4. Results

	Location	Typical load (kW)	Average power factor
1	Hostels	650	0.72
2	Water pumps	105	0.72›

Results of the questionnaire responses showed the following:

- Over 90 per cent of respondents cook for less than 8 hrs per day, about 30 per cent play radios for 18-24 hours per day, and 90 per cent use fluorescent lamps for lighting systems.
- About 70 per cent of respondents leave lights on 16-24 hours per day; about 79 per cent realize the need to use natural daylight while 21 per cent do not see the need for using daylight to conserve energy.
- About 68 per cent of respondents suggested that the institution should set up measures to ensure that the number of electrical appliances purchased is regulated. They also suggested that students be made aware of the need to save energy.
- There is no use of low power consuming appliances or automatic switching systems.
- About 11 per cent of respondents suggested that the Government should raise meal allowances to enable them to purchase meals from cafeterias since this would minimize cooking in rooms.

5. Description of recommended actions

- For lighting, replace 54 watt fluorescent tubes with more efficient 18 watt tubes; replace incandescent lights with more efficient CFLs and reduce usage by 10 per cent; use automatic switches on lighting systems; increase awareness on the use of natural daylight.
- Install capacitor banks to raise power factor from 0.72 to 0.95 as required by the utility to save on money being paid on penalties for low power factors.
- Regulate the types and number of electrical appliances used.
- Set up an energy management centre for training and conducting awareness programmes, and study implementation of energy saving measures.

6. Lessons learnt

The study identified various energy saving opportunities and overall substantial savings in energy that can be realized. It was recommended that feasibility studies be undertaken to determine the savings from reduced energy consumption from specific actions and the cost of implementation. The next step would then be to implement items with payback periods under two years. A two-year payback period is generally regarded as a good guideline for implementation of DSM actions.

Industrial and commercial DSM practices

Energy management

The aim of energy management is to lower energy costs and bring immediate benefits to an organization or enterprise. Energy management is the structured application of a range of management techniques that enables an organization to identify and implement measures for reducing energy consumption and costs.

Energy management activities typically cover:

- Energy purchasing;
- Metering and billing;
- Performance measurement;
- Energy policy development;
- Energy surveying and auditing;
- Awareness-raising, training and education;
- Capital investment management (including equipment procurement).

The specific tasks of an energy management department will depend on the nature of the organization and the budget and staff skills available. Energy management is a continuous process, with continuous monitoring of energy performance and always seeks to maintain and improve the efficient use of energy.

Once top management has given its approval to undertake energy management in the organization, and appropriate resources have been authorized, the next step is the appointment of an energy manager. The role of an energy manager will vary from organization to organization but they will normally be concerned with the following tasks:

- Collecting and analysing energy-related data on a regular basis;

- Monitoring energy purchases and equipment procurement;
- Identifying energy saving opportunities;
- Developing projects to save energy, including technical and financial evaluations;
- Implementing projects and checking post-implementation performance;
- Maintaining employee communications and public relations.

An important part of this job is the collection and analysis of data. Thus the energy manager must be aware of load profiles or time of use for all forms of energy consumption. Reliable quantitative information on load profiles is needed to analyse the opportunities for load shifting and load levelling. To obtain the data, automated measurement and recording equipment is available to record load profiles, and indeed to control and manage the use of electricity, gas, liquid fuels, steam and water.

As an example, advanced software programs are available to organize data on energy use (and other key operating parameters) and provide a series of utility cost management applications, such as (C. Martel Chen, 2004):

- Load profiling of individual and multiple facilities to ease energy decisions;
- External and internal benchmarking of energy performance;
- Utility bill verification and budget tracking;
- Energy accounting, baselining and savings analysis;
- Measurement and verification of energy conservation measures;
- Internal cost allocation by cost centres, product lines, etc.;
- Tenant billing for multiple occupancy buildings;
- Facility management reporting to senior management.

Housekeeping

Measures to reduce energy consumption and improve energy efficiency in enterprises and other organizations may be divided into three basic categories (as discussed below for “energy audits”):

- No-cost and low-cost measures;
- Measures requiring moderate levels of investment;
- Measures requiring significant investment.

Each organization will have to make its own decision regarding what “moderate” and “significant” mean, as this depends on many factors, such as the size of facilities, levels and cost of energy consumption, and the financial situation of the organization.

The first category—the no and low-cost measures—covers items usually known as "good housekeeping" and these should be implemented by the organization to "tidy up" its operations. Organizations should always consider implementing housekeeping measures promptly because they can reduce energy demand in the short term, usually for very small capital investments and low installation costs.

Some examples of good housekeeping are:

- Removing redundant lighting fixtures—many plants undergo modifications and reorganization but lighting systems are often not correspondingly moved, with the result that lights may become redundant;
- Removing redundant pipework—as for lighting, process changes or increases in production capacity often result in piping (and sometimes equipment) being redundant. Unless properly insulated or removed, the redundant items may contribute to unnecessary heat losses and leaks of steam etc;
- Switching off unnecessary loads, such as:
  - Lights—in unoccupied areas, and in areas where daylight provides adequate lighting (manually—light switches at strategic points can facilitate manual switching; or by automatic controls—motion detectors, time controls and photo sensors);
  - Computers and monitors—when not in use, switching off reduces the load and also reduces heat and therefore the demand on space cooling;
- Improving distribution systems for electricity, steam and other utilities e.g. better insulation of hot and cold services, replacing electricity lines to cut line losses;
- Repairing steam leaks—improves the system efficiency and reduces energy needed to compensate for energy losses in the leaked steam;
- Maintaining appropriate process control settings—optimizing the efficiency of the processes and other energy-dependent activities, thus reducing energy needs.

Review question

What are three housekeeping practices that would improve efficiency and reduce energy demand?

Preventive maintenance

Good maintenance has an essential part to play in achieving good levels of energy efficiency. For example, some typical deficiencies in industrial plants are:

- Meters are uncalibrated or out of service;
- Steam traps are defective;
- Valves are leaking at the spindle, losing steam, water, compressed air and process fluids;
- Insulation of steam and refrigeration distribution piping is inadequate.

Most plants and many commercial buildings will benefit from improved maintenance, increasing their energy efficiency performance and reducing emissions correspondingly. All too often maintenance is only performed when a breakdown occurs, whereas prevention of breakdowns can contribute greatly to long-term energy efficiency. Preventive maintenance can take various forms, some examples of which are:

- Developing and applying routine lubrication schedules;
- Replacing critical items on a regular schedule (e.g. steam traps);
- Monitoring lubricant composition to determine when excessive wear of metal parts is occurring;
- Monitoring noise and vibration of bearings before failure actually occurs;
- Regular filter cleaning on air compressors, pumps, upstream of steam traps, in ventilation ducts, etc;
- Continuous scale removal from water heating equipment or appliances;
- Monitoring hot spots on boilers and furnaces, to check for refractory failure;
- Monitoring transformer temperatures for abnormalities.

Introducing a preventive maintenance system should include good records of actual failure rates and an analysis of the reasons for breakdown of different types of equipment. Preventative maintenance thus contributes to machines and processes running at optimum efficiency, as well as minimizing unscheduled downtime.

Buildings regulations

The design and construction of buildings is regulated in most countries by "buildings regulations" which set minimum standards for various items that impact on the energy consumed to operate a building (as well as on items affecting safety). The detail contained in regulations can be quite comprehensive and designed to require architects, designers and constructors to adopt good energy efficiency practices and thus reduce energy consumed in the built environment. Typically regulations will cover, for example:

- Improved materials of construction of buildings—to reduce heat losses though walls and floors;
- Insulation of roof spaces—to reduce heat losses;
- Window design and construction—to minimize heat losses/gains;
- Standards for the performance and control of air conditioning systems;
- Efficiency standards for lighting, and use of passive lighting;
- Minimum efficiency standards for central heating boilers and hot water heaters;
- Timers and temperature controls on electric hot water cylinders;
- Application of solar water heaters and passive space heating.

Appliance labelling

Labelling appliances, selected equipment and even buildings to indicate their expected energy consumption is a well-known and tested tool for raising customer awareness. Educating energy consumers can contribute to reducing energy consumption by making them aware of the consumption levels of, for example, household appliances, cars and buildings and thus encouraging the choice of items with the highest energy efficiency.

Domestic appliances represent an important source of energy consumption in households, especially refrigerators and water heaters. Appliance labelling allows the consumer to compare appliances from various manufacturers and make an informed judgement when buying a new appliance. Generally the label contains a simple means of rating consumption, for example a letter from A to G (where A is the most efficient). The label may also contain the consumption of the appliance in kWh per year, or expressed as an estimated cost of operating the appliance for say one year.

Energy labelling needs to be in place for at least a couple of years before the effect can be observed on consumption levels. This is because consumers need to become familiar with the content of the label and will then make their choice for energy efficiency only when they need to replace a particular appliance.

Energy auditing

Introduction

For many enterprises, energy consumption data is limited to a few utility bills, e.g. for electricity, gas, coal, fuel oil, and these apply to the whole organization. Separate consumptions for different workshops, processes or buildings are rarely known. For such enterprises, there may be only one meter for the energy supplied to the factory fence, and sub-metering to different parts of the site may not exist. In other organizations, sub-meters may well exist but readings are not always taken at the same time every month, and records may be unreliable. Data on production and other key parameters maybe available but are not related to the corresponding energy consumptions. In this situation, it is impossible to determine with any certainty the energy performance of different departments.

