CHAPTER 6: ENERGY MAINTENANCE MANAGEMENT

"Our failure rate is one-in-a-million, but what do we tell that one customer?"

IBM

6.1 INTRODUCTION

The previous chapter introduced the Energy Load Management area-of-activity as the area most likely to produce the reduction in the electricity cost per student or academic faculty. From chapter 1 it was noted that although this is the goal of the energy management programme, the programme is not complete without addressing both the needs of the personnel and students through energy education, and ensuring that the electricity network and all equipment attached to it is maintained.

The case examples in chapter 1 referred to some institutions that do not consider the maintenance of the electricity systems on campus as part of the energy management programme whereby the facilities department of the institution addresses the maintenance component. Unfortunately no direct link is made between the two and as such, the maintenance aspects of the energy management programme become forgotten leading to poor energy benchmarks and the appearance of bad maintenance on campus as a result of equipment attrition from information loss.

In all practicality, the maintenance of the electrical equipment must fall under the auspices of the facilities department for the simple reason that respect must be paid to the existing maintenance schedules and that the procurement and stores duties are centralised. However, this is mainly acceptable if the link between the every-day maintenance on campus and the energy management programme is made clear.

This chapter firstly looks at the maintenance on campus as a separate business activity and then links the energy management programme to this activity. The importance of maintenance is based on the simple logic that without the electricity reticulation systems, there is no energy to manage in the first place. According to Kennedy [51], a good electricity system maintenance programme can save the institution a substantial amount of money in wasted electricity, lost production and the additional expense caused by preventable equipment breakdowns. Other benefits include general cleanliness, improved personnel and student morale and increased safety and reliability.

6.2 INSTITUTION MAINTENANCE

The maintenance on campus contains two basic elements namely breakdown maintenance and preventive maintenance. Both are based on a maintenance body of knowledge as illustrated in figure 6.1.

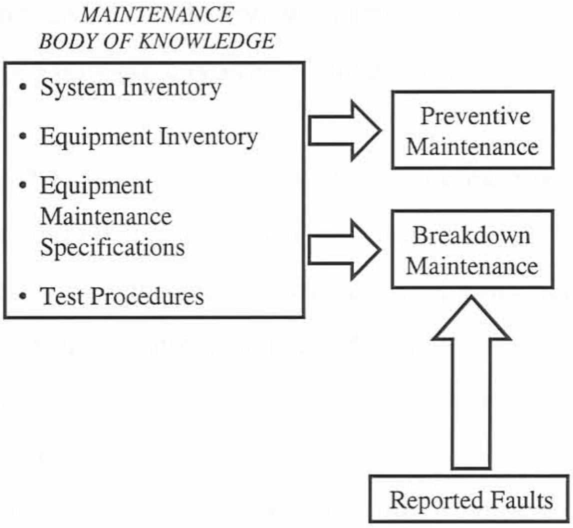

Figure 6.1: Basic Representation of the Maintenance Function of an Academic Institution

The structure of the maintenance activity on campus presented in figure 6.1 is a basic representation and may have omitted certain maintenance items. The detailed functions of facility maintenance are the subject of separate study and not the focus of this study. It must be respected though and the link clearly defined.

Preventive maintenance is defined by Westerkamp [52] as the systematic planning, annual scheduling at regular intervals and on-time completion of needed cleaning, lubricating, repairing and replacing of components in order to:

- Minimise production losses caused by breakdowns
- Prolong the useful life of capital assets
- Lower overall costs

Breakdown maintenance is explained by Stewart [53] as the maintenance that is required when equipment is allowed to continue in service until it cannot perform its normal function any longer. The name is self-explanatory and examples include lighting lamps that burn out or windows that are broken. Breakdown maintenance usually occurs on the input of some form of fault reporting received from building occupants or residents. If not already in operation, a customer care-line should be established that can incorporate electricity faults and other maintenance problems.

Knowledge of the equipment within the institution is vital to the success of the maintenance programme and is collectively grouped under the maintenance body of knowledge. The body of knowledge typically contains the following information:

- System inventory of the layout of all reticulation systems from point of supply to end-use application including all components of each system
- Equipment inventory of all equipment on campus including quantities, suppliers, stock requirement and performance ratings and specifications
- Library of the maintenance requirements of equipment as recommended by the manufacturers and suppliers
- Library of test procedures for all equipment requiring regular maintenance

The body of knowledge should be further expanded to include the capture of the experiences of the maintenance personnel on campus. This should be done to prevent "Technology on the Hoof" whereby, according to Botha [54], the information and experiences of the personnel on campus are not lost when staff members are no longer attached to the institution.

In closing this section, it is important to remember that maintenance at an academic institution does not only address the electrical equipment on campus but attends to all assets such as lecture halls, institution vehicles and civil construction items (buildings and roads) too.