When setting up an energy management programme, it is necessary for an organization to undertake a complete review of energy consumptions and corresponding activities, e.g. quantities manufactured, buildings heated or cooled. An "energy audit" is done to gather together all the relevant data and to analyse performance throughout the organization, from which deficiencies can be identified and recommendations for improvement made.

There are various types of audit and levels of complexity that can be applied for an organization, as well as various objectives of an audit in specific circumstances. Audits may be applied, for example, to industrial operations, commercial buildings, transport companies, and domestic premises. A typical audit for an industrial company might carry out some or all of the following:

- Obtain information on the processes employed, on plant equipment and physical facilities, design data, machinery characteristics and production capacities;
- Determine from historical records the emissions, energy consumptions and production levels for the plant and key departments (over a period of say 2-3 years);
- Determine—if necessary from on-site measurements using portable instruments—the actual operating parameters and performance of equipment and processes;
- Observe the nature and extent of energy management procedures and reporting, and the corresponding management structure in the organization;

- Analyse the data obtained and the observations made, establishing the efficiency of energy utilization by key equipment;
- Identify and characterize the constraints to improving performance, including organizational, technical and financial constraints;
- Identify potential measures for improvement and carry out financial evaluations where investment is needed;
- Develop a logical action plan to address the constraints, including specific recommendations and priorities for the different measures.

For buildings or transport activities, corresponding information will be collected and similar analyses carried out.

For convenience, audits may be divided into "preliminary" and "detailed" audits. In practice of course, many audits will be "between" the two. Practical audit work requires a flexible approach, in which procedures are adapted to meet the needs of the specific organization. Various types of audit are discussed below.

Preliminary audits

A preliminary audit (PA) is an initial data-gathering exercise and may be known by many names, such as walk-through audit, short audit or initial survey. Typically the PA can be completed without sophisticated instruments and uses only data that are already available in the organization. The work is carried out in cooperation with plant personnel. Data from plant records are collected and supplemented by a "walk through" of the plant (or building) during which the audit team observes the general condition of equipment, the standard of maintenance, the level of operations control exercised by management, and the reporting procedures in effect.

Few measurements are made during a PA, other than perhaps making some limited stack gas analyses on boilers and furnaces. This is because combustion gas compositions are relatively simple to determine and easily used to estimate the excess air applied and the stack losses. Excess air should be set at levels that depend on the fuel type and composition, and on the design and condition of the equipment.

The PA can be completed in a short time. The energy auditors rely on their experience to gather information for a rapid diagnosis of the energy performance of the organization. The typical output of the PA will include a report with a series of low-cost improvement measures, the housekeeping measures discussed earlier in this module. The report will also include recommendations for the scope of a detailed audit, if this is justified.

Detailed audits

A detailed audit (DA) is a more comprehensive study of the plant (or building). Portable instruments are usually used to check parameters on equipment and processes, followed by a detailed analysis of the different systems. Although instruments are needed, this does not mean that auditing is an exact science. The auditors must always use their experience and judgement in collecting and interpreting data. Plant personnel will also be involved and should participate closely at all stages with the audit team.

The specific measurements required vary according to the type of plant and its condition. In general terms, about half of the effort on a DA will be spent for data collection on-site and the other half on analysing data and preparing the report. Measures that require investment should include financial analyses with estimates of likely returns on the capital invested. An example of a typical report is given in box 6.

While some audits allow a good understanding to be gained of the performance of equipment and workshops, they do often have limitations. An audit will typically require a significant amount of effort to complete, and many tend to be "static", giving a comprehensive picture of performance at one particular time. An audit should therefore be considered as a start to a continuing activity of data collection and performance analysis, in which the results from one time period to the next are compared and trends in energy efficiency—better or worse—are identified. A good energy management programme will include the initial auditing and also a longer-term activity of performance monitoring.

Finally, we may note that an advantage of having an energy audit conducted at an organization is the raising of awareness of the staff members who may well take this knowledge back to their own home and apply the same principles and carry out their own energy efficiency measures.

Box 6. **An energy audit report template and guidelines**

1. Title page

- Report title
- Client name (company for which facility has been audited)
- Location of the facility, date of report
- Audit contractor name

2. Table of contents

3. Executive summary

All information in the executive summary should be drawn from the more detailed information in the full report. The executive summary should contain a brief description of the audit including:

- Name, plant(s), location(s) and industry of the company audited
- Scope of the audit
- Date the audit took place
- Summary of energy consumption data
- Results:
  - Assessment of energy-consuming systems
  - Identification of energy management options (EMOs) and estimates of energy, greenhouse gas (GHG), and cost savings associated with each option, with the relevant implementation cost and the expected payback period (and return on investment). In the event that an audit covers more than one facility, the statistics for each facility should be reported on an individual basis to the extent possible. Results are conveniently expressed in concise tables.
- Recommendations summarized in table form.

4. Introduction

The introduction should include:

- Audit objectives: a statement that defines the scope of the energy audit in clear and measurable terms—example, space(s), systems and/or process(es) to be audited
- Background information: a description of the facility where the audit will be conducted, as well as information regarding facility layout, products/services produced/distributed, operating hours including seasonal variations, number of employees and relevant results of previous energy initiatives.

5. Audit activity and results

This section should make reference to:

- Description of the audit methodology (techniques, e.g. inspection, measurements, calculations, analyses and assumptions)
- Observations on the general condition of the facility and equipment
- Identification/verification of an energy consumption baseline in terms of energy types, units, costs and greenhouse gas (GHG) emissions for the facility/system being assessed

- Results of the audit including identification of EMOs and the estimated energy, GHG, and cost savings associated with each measure as well as the required investment and payback period associated with each of the EMOs identified.

6. Recommendations

This section should list and describe the recommendations based on the identification of EMOs and may include details concerning implementation. An explanation should be provided for recommending or not recommending each EMO identified in the results.

7. Appendices

Appendices include background material that is essential for understanding the calculations and recommendations and may include:

- Facility layout diagrams
- Process diagrams
- Reference graphs used in calculations, such as motor efficiency curves
- Data sets that are large enough to clutter the text of the report

5.2. Load management programmes

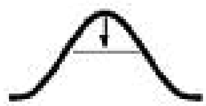
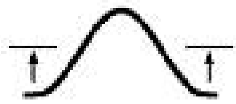
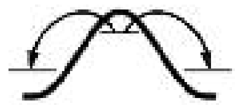
Electricity suppliers can influence the redistribution of the demand and time of electricity usage by load management by their customers. Similar activities can be encouraged by gas utilities. Load management of any kind will generally be conducted so that the energy user will be able to continue production while the utility achieves a modified load curve. The types of load management techniques are (www.cogeneration.net, 2006):

- Load levelling;
- Load control;
- Tariff incentives and penalties.

Load levelling

Load levelling helps to optimize the current generating base-load without the need for reserve capacity to meet the periods of high demand. Classic forms of load levelling are presented in table 2 below.

Table 2. Classic forms of load levelling

Peak clipping—where the demand peaks (high demand periods) are "clipped" and the load is reduced at peak times. This form of load management has little overall effect of the demand but focuses on reducing peak demand.	
Valley filling—where the demand valleys (low demand periods) are "filled" by building off-peak capacities. This form of load management can be achieved by thermal energy storage (water heating or space heating) that displaces fossil fuel loads.	
Load shifting—where loads are "shifted" from peak to valley times (achieving clipping and filling). Examples of applications include storage water heating, storage space heating, coolness storage, and customer load shifting. Shifting is different to clipping in that the load is present in the overall demand whereas in clipping it is removed.	

Source: engineering.purdue.edu, 2006

Load control

Load control is where loads (e.g. heating, cooling, ventilation and lighting) can be switched on or off, often remotely, by the utility. In this case, the customers may have back-up generators or energy storage capability and generally have an interruptible agreement with the utility in return for a special rate. Utilities may even call on on-site generators to meet peak demand on the grid.

The energy distribution industry may use rolling blackouts to reduce demand when the demand surpasses the capacity. Rolling blackouts are the systematic switching off of supply to areas within a supplied region such that each area takes turns to "lose" supply. Utilities or municipalities in these cases would try to publish or announce a schedule so that businesses and homes can plan their use of energy for that period. Recently, in Western Cape of South Africa, consumers were subject to a fairly long period of rolling blackouts. This was due to demand surpassing capacity at one unit of Koeberg Power Station under unplanned maintenance. These cuts were not always well communicated to the customers or did not run according to the published schedule causing much confusion, lost production and even lost goods such as refrigerated products. However, the winter demand was largely met due to customer participation in energy efficiency and DSM initiatives.

Tariff incentives and penalties

Utilities encourage a certain pattern of use by tariff incentives where customers use energy at certain times to achieve a better-priced rate for their energy use. These include:

- Time-of-use rates—where utilities have different charges for power use during different periods. Higher peak time charges would encourage a user to run high load activities in an off-peak period when rates are lower.
- Power factor charges, where users are penalized for having power factors below a fixed threshold, usually 0.90 or 0.95 (see box 7).
- Real-time pricing, where the rate varies based on the utilities load (continuously or by the hour).

Box 7. **Power factor correction: the Posta House case**

Background

Whenever loads are connected to an alternate current (AC) supply, there is a possibility that current and voltage will be out of phase. Loads such as induction motors draw current that lags behind voltage, while capacitive loads (e.g. synchronous motors, battery chargers) draw current that leads the voltage. Loads that are predominantly resistive such as heaters and cookers draw current in phase with voltage. The angle between the current and voltage is known as the "phase angle φ"—this can be leading or lagging (or zero) depending on the load. The power factor (PF) is defined as cosine φ and is always less than 1. It represents the ratio of active power (or useful power) to the total power supplied by the generating station.

When power factor is less than unity, the amount of useful power supplied by the generating plant at maximum output will be less than its full capacity (in other words, when the PF is less than one not all the power supplied is turned into useful work). This represents an inefficiency and therefore utility companies usually require customers to achieve a power factor of at least 0.9 (sometimes 0.95). Those who fail to meet the minimum required value will be charged a penalty on their bills to compensate for the various losses incurred by the generator (e.g. losses in distribution cables and transformers).

Power factor correction

Operating at a high power factor allows energy to be used more efficiently. In most cases, a low power factor can be increased ("corrected") by installing capacitors in the system. In most plants, a practical solution is to install capacitor banks at the main point of power supply. Depending on the power factor, more or less capacitance can be connected at any time.

Power factor correction: the Posta House case

The head office of Tanzania Posts Corporation experienced substantial monthly bills and it was found the power factor averaged 0.75. Based on meter readings for electricity consumption in the existing situation, the active power (useful power) was 225 kW while reactive power (not useful) was 198 kVAr, for a total chargeable power demand of 300 kVA.

Improving the PF to 0.98 would reduce the reactive power to 45.7 kVAr and the total chargeable power demand to 230 kVA. To achieve a PF of 0.98, the required capacitor bank investment would amount to Tanzanian Shillings (T Sh) 9,850,000 while the annual energy saving accrued through the lower power demand would be T Sh 6,472,000. The PF improvement would therefore result in having a payback of 1.52 years or just over 18 months. Power factor correction by installing capacitor banks was therefore recommended to the management as a means of reducing the monthly costs in the electricity bill.

Review question

Describe briefly the main load management programmes.

5.3. Load growth and conservation programmes

Load growth programmes are implemented with the intention of improving customer productivity and environmental compliance while increasing the sale of kW for the utilities. This increases the market share of the utility and enables an ability to fill valleys and increase peaks. These programmes can often divert unsustainable energy practices to better and more efficient practices such as the reduction of the use of fossil fuels and raw materials.

Strategic load growth is the load shape change that refers to a general increase in sales beyond the valley filling described previously. This is represented schematically in figure I.

Figure I. Strategic load growth

Source: engineering.purdue.edu, 2006

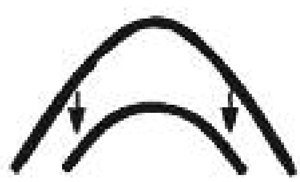
Load growth may involve increased market share of loads that are, or can be served by competing fuels, as well as area development. In the future, load growth may include electrification. Electrification is the term currently being employed to describe the new emerging electric technologies surrounding electric vehicles, industrial process heating and automation.

An example is the promotion of electro-infrared technologies to heat, dry or cure a variety of products such as wood, paper and textiles. Electro infrared technology replaces the use of fossil fuel furnaces or other energy hungry and environmentally problematic technologies (www.epri.com, 2006). Other examples are the promotion of electric space heating in residential areas, electric vehicles and automation.

Load conservation programmes are generally utility-stimulated and directed at end-use consumption involving a reduction in sales as well as a change in the pattern of use. Examples include weatherization (insulation, sealing, double glaze windows, etc., for homes) and appliance efficiency improvement (engineering.purdue.edu, 2006).

Strategic conservation is the load shape change that results from utility-stimulated programmes directed at end use consumption. This is represented schematically in figure II.

Figure II. Strategic load conservation



Source: engineering.purdue.edu, 2006

Not normally considered load management, the change reflects a modification of the load shape involving a reduction in sales as well as a change in the pattern of use. In employing energy conservation, the utility planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended utility programmes to accelerate or stimulate those actions. An example is appliance efficiency improvement.

6. INFORMATION DISSEMINATION ON DSM

Energy savings and energy efficiency improvement depend on the combined efforts of many individuals. Well-motivated personnel are best able to develop and implement energy efficiency policies that are crucial for continued energy efficiency improvement in their organizations. It is therefore necessary to raise awareness by campaigns informing the staff of energy-consuming organizations about energy efficiency options and specific DSM techniques (Lugano Wilson, 2006).

These campaigns may be marketed by personal contact and visual media (such as posters, fliers, leaflets, brochures and video clips), as well as carrying out energy audits, which also have benefits with respect to energy awareness. An IEA survey (INDEEP Analysis Report, 2004) showed that most DSM programmes in industrialized countries used "personal contact" as the means of marketing. This was closely followed by "direct mail" or "advertising" and lagging a bit further behind was marketing by conducting "energy audits".

Box 8. **DSM promotion**

DSM programmes and policies can be promoted and implemented at different levels of society, such as:

- Government policies and regulations;
- Utilities programmes;
- Energy consumer participation.

Each of these categories has its own significant role to play. But the optimum results can be obtained by coordinating all three. Government agencies can make various policies and regulations, and provide subsidies for these programmes. Utilities can implement these effectively through various programmes, preferably with customized programmes developed and operated in coordination with the end-users i.e. the energy consumers (Satish Saini, 2004).

7. CHALLENGES OF IMPLEMENTING DSM PROGRAMMES

In developing countries there is generally a low awareness of energy efficiency and DSM programmes, and therefore marketing is necessary to promote these. In the service area of a utility company, the sectors and end-users that can benefit from DSM need to be identified, customized programmes developed (and their cost effectiveness evaluated) and then a plan to market and implement the programmes needs to be prepared.

Many industrial and commercial companies still have not carried out energy audits to collect reliable information on their current operations. While this may be due to a failure by management to appreciate the potential benefits of energy efficiency, some companies will lack skilled personnel able to perform audits. Consideration should be given to using outside experts, as the cost will normally be well justified. Organizations conducting energy audits or advising on DSM measures need to: (Eskom DSM, 2004).

- Have a knowledge and understanding of DSM systems and opportunities;
- Demonstrate the competence and comprehensiveness of their assessment;
- Consider the accuracy of their assumptions;
- Be aware of the production and safety constraints of involved plants/ companies.

Often as a result of completing an audit, a variety of DSM measures may be identified. Load management programmes to increase energy efficiency need to consider the following factors (Satish Saini, 2004):

- The cost to the customer;
- Variations in the prices of electricity and other fuels;
- The value of avoided losses resulting from improved electricity system reliability;
- Any potential losses in production when implementing DSM programmes.

It is essential that a proper financial analysis of the benefits of energy efficiency improvement be carried out when considering setting up DSM activities. For example, too much emphasis may be placed on the initial cost of equipment used by DSM programmes rather than on life cycle costs. Also there is often a perception that electrical energy is a small component of overall cost and therefore there is little motivation to pay for DSM measures to modify load profiles. Where fuels are involved, proper sensitivity analyses may not be performed to take account of potential energy cost variations or inaccuracies in capital investment estimates.

All investments need to be justified as part of the procedure of finding funds for DSM projects. This applies both to funds from company internal resources and to funds from banks or other funding institutes such as international cooperation agencies and the World Bank. Without a competent evaluation of a project, it will be difficult to get funds approved, internally or externally. The failure to get funds is one of the most important challenges of implementing DSM projects (see modules 17, 18 and 19 to know more on financing for energy efficiency and DSM measures).

Discussion/research question

What do you think are the main challenges to implementing DSM in your country? Consider the level of awareness and the technical capabilities of industry and commerce staff with reference to DSM implementation and any suspicion towards the utilities or regulators on the part of the energy user.

8. CONCLUSION

DSM in its various forms is an important tool for enabling a more efficient use of the energy resources available to a country. For example, DSM applied to electricity systems can mitigate electrical system emergencies, minimize blackouts and increase system reliability, reduce dependency on expensive imports (in some countries), reduce energy prices, provide relief to the power grid and generation plants, defer investments in generation, transmission and distribution networks and contribute to lower environmental emissions. Similar benefits can be achieved from DSM when applied to the use of other types of energy. Thus DSM can offer significant economic and environmental benefits.

Housekeeping and preventive maintenance are simple and cost-effective ways to reduce demand and have other benefits like process improvement. Opportunities may exist to take advantage of special tariff rates by changing load profiles or entering into contractual agreements with the utilities. It is therefore important to market DSM programmes to show potential customers their life cycle benefits and the techniques—often quite simple—for reducing demand.

LEARNING RESOURCES

Key points covered

These are the key points covered in the module:

- The reasons for promoting DSM measures in an energy sector and market;
- The main drivers of DSM measures motivated by economics, environment and regulation;
- The main types of DSM measures including energy reduction programmes and load management;
- DSM practices such as housekeeping and preventative maintenance in industry and commerce;
- The marketing and promotion of DSM;
- Challenges of implementing DSM programmes.

Answers to review questions

Question: Describe in short the main load management programmes.

Answer: Load levelling—the extremes of the peaks and valleys of the load profile can be flattened by peak clipping (high demand periods are reduced), valley filling (low demand periods are built up) or load shifting (where loads are "shifted" from peak to valley times).

Load control—utilities have interruptible agreements with customers (at special rates) and can switch off loads, e.g. heating, cooling, ventilation, and lighting when capacity is needed.