No maintenance can commence on campus until the maintenance body of knowledge has been established. As an example, the University of Pretoria, through its programme of privatisation and outsourcing of maintenance duties by the end of 1998 had suffered a major setback through "technology on the hoof". The outsourcing saw maintenance companies being awarded contracts for specific maintenance tasks through in-house contract managers retained for this purpose. During the privatisation, most of the knowledge of the 380V electricity distribution system, once it was transformed from the 11kV sub-station level, was lost. To remedy this problem, great attention was paid to acquiring this vital information through a series of sub-station walk audits aimed at identifying each circuit on the secondary side. Unmarked circuit breakers were switched off, after localised power outage warnings, to identify the end-user groups supplied by them and this information meticulously documented.

6.3 INSIDE THE ENERGY MAINTENANCE MANAGEMENT AREA-OF-ACTIVITY

Kennedy [51] explains that there are four steps in developing a maintenance programme for the energy systems. The first step is to determine the present condition of the existing campus. This includes a detailed examination of each of the major energy-consuming systems. The second step is the preparation of a list of routine maintenance tables with an estimate of the number of times each task must be performed. The third step involves the incorporation of this list into a regular schedule for the accomplishment of the desired maintenance and finally culminating in the monitoring of the programme once it has been initiated as the final fourth step.

This thinking, when applied to the systematic approach of the energy management programme, is mostly already applied through the Energy Diagnosis area-of-activity and the existing maintenance activities of the facilities department on campus. Once again it is important to remember that the maintenance of the energy systems must fall into the other maintenance requirements on campus as illustrated in figure 6.2.

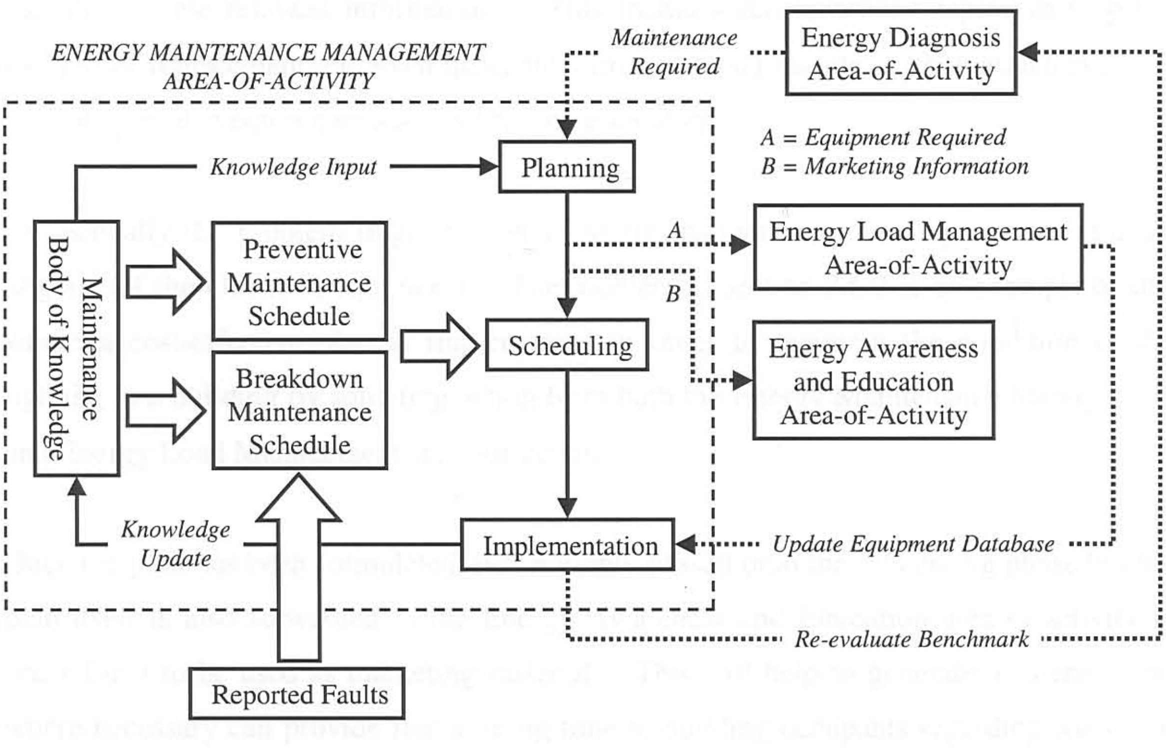

Figure 6.2: Functionality of the Energy Maintenance Management Area-of-Activity

The maintenance component of the energy management programme reacts on the commands that are received from the Energy Diagnosis area-of-activity. Here the solution to the problem is planned based on the input from the body of knowledge. The plan is integrated into the existing maintenance schedule of the institution and then implemented. Incorporating the implementation into the maintenance schedule of the institution ensures the recovery of vital