Tariff incentives or penalties—customers can choose lower rates at off-peak times to run loads (time-of-use), customers can raise the power factor of electric motors using capacitors to avoid penalties (power factor charges), customers can choose real time pricing where the rate varies based on the utilities load.

Question: What are three housekeeping practices that reduce demand?

Answer:

1. Switching off unnecessary load (like lights in unoccupied areas or in areas where daylight provides adequate lighting, and computers while not in use). This not only reduces direct load but may also reduce cooling loads due to the reduction of heat production.

2. Repairing steam leaks improves the system efficiency and reduces energy needed to compensate for lost heat through the leak, and possibly that needed to cool the area where the leak is.

3. Proper process control settings—optimizing the efficiency of the process thus reducing energy needs.

Exercises

1. Which type of DSM interventions could be implemented with the most ease/most rapidly in your country? Which interventions would be the most effective in your opinion and why?

Write a one page answer.

2. What do you think are the main challenges to implementing DSM in your country? Consider the level of awareness and the technical capabilities of industry and commerce with reference to DSM implementation and any political suspicion towards the utilities or regulators on the part of the user.

Write a 1-2 page answer.

3. Imagine a typical manufacturing industry housed in an old building with many old electric motors and large and numerous light fixtures. Imagine too that the main electrical load is currently, and mainly due to tradition, run from 6am to 9pm. Imagine lastly that the company does not follow (or even know of) any DSM programmes and yet has high energy costs.

Describe the possible DSM programmes that the industry could implement and how they would get to know of them, giving consideration to initial costs and long-term savings. Take into account the minimum that can be done that will result in the greatest demand reductions.

Write a two-page essay discussing these options.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 14: Demand-side management

Suggested discussion topic:

1. "DSM programmes can be win-win measures for suppliers and customers". Discuss, considering the benefits and drawbacks

2. "Energy efficiency (both supply and demand-side) should take priority over development of renewables." Do you agree with this statement? Why? Why not?

Relevant case studies

1. Lighting retrofitting in the United Republic of Tanzania
2. United Republic of Tanzania: power factor correction
3. Zambia: automatic load control and alternative energy supply at Lusaka water and sewerage company
4. Zambia: university energy assessment
5. Why DSM initially failed in Ghana

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INTERNET RESOURCES

1. International Energy Agency
dsm.iea.org

The **IEA Demand-Side Management Programme** (started in 1993) is an international collaboration with 17 IEA Member countries and the European Commission, to promote opportunities for demand-side management (DSM). For the purposes of this programme, DSM is defined to include a variety of purposes such as load management, energy efficiency, strategic conservation and related activities. The programme undertakes work suited to different regulatory regimes and market structures and has a website with detailed reports of specific projects. A key resource on the website is the International Database on Energy Efficiency Programmes (INDEEP), where the IEA has brought together and analysed information on DSM from a large number of IEA countries. There are also other databases with useful information on the site and it is a good source of information on who are the experts in this field.

2. Energy Futures Australia
www.efa.com.au

DEFA is run by David Crossley who has led much of the IEA's work on demand-side management. He has undertaken considerable work for governments in Australia and elsewhere on energy efficiency policy development. The EFA web site contains many publications written by Crossley and also has links to other useful publications on DSM in Australia and elsewhere.

GLOSSARY/DEFINITION OF KEY CONCEPTS

Activity	Used in this module in the context of "energy-dependent activity", such as the production level in an industrial plant, or heating and cooling of buildings.
CFL	Compact fluorescent light bulbs
DSM	"Demand-side management", typically used in the specific sense of actions to modify electricity loads to achieve higher system efficiency. Also used (including in this module) to refer to efforts to modify demands for any type of energy—e.g. fuel oil, gas, coal—so as to improve energy efficiency and reduce energy consumption for a given output.

Energy audit	Evaluation of the energy-related performance of a manufacturing plant or building, used to identify energy efficiency opportunities.
EE	Energy efficiency, the utilization of energy in a cost effective way to carry out a manufacturing process or provide a service. Depending on the context, typically expressed as an amount of energy consumed per unit of output (e.g. kilocalories per ton of cement).
EMO	Energy management opportunity or option, often identified through an energy audit of a plant or building.
Interruptible load	DSM programme activities that, in accordance with contractual arrangements, can interrupt consumer load at times of peak load by direct control of the utility system operator or by action of the consumer at the direct request of the system operator. This type of control usually involves commercial and industrial consumers. In some instances, load reduction may be effected by direct action of the system operator (remote tripping) after notice to the consumer in accordance with contractual provisions (Satish Saini, 2004).
Load shape	A method of describing peak load demand and the relationship of power supplied to the time of occurrence (Satish Saini, 2004).
Load shifting	Loads are "shifted" from peak to valley times (achieving clipping and filling).
Lumens	A measure of the illumination provided by a lighting source (e.g. incandescent bulb, fluorescent tube).
Luminaires	Fittings to hold a light source (light bulb, fluorescent tube, etc.)
Peak clipping	Demand peaks (high demand periods) are "clipped" and the load is reduced at peak times.
Preventive maintenance	Maintenance efforts that are designed to prevent or avoid a breakdown before it happens. This should reduce unexpected breakdowns.
Real-time pricing	The electricity rate varies based on the utilities load (continuously or by the hour).
SSM	"Supply side management" refers to efforts made to improve the energy efficiency of the supply of energy to customers. Commonly refers to the generation, transmission and distribution of electricity.
Time-of-use	Utilities have different charges for power use during different periods.

Case study 1.

LIGHTING RETROFITTING IN THE UNITED REPUBLIC OF TANZANIA

CONTENTS

1. INTRODUCTION

1.1. Background

Lighting is essential in industrial plants, commercial centres and at the household level. For aesthetic and for occupational and health reasons, different activities require specific illumination levels. For instance, stairways require illumination of only 160 lux, library reading tables and hand tailoring will require 500 lux and 1,000 lux respectively.

The cost of lighting an industrial plant can be substantial with electricity representing the major proportion of operational costs. Good effective lighting can have a major impact on workers' productivity and safety. Effective industrial lighting depends not only on providing the right lighting levels for a task but also on selecting the best suited light source and equipment, optimizing lighting controls and utilizing daylight.

1.2. Light sources

There exist a variety of light sources. These sources convert electrical energy into light energy and the efficiency to do so (efficacy) is measured in lumens per watt. Consequently, the higher the efficacy, the lower the cost of lighting. Table 1 summarizes the characteristics of common light sources.

Incandescent lamp

Figure I. Incandesent light bulb

In the incandescent lamp, light is produced by passing an electric current through a tungsten filament contained in an evacuated glass bulb partially filled with an inert gas. The current heats the filament to incandescence. The pressure of the inert gas slows down the evaporation of the filament. Only 3-6 per cent of the input energy results in light production, the rest is dissipated as heat. As shown in table 1, this type of light is very inefficient. The Tungsten-halogen, also called quartz or quartz-iodine lamp is an incandescent filament lamp that operates at very high temperature.

Halogen gas prevents rapid depreciation of the lamp filament and darkening of the lamp bulb. The lamp bulb is made of quartz glass to withstand the high operating temperatures.

Table 1. Light sources characteristics

CHARACTERISTIC	LAMP TYPE					
	Incandescent (tungsten-halogen)	Low pressure discharge		High pressure discharge		
		Fluorescent	LPS	MV	MH	HPS
Efficacy initial lumens/watt	20 (23)	70	140	50	80	120
Rated life hours	1,000 (2,000)	12,000 - 20,000	18,000	16,000 - 24,000	7,500 - 15,000	20,000 - 24,000
Ballast required	NO (YES)	YES	YES	YES	YES	YES
Colour of light	Warm	Cool/warm	Yellow	Cool/warm	Cool	Warm
Lamp cost	Low	Low	Low	Medium	High	High
Lamp lumen depreciation factor (LLD) %	90 (99)	85	103	75	70	90
Operating cost (comparative only)	1.0	0.25	0.15	0.36	0.22	0.2
Warmup/restrike time (minutes)	Instant	Immediate	12/0.5	7/7	5/10	3/1

Fluorescent lamp

The fluorescent lamp is a tubular, low-pressure discharge lamp containing small amounts of mercury with argon as the fill gas. The lamp tube is coated on the inside with phosphor. In operation, ultraviolet radiation resulting from the luminescence of the mercury vapour due to an electrically induced gas discharge is converted to visible light by the phosphor. As with all gas discharge lamps, a ballast is needed to aid in starting and sustaining the operation of the lamp. Being a linear lamp with a large surface area, its brightness is comparatively low and its potential for discomfort and glare is also low. Principal applications are for the office and industrial interiors and utility areas in the home.

Figure II. Compact fluorescent light

Energy saving fluorescent lamps are available in most sizes and colours. Rapid start versions are also available. They are lower wattage, in the order of 12 per cent, than the equivalent standard lamp but are nearly equal in light output. Energy saving ballasts are also available—with high efficiency and electronic rapid and instant start capability. Savings in energy, using electronic ballasts can be as much as 25 per cent. Fluorescent lamps controlled by electronic ballast operating at high frequency, 20 kHz, are 10 per cent more efficient. Electronic control starters are also available for preheat starting. Although up to 25 times more expensive, electronic starters last longer and start lamps without flicker, thus extending lamp life.

Compact fluorescent lamps are now available from various manufacturers as replacement for incandescent lamps up to 100W. The lamp, complete with electronic ballast can be fitted in the lamp holder of the incandescent lamp to be replaced with no modifications required. Although more expensive (up to 20 times), they consume less than 25 per cent energy for the same light output and last up to 10 times as long.

Low pressure sodium (LPS) lamp

The LPS lamp is among the most efficient light source presently available. The LPS is a discharge lamp where the arc is carried through vaporized sodium, producing the characteristic yellow sodium light colour. Unlike other light sources, LPS lamp wattage rises with use to approximately 3 per cent above the initial value by the end of the rated life expectancy of the lamp. This is coupled with an increase in light output of approximately 5 per cent above initial rating. As a result, the LPS lamp is able to maintain fairly uniform output during its life. The monochromatic yellow characteristic of LPS makes all colours appear yellow or as shades of brown. It is most suitable for outdoor areas and security lighting. The high pressure sodium (HPS) lamp counterpart utilizes a ceramic arc tube containing sodium, mercury and xenon gas. The xenon gas acts as a starting gas and as the arc tube heats up, the mercury and sodium vaporize to produce the golden-white discharge. Principle applications are in roadways, area and industrial lighting. HPS can also be used in non-colour sensitive areas, such as warehouses and gymnasiums.

Metal halide (MH) lamp

The MH lamp is an improved version of the mercury vapour (MV) lamp where iodine compounds are added in the arc tube to produce a whiter coloured light at a higher efficacy than in MV lamps. The “white” light produced by metal halide lamps make them the choice for sports fields and architectural lighting, and for colour sensitive industrial processes.

2. ENERGY MANAGEMENT OPPORTUNITIES

2.1. Switch off unnecessary lights

Switching off lights in unoccupied areas, and in areas where daylight provides adequate lighting levels is an opportunity for energy saving. Switching can be done manually or by automatic controls. Providing light switches at strategic points can facilitate manual switching.

2.2. Remove redundant fixtures

Many plants undergo modifications and reorganization. Areas are redesignated and equipment moved but the lighting system is not correspondingly updated, with the result that lights may become redundant. On removing redundant fixtures, energy and lamp costs are reduced, and the removed fixtures can be reused.

2.3. Fixture delamping

This measure simply entails removing selected lamps from existing light fixtures. Either lamps are removed in a uniform pattern throughout specific areas to reduce overall lighting or selected lights that do not contribute to a task or safety lighting are removed. Flickering fluorescent tubes should be removed from the fixture as the ballast will continue to consume power, at approximately 15 per cent of the lamp wattage.

2.4. Lighting retrofitting

Lighting retrofitting is the replacement of an existing lamp with a new more efficient light source. The retrofitting will involve more initial cost than delamping but has a long-term benefit from low energy consuming new fixtures.

2.5. Application of energy management systems

Lighting can be switched on or off automatically by using a varied scheme of automatic controls. The principal devices employ occupancy sensors (motion detectors shut off light in unoccupied space), time controls (through programmed schedules), and photo sensors (by detecting daylight illumination levels). Energy savings from the application of these controls are highly sensitive to baseline assumptions, especially hours of use and occupancy patterns. However, it has been shown that programmable timers are capable of saving 10-30 per cent of lighting energy where as occupancy sensors and photo sensors are capable of saving 30-60 per cent and 10-35 per cent respectively.

3. LIGHTING RETROFITTING; THE CASE OF THE UNIVERSITY OF DAR ES SALAAM

The University of Dar es Salaam has been paying monthly electricity bills amounting to T. Shs. 80 million ($US 78,640).[1] The electricity consumption and monthly bill has been on the increase, a fact attributable to various factors including the increased population of students and increased installed facilities coupled with energy inefficiencies. The university management therefore commissioned a study to search for options to reduce its energy costs.

The study findings were submitted to the university management in early 2006, and among other things, revealed that the university's lighting had a varied mixture of inefficient fixtures including fluorescent tubes in ranges of 120-150 cm bulbs, mercury vapour and incandescent bulbs. About 47 per cent of lighting fixtures in the hostels and halls of residence were inefficient incandescent bulbs and 4 per cent of lighting fixtures in the university offices, laboratories and lecture rooms were also using inefficient incandescent light bulbs. In total, 3,653 incandescent bulbs were being used.

[1] Exchange Rate: 1 $US = 1,017.720 TZS (Tanzanian Shillings)

As shown in table 2, when all the incandescent bulbs are replaced with efficient compact fluorescent bulbs, an annual energy saving of about 421,000 kWh is achievable giving annual cost savings of about T. Shs 49 million ($US 48,167). The cost of implementation of this measure is about T. Shs 11 million ($US 10,813), which results in a simple payback period of 0.24 years (3 months). It should be noted that the retrofitting is done without impairing the illumination level.

Upon receiving this recommendation, the university management acted promptly by drawing up an implementation plan for the energy study's findings. However, the implementation was subject to allocation of financial resources, which are budgeted annually. In order to maintain and keep on improving energy efficiency at the university, the management went further by deciding to put in place an "Energy Policy". The policy will put down an institutional framework for energy conservation and management through awareness-raising and by providing standards and guidelines for new equipment installation and maintenance practices.

Table 2. Replacement of inefficient incandescent lights with efficient compact fluorescent lights

Location:	University of Dar es Salaam - offices, hostels and halls of residence
Identification:	General lighting

Data Required:

	Existing	Proposed	Symbol
Watts of light (and choke), watts	100	20	WL
Annual operating hrs of lighting	1,440	1,440	h
Unit cost of lights, THS	250 (0.245)	6,500 (6.39)	CL
Life of lights, Hrs	750	10,000	LL
Number of lights	3,653	3,653	N
Lumens per watt	15.7	60	LW
Cost of electricity, THS/kWh (USD/kWh)	116.25 (0.114)	116.25 (0.114)	CE

Calculations:

Existing total lumens	5,735,210	TLe = LWe*WLe*Ne
Suggested total lumens	4,383,600	TLp = LWp*WLp*Np
Existing energy consumption, kWh	526,032	ECe = Ne*WLe*he÷1,000
Proposed energy consumption, kWh	105,206	ECp = Np*WLp*hp÷1,000
Annual energy savings, kWh	420,826	ES = ECe - ECp
Annual cost savings, TSH	48,920,976	CS = ES*CE
Cost of implementation, TSH	11,567,833	CI = (CLp*Np) - (Ne*Cle*LLp÷Lle)
Simple payback, years	0.24	SP = CI÷CS

Note: In above calculations, "e" stands for existing and "p" for proposed values.

Annual energy savings, kWh	420,826
Annual cost savings, TSH	48,920,976 (48,089)
Cost of implementation, TSH	11,567,833 (11,371)
Simple payback, Yrs	0.24

4. CONCLUSIONS

Lighting plays an essential role for human activities in industrial and commercial centres and in households. However, the cost of lighting can occupy a substantial portion of total operational costs. Consequently, it is desirable to have good, effective and efficient lighting. Good efficient industrial lighting depends not only on providing the right lighting levels for the task but also on selecting the best suited light source and equipment, optimizing the lighting controls as well as utilizing daylight.

In the case of existing inefficient light sources, retrofitting them with efficient ones offers an opportunity for energy conservation and cost saving. Feasibility studies of lighting retrofitting have shown that, on top of the high energy and cost savings, they have instant payback periods of less than half a year, making them an attractive investment.

Case study 2.

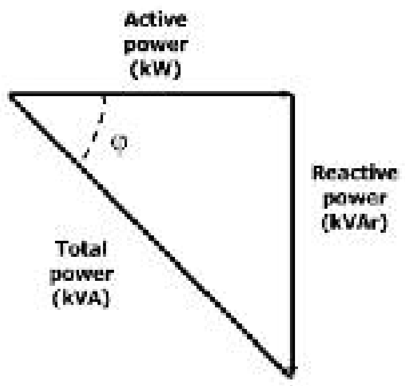
UNITED REPUBLIC OF TANZANIA: POWER FACTOR CORRECTION

CONTENTS

1. BACKGROUND

Whenever inductive loads such as air-conditioners and all other equipment that make use of an inductive motor are connected to an electrical installation there is a tendency for these loads to draw current that is lagging the supply voltage, i.e. the current phaser will be trailing by a certain angle φ with respect to the voltage phaser. Similarly, whenever there are capacitive loads such as battery chargers and equipment that comprise dominantly of capacitors or synchronous machines, the load will draw current that is leading the supply voltage, i.e. the current phaser will be ahead by a certain angle φ with respect to the voltage phaser. However, for loads that consist of dominantly resistive loads such as heaters and cookers, the supply voltage and current will be in phase.

Figure I. Power triangle



Power factor (PF) is defined as the cosine of the phase angle φ between the supply voltage and current. Therefore inductive loads will have a lagging power factor, and capacitive loads will have leading power factor, in other words leading or lagging power factors indicate whether the current is leading or lagging the supply voltage respectively. Figure I, known as the power triangle, shows the relationship between total power, active power, reactive power and power factor.

$$PF = \frac{\textit{Active Power}}{\textit{Total Power}} = Cos\ \varphi \qquad \text{---------------------------------} \ (1)$$

2. EFFECTS OF LOW POWER FACTOR

With a power factor less than unity, the amount of useful power that can be supplied by the supply system's generating plant will be less than its full total power capacity. In other words, although the generators may be delivering their full current capacity, not all of this current results in useful power. Consequently, the electricity supply authorities generally require consumers to restrict their reactive power demand such that their power factor level is maintained above 0.9. Defaulters are subject to significant cost penalties, some of which are reflected in the tariffs customers pay.

2.1. Effects to the electricity supplier

Reactive power actually costs something to produce at the generating station since low power factor causes a large drop of voltage in the generators, hence requiring larger exciters. It also increases transmission and distribution losses. The losses in the cables or conductors are proportional to the square of the current, and consequently they are inversely proportional to the square of the power factor. Thus, for example, the losses in the cable conductors at a power factor of 0.8 are 1.57 times the losses at unity power factor, and the losses at a power factor of 0.4 will be 6.25 times that at a unity power factor.

The ratings of transformers, cables and protective switchgears are proportional to the current and therefore inversely proportional to the power factor. Therefore higher ratings of transformers and cables are required for loads that operate at low power factor.

2.2. Effects to the consumer

When there is extensive application of inductive motors and associated devices, consumers will have a low system power factor, which causes a significant voltage drop across the cables. Low voltage results in inefficient operation of equipment such as motors and lighting. Consequently, extra voltage regulating/ stabilizing equipment needs be installed.

When demand charges are based on the total power demand (kVA), electricity costs are inversely proportional to the power factor level and therefore a low power factor results in higher costs. The cost of electricity to consumers whose demand charges are based on their kW or active demand is unaffected by the level of the plant's power factor, unless there is a low power factor penalty provision in the tariff agreement.

3. POWER FACTOR CORRECTION

Operating at a power factor above 0.9 (most electricity suppliers set the threshold value at this level) is a way of conserving and utilizing energy efficiently and it is beneficial to both the electricity supplier and the consumer.

A low electrical system power factor can be corrected by installing capacitors locally to the load. A power factor of unity is the optimum level, but this is not always feasible. Economics dictates that individual compensation is generally only feasible with larger motors, say in excess of 30 kW. In most plants, the more practical solution is to install capacitor banks with a control unit at the main service entrance board. The control unit senses the power factor level, which changes with the load, and automatically switches the required capacitors in and out of service to maintain the power factor level within prescribed limits.

3.1. Power factor correction: the Posta House case

Tanzania Posts Corporation is a Government-owned organization charged with the provision of postal services. A twelve-storey building (Posta House) located along Ohio Street accommodates the headquarters of the Posts Corporation. The Posta House was experiencing increased monthly electricity bills, which in 2003 amounted to over T. Shs. 5.5 million per month ($US 5,406)[1] . The money paid for the monthly electricity bill increased the operational costs of the Posts Corporation. Consequently, the management contacted a consultant to conduct an energy study whose purpose was to identify energy losses and provide advice to the management on how to reduce the monthly electricity bill.

The existence of a low power factor profile, averaged at 0.75, was one of the main findings of the study. As shown in fig. II, the demand profile at the Posta House increased from 160 kVA in 2000 to almost 300 kVA in 2003. In this period, energy consumption increased marginally. This was an indication of a deteriorating power factor.

[1] Exchange Rate: 1$US = 1,017.720 TZS (Tanzanian Shillings)

Figure II. Demand and energy consumption profiles at the Posta House

Monthly Maximum Demand (kVA)

Demand (kVA)	January	February	March	April	May	June	July	August	September	October	November	December
2000			157	150	138	136	122	157	163	155	196	211
2001	211	199	214	218	225	205	170	149	163	178	210	220
2	228	224	228	228	210	213	197	204	200	204	235	285

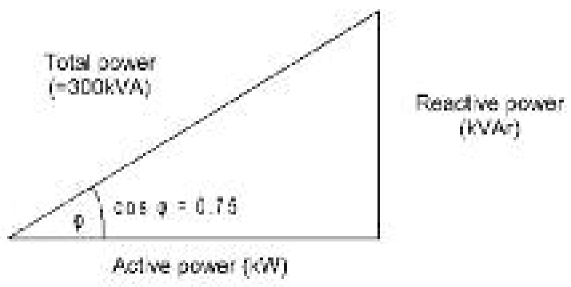
Monthly kWh Consumption

Energy (kWh)	January	February	March	April	May	June	July	August	September	October	November	December
2001	26.000	37.100	35.800		36.100	39.500	34.800	33.000	35.200	36.700	42.200	45.000
2002	37.500	41.580	41.580	41.580	39.500	42.400	37.850	41.500	38.400	40.900	48.000	49.300

Power factor correction by installing capacitor banks was therefore recommended to the management as a means of reducing monthly electricity bills.

The power triangle as reproduced in figure III is utilized to estimate the capacitor bank size (reactive load in kVAr to be supplied by the capacitors) for the power factor correction. This is indicated in the following calculations:

Figure III. Power triangle with Posta House data



Active and reactive power is calculated using equations (2) and (3) respectively

KW = KVA * $Cos\ \varphi$--(2)

$(KVA)^2$ = $(kW)^2 + (kVAr)^2$------- --------------------------------- (3)

Consequently, in the existing situation, active power is found to be 225kW where—as the reactive power is 198.4kVAr.

Similarly, after the power factor has been improved to 0.98, the maximum demand becomes 229.59 (=225/0.98) kVA and the reactive power is lowered to 45.69kVAr. The size of the capacitor bank is defined by the difference between the initial and corrected reactive power, which is 152.74 kVAr. On enquiring from suppliers, the cost of supplying and installing the capacitor banks was T. Shs. 9,850,000 ($US 9,682). Monthly kVA reduction is therefore 70.41 (300—229.59) kVA. From the tariff, the cost of 1kVA is T. Shs. 7,660 ($US 7.53). Therefore, reducing the maximum demand by 70.41 kVA gives monthly demand cost savings of T. Shs 539,326 ($US 530) and yearly cost savings of T. Shs. 6,471,912 (6,360 $US).

The simple payback period (in years) is defined as the ratio of cost of implementation to the respective annual cost savings. For this measure it was found to be 1.52 years.

Payback period = (cost of implementation) / annual cost savings ---------------- (4)

3.2. Follow-up to the Posta House

A recent follow-up visit to the Posta House revealed that the management had not implemented power factor correction. It was evident that the main reason for not implementing the measure was the scarcity of financial resources for the purchase of capacitor banks.

4. CONCLUSION

Power factor correction offers an opportunity for energy cost reductions at facilities by reducing losses from their distribution systems. Since power factor correction reduces the apparent demand, the saved demand is therefore made available for other needy consumers.

However, facility and commercial centre owners find it difficult to implement power factor correction due to the up-front capital required to purchase the necessary equipment. The scarce financial resources available to managers and owners are usually allocated to the most pressing issues at hand and power factor correction is often neglected. Awareness-raising on the long-term benefits of power factor correction needs be carried out, followed up by innovative policies that create incentives and make resources available for power factor correction implementation.

Case study 3.

ZAMBIA: AUTOMATIC LOAD CONTROL AND ALTERNATIVE ENERGY SUPPLY AT LUSAKA WATER AND SEWERAGE COMPANY

CONTENTS

1. BACKGROUND

The Lusaka Water and Sewerage company (LWSC) is involved in waste treatment and supply. It services Lusaka and surrounding areas. For pumping purposes LWSC has a total of 172 AC induction motors with a total demand of 10.4MW. In view of the high poverty levels of its customers, LWSC is unable to charge economic tariffs to a large part of the population of the city. As a result LWSC is unable to fully pay its high electricity bill to the power utility, ZESCO. Despite the huge electricity bill, it also ironic that LWSC operates its electric motors not at full load, thereby losing energy since the motors are always drawing energy regardless of its load. In addition, the power factor is low, at around 0.58.

2. MAIN ACTORS

The main actors in the study were Chavuma Water Falls Ventures, an ESCO involved in the installation of automatic load control devices, and LWSC. The automatic load control is based on the Powerboss design concept. Powerboss is a motor power controller, manufactured by SOMER International of the U.K. Since electric motors have no way of intelligently matching the power they consume in relation to the load, most energy is lost during partial running load conditions. The Powerboss on the other hand, is a device that will control the current being consumed in relation to the load, thereby saving energy in the process.

3. PROJECT OBJECTIVES

The project had two objectives:

- To investigate the operational, financial and environmental benefits of the use of a Powerboss motor power controller.
- To Investigate the possibility of introducing an alternative energy supply through the generation of electricity from methane from the sewerage plant.

4. DESCRIPTION OF THE PROJECT

The project attempted to undertake:

- A feasibility study on the installation of automatic load control (Powerboss) to all the electric motors amounting to 10.4 MW.
- A feasibility study on the generation of electricity from methane combustion from sewerage ponds at Manchinchi Sewer.
- Studies initially needed to ascertain the amount of electricity consumed by all electric motors.

5. RESULTS

5.1. Electricity consumed

Under baseline conditions and project conditions, savings made and amount of CO_2 savings for LWSC are given in table 1.

Table 1. Energy and CO_2 savings

Company	Total motor capacity (kW)	Average operating hours per year	Annual energy consumpt. ('000' kWh)	Average energy efficiency gain.	Annual energy saved ('000' kWh)	Annual CO_2 saved (tons)
Lusaka Water & Sewerage	10,400	6,570	68,328	15%	10,249	10,249

The savings are made as a result of the installation of a Powerboss motor controller, which leads to electric motors working efficiently in relation to the actual load being delivered at a particular time.

Table 2 shows the investment costs, O+M costs, IRR and NPV.

Table 2. Investment costs, O +M costs, IRR and NPV

Company	Total motor capacity (kW)	Investment (US $)	O+M (US $)	Annual CO2 saved (t)	IRR (%)	NPV ($'000')	Payback period
Lusaka Water	10,400	354,000	153,649	10,249	24.95	229,07	14 months

In conclusion, installations of automatic load control devices will lead to an annual saving of $US 310,000 per annum in electricity consumption and the investment of $US 364,000 will yield an IRR of 25 per cent with a positive NPV and a payback period of about 14 months.

5.2. Electricity generation from methane combustion generated from sewerage system

A detailed study was undertaken for the production of energy from municipal sewerage waste. Based on the results, it was found and recommended that electricity can be generated from waste material at Manchinchi sewerage plant through the combustion of methane in a gas engine with a capacity of 1.0 MW. 1.0 MW will go a long way to reducing LWSC power requirement of 10.4 MW, and save substantial amount of money from electricity billing.

6. DESCRIPTION OF FOLLOW-UP ACTION

LWSC is in the process of sourcing funds for the Powerboss project, and for the biomethenation project through CDM arrangements. Implementation of the methane combustion project will result in savings of 26,000 tonnes of CO_2 equivalent.

Case study 4.

ZAMBIA: UNIVERSITY ENERGY ASSESSMENT

CONTENTS

1. BACKGROUND

Since the cost of energy has risen sharply in the past few years throughout the world, and as energy is an essential service in the running of big learning institution, the University of Zambia decided to undertake an energy audit to reduce and/or optimize the use of energy, and recommend means of reducing energy costs.

At the time of the commencement of the study, the University of Zambia owed ZESCO close to $US 1.0 million in unpaid electricity bills. This is a colossal sum of money, which the university in its current financial state cannot sustain. Therefore, the consumption of electricity had to be reduced to levels that are sustainable to the university. The advantages of energy efficiency to the university were indeed very significant as the financial savings can be channelled to more needy sections in the university.

2. MAIN ACTORS

The main actors in the study were the Centre for Energy, Environment and Engineering and the Department of Mechanical Engineering, School of Engineering, and the University of Zambia who worked closely with university administration on the audit.

3. PROJECT OBJECTIVES

The objectives of the audit were formulated as follows:

- To undertake an energy audit for the University of Zambia and make recommendations on how energy costs could be reduced.
- To evaluate the possibility of the use of an energy substitution system aimed at reducing electricity bills and thus reducing dependence on ZESCO power.

4. DESCRIPTION OF THE PROJECT

The key tasks of the audit comprised of the following:

- To identify the energy consuming units;
- To estimate the quantity of energy consumed by each unit;
- To identify energy saving opportunities;
- To recommend conservation measures;

Specifically the study undertook the following:

- Energy consumption estimation was undertaken for the student hostels and water pumping systems through measurements of the currents and voltages by clamp-on meters because these units are fed by sub-stations with faulty energy meters. There are all together 52 hostels and about 124 students live in each hostel. Students do not pay for electricity since this is paid in bulk by the university authorities. There are three substations to cover the 52 hostels and currently five borehole-pumping systems to supplement water supply from the municipal source.
- Power factor measurements were carried out from a sample of about 14 hostels for a continuous period of three months.
- A questionnaire was also administered to study the energy consumption pattern.

5. RESULTS

Table 1 shows the power consumption and average power factor at the hostels and the water pumps as found by the assessment.

Table 1. Power consumption results

	Location	Power consumption (kW)	Average power factor
1	Hostels	650	0.72
2	Water pumps	105	0.72

The questionnaire responses revealed the following:

- More than 90 per cent of the respondents use their cookers for not more than eight hours per day, about 30 per cent, play their radio sets for 18-24 hours per day, 90 per cent use fluorescent lamps for lighting systems.
- About 70 per cent of the respondents leave their lights on for 16-24 hours per day; about 79 per cent realize the need to use natural daylight while 21 per cent do not see the need to use natural daylight and thereby conserve energy.
- About 68 per cent of the respondents suggested that the institution should set up measures to ensure that the number of electrical appliances that are bought into the university should be regulated. They also suggested that students be sensitized.
- There was no use of low power consuming appliances and automatic switching systems.
- About 11 per cent of the respondents suggested that Government should increase their meal allowances so that they are able to afford to eat at cafeterias since this would stop them cooking in their rooms.

6. DESCRIPTION OF FOLLOW-UP ACTIONS RECOMMENDED

These follow-up actions are recommended:

- Replacement of fluorescent tubes for lighting with a power rating of 0.054 kW with more efficient ones with a power rating of 0.018kW thereby saving on what is currently being paid.
- Replacement of incandescent lights with more efficient compact lights to reduce their use by 10 per cent.
- Increase awareness of the use of natural daylight.
- Use of automatic switching lighting systems.
- Regulation of types and number of electrical appliances used.
- Setting up an energy management centre for training and conducting awareness programmes, and to undertake feasibility studies for implementation.
- Installation of capacity banks to improve the power factor from its current average figure of 0.72 to 0.95 as required by the utility to save money being paid in penalties for low power factors.

7. LESSONS LEARNT

The study identified the electricity-consuming units, the amount of power/energy consumed, and identified a number of energy saving opportunities. It is clear from the results that with an energy management system put in place as part of total management system of the university, substantial savings in energy can be realized.

It is being recommended that feasibility studies be undertaken to first determine the amount of savings both by reduced energy consumption and the value to be realized through implementation of the suggested options. To undertake such implementation requires calculation of the payback period of each option, and for this to be determined, it is important to ascertain the amount of positive savings and the investment cost of implementing the suggested options. If the payback period is found to be less than 2 years, the options are viable and should be implemented.

Case study 5.

WHY DSM INITIALLY FAILED IN GHANA

CONTENTS

1. BACKGROUND

From 2000 to 2003, the residential sector of the Ghanaian economy accounted, on average, for about 50 per cent of the country's total energy consumption. This highlights the importance of domestic energy consumption in Ghana, while at the same time pointing out the small share of energy consumption for productive (income-generating) purposes.

Table I. Energy use by sectors 2000-2003

	2000	2001	2002	2003
Residential	49,8	50,2	50,5	51,7
Agriculture & fisheries	1,3	1,2	1,2	1,2
Industry	23,6	23,9	23,6	21,6
Transport	22,4	21,4	21,3	22
Commercial & services	2,9	3,3	3,4	3,6

Energy utilized between 2000 and 2003 in the other main sectors was as follows:

- Transport used between 21 per cent and 22 per cent.
- Industry including indigenous (informal) industry such as textiles (tie and dye and batik) accounted for 21 per cent to 24 per cent.
- Commercial and services consumed between 3 per cent and 4 per cent.
- Agriculture and fisheries accounted for just about 1.5 per cent of total energy used.

In addition, the residential sector (mainly households) accounted for approximately 72 per cent of all wood fuels consumed in Ghana, whilst about 25 per cent was used by the informal manufacturing category of the industrial sector.

About 81 per cent of petroleum fuels were consumed by transportation, whilst about 7 per cent and 5 per cent were accounted for by the industrial and the residential sectors respectively. About 35 per cent of the electricity produced in Ghana was consumed in the aluminium smelter operations at VALCO, whilst the residential sector and other industries accounted for about 32 per cent and 25 per cent respectively.

2. THE CASE FOR ENERGY EFFICIENCY

The economic, social and environmental advantages of energy efficiency have been proven worldwide and have become an integral component of the energy policies of governments in both developing and developed countries since 1975. Modern energy efficient technologies such as energy efficient lighting systems, more productive industrial processes and energy efficient industrial equipment are increasingly being exploited to reduce the energy intensities of world economies.

By exploiting the benefits of energy efficiency, countries that belong to the Organization for Economic Cooperation and Development (OECD), led by Japan, Germany and the United States, managed to increase industrial output by over 40 per cent from 1975 to 1995 with only a 6 per cent increase in energy consumption.

It is on record that the State of California, in the USA, during the power crisis in 1999-2000 spent $US 20 billion in new power supply contracts and was only able to increase electricity supply by 2 per cent. An expenditure of $US 1 billion on energy efficiency promotion and retrofits resulted in a 10 per cent reduction in electricity demand emphasizing the effectiveness of energy efficiency as a tool for sustainable development even in advanced and sophisticated economies.

In Ghana, it has been established that 30 per cent of electricity supplied is wasted in homes, industrial and commercial premises. Unless efforts are made to reverse this trend, government efforts aimed at expanding energy supply will yield few dividends.

Energy consumers tend to blame government for high energy costs whilst in reality the consumers have the ability to reduce their energy costs through end-use energy efficiency practices and technologies.

The government energy policy framework identifies energy as a necessary engine for the economic development of the country and mentions the efficient and productive use of energy as a way forward to sustainable development.

3. WHY INITIAL UTILITY-BASED DEMAND-SIDE MANAGEMENT FAILED

The use of demand-side management (DSM) as a tool by the supply utilities to defer investments in energy supply facility expansion through efficient end-use was introduced by the Volta River Authority (VRA)[1] in the early 1990s following the earlier introductory programme in 1988 by the then National Energy Board.[2] Though these initiatives were made with the best of intentions, they were not well received by consumers and were in some cases rejected outright for political and other logistical reasons.

The Ministry of Energy's programme in particular was wrongly perceived by the public as a politically motivated attempt by government to shift blame for supply-side inefficiencies from state-owned utilities to the consumer. This was mainly because the activities were initiated and implemented from and by officials of the Ministry of Energy, which was at the same time responsible for tariff setting, energy policy formulation, rural electrification and energy efficiency project implementation.

Some industrial and commercial consumers called on the government to reduce tariffs, if it was interested in assisting industry to reduce costs and promote competitiveness. In addition, some government-owned utilities viewed the promotion of energy efficiency and conservation by the Ministry with scepticism and adopted a “wait and see” attitude.

The situation was aggravated by the fact that VRA traditionally sells power to consumers through distributor utilities who are in fact “middlemen” and therefore regard DSM as a threat to their existence since consumer savings lead to lower revenues for distributing utilities. As expected, the interests of the two utilities with regards to efficiency promotion did not always coincide. Whilst VRA was interested in reducing investments in power plant development by initiating efforts to reduce demand, the Electricity Company of Ghana (ECG) found network expansion and increased power sales more attractive. In fact, ECG occasionally did ask its customers to reduce demand but this occurred only when local constraints, such as transformer and cable overloads, were encountered.

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[1] The VRA introduced compact fluorescent lamps and sold them at reduced prices in 1994. This initiative failed because of poor quality of the lamps and inadequate marketing by the ECG, which sold the lamps on behalf of the VRA at its customer service points.

[2] The activities of the National Energy Board were taken over by the Ministry of Energy in 1991 when the Board was dissolved and its staff were integrated into the Ministry as the technical wing.

One other factor that aggravated the diversity in the interests of the utilities towards DSM is the issue of capacity or demand charges. VRA sells electricity to ECG on the basis of energy (kWh) only and does not charge ECG for demand. Investments in additional capacity by VRA therefore do not directly reflect in the finances of ECG and this further eroded any interest ECG might have had in DSM.

The inapplicability of utility-based DSM has also been compounded by the fact that a lot of electrical appliances or "white goods" that are imported into Ghana are "used" appliances, imported from Europe, often based on old technologies which are inherently technically inefficient in terms of energy consumption. Until their continuous importation is curtailed, utility-based DSM, which in most cases involves subsidies on appliances and energy services, cannot not achieve the desired results.

Electricity tariffs in Ghana, which have been generally low over the years due to subsidies, also contributed to the failure of initial energy efficiency programmes. However, in line with the Government of Ghana's Energy Sector Reform Process initiated in 1995, which has the aim of introducing and encouraging private sector participation in the power sector, the price and cross-subsidies are gradually being removed. The removal of subsidies, the separation of functions and assignment of regulatory responsibilities to institutions other than the Ministry of Energy through the reforms, since 1997, have prompted a change in consumer attitude towards energy efficiency.

4. CONCLUSION

Energy management has generally been accepted as an effective tool for reducing operational costs in industry and commerce, and the utilities have come to accept the concept as a "win-win" measure, both for the consumer and the utilities. However, the prospect that utility-based demand-side management will succeed in Ghana given the structure of the power generation and distribution industry as well as the financial positions of the utilities is very gloomy.

Under the existing utility-consumer relationship, and with the memories of occasional power shortages since 1983 (the most recent was in 1998) still in the minds of consumers, it will be extremely difficult to build consumer confidence to enable the acceptance and patronage of purely utility-based demand-side management (DSM) programmes. This is especially so, since consumers would now want compensation for utility inefficiencies, some of which are due to transformer overloading leading to brownouts, voltage fluctuations and reduced reliability.

The utilities on the other hand, are going through difficult times as low tariffs and high levels of commercial and technical losses as well as poor consumer behaviour are affecting their cash flow. The Electricity Company of Ghana (ECG), which is responsible for the distribution of power in the southern part of Ghana, in particular, has a backlog of meters to install to measure consumption accurately and would rather invest in this area than in DSM. With a technical and commercial loss rate of over 25 per cent, utility-based DSM would only compound the cash flow difficulties of the utilities.

In the ensuing vicious circle, it has become clear that only a politically neutral institution with the required technical expertise could play the efficiency promotion and advocacy role.

5. THE WAY FORWARD: FORMATION OF THE ENERGY FOUNDATION

The Private Enterprise Foundation (PEF), which brings together the major energy consumer groups, such as the Association of Ghana Industries (AGI), the Ghana Chamber of Mines (GCM), the Ghana National Chamber of Commerce and Industry (GNCCI), the Ghana Employers Association (GEA), the Federation of Associations of Ghanaian Exporters (FAGE), the Association of Ghanaian Banks and others collaborated with the Ministry of Energy to establish the Energy Foundation, whose activities cover: the promotion of energy efficiency and conservation, sustainable development of energy and protection of the consumer from the inefficiencies of the utilities.

The Foundation has created a more direct channel of communication between the key players in the area of energy supply and consumption. A public-private cooperation for energy efficiency improvement has been adopted because of the effectiveness of the “win-win” nature of energy efficiency to both government and the private sector. This structure, the first in Africa, has been used very successfully in Brazil, Thailand, the United Kingdom and United States.

Since 1998, the government has transferred the entire government Energy Efficiency & Conservation Programme to the Energy Foundation, which is the current implementing agency. The government finances the activities of the Energy Foundation. Since the Energy Foundation has taken up the promotion of energy efficiency measures, the success rate in communicating the energy efficiency message to the public and improving public perception of DSM measures has increased significantly.

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 14:
DEMAND-SIDE MANAGEMENT

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Demand-side management (DSM) traditionally = reducing electricity demand to:
  - Defer building further capacity
  - Mitigate electrical system emergencies
  - Reduce dependency on expensive imports of fuel
  - Reduce emissions
- Economic, reliability and environmental benefits
- This module will examine:
  - Why promote DSM? What Drives DSM?
  - Types of DSM measures
  - Information dissemination of DSM
  - DSM programme challenges

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To introduce the concept of demand-side management for residential, commercial and industrial energy users
- To give an overview of the different types of DSM
- To show how housekeeping and preventative maintenance in commerce and industry can be used to reduce energy demand
- To describe energy auditing and routine data collection and monitoring, and to indicate their benefits.
- To outline information dissemination on DSM

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define demand-side management
- To understand the different types of DSM and suitability to various energy users
- To be aware of the benefits of good reliable data for regular performance analysis, and as an essential part of energy auditing
- To appreciate the need for effective information dissemination on DSM
- To understand the challenges facing implementation of DSM

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Demand-Side Management

DSM refers to "Actions taken on the customer's side of the meter to change the amount or timing of energy consumption. Electricity DSM strategies have the goal of maximizing end-use efficiency to avoid or postpone the construction of new generating plants."

[USA Department of Energy]

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Promote DSM?

- Cost reduction of meeting energy demand
- Environmental and social improvement—reduced emissions
- Reliability and network issues—improve reliability and defer expansion
- Improved markets—demand response
- Improved national energy security

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What Drives DSM?

- Cost reduction and environment:
  - Reduce utility costs / customer costs
  - Rising fuel prices
  - Opposition/financial limitation to building new plants
  - emission/environmental concerns
- Network and market
  - Delay or avoid expansion
  - Competition
  - Demand shifting

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types of DSM Measures

- **Energy reduction programmes**—reducing demand through more efficient processes, buildings or equipment
- **Load management programmes**—changing the load pattern and encouraging less demand at peak times and peak rates
- **Load growth and conservation programmes**

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Reduction Programmes

- Improving performance of boilers, steam systems, etc.
- Efficient lighting
  - CFLs
  - Using natural light
- Appliance labelling
- Building regulations
  - Efficient and alternative energy use
- Efficient use of electric motors
- Preventative maintenance

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Reduction Programmes (2)

- Energy management
  - Energy purchasing
  - Metering and billing
  - Performance measurement
  - Energy policy development
  - Energy surveying and auditing
  - Awareness-raising, training and education
  - Capital investment management
- Hiring an energy planner

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Reduction Programmes (3)

- Housekeeping
  - No cost / low cost measures
  - Measures requiring some level of investment
- Energy auditing
  - Preliminary audit
  - Detailed audit
  - Financial analysis

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Load Management Measures

- Load levelling:
  - Peak clipping
  - Valley filling
  - Load shifting
- Load control:
  - Loads (e.g. heating, cooling, ventilation, and lighting) switched on or off, often remotely, by the utility
- Tariff incentives or penalties:
  - Time-of-use & real time pricing
  - Power factor penalties

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Load Growth and Conservation Programmes

- Growth diverting other energy sources (fuel) to better (more efficient) electrical sources
- Growth strengthens the utilities capability to load manage
- Conservation results in a reduction in sales as well as a change in the pattern of use

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Information Dissemination of DSM

- Awareness campaigns
  - Promoting user benefits
  - Explaining no cost/low cost actions
- Marketing
  - Most programmes are marketed by “personal contact”
  - Talking directly with people important
  - Media also useful: radio, television, newspapers

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

DSM Programme Challenges

- Developing countries
  - Awareness
  - Technical capabilities
- Production and safety constraints
- Cost to customer
- Financing constraints

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- DSM is important for enabling the more efficient use of base load capacity
- It mitigates electrical system emergencies
- Significant economic, system reliability and environmental benefits
- Cheap, fast way to solve electricity problems
- Market DSM programmes to show potential customers their life cycle benefits and often simple techniques for reducing demand

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

"DSM programmes can be win-win measures for suppliers and customers"

Discuss

Considering the benefits and drawbacks of DSM programmes

Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (2)

"Energy efficiency (both supply & demand-side) should take priority over development of renewables."

Do you agree with this statement?

Why? Why not?

Discuss

considering the benefits and drawbacks

Module 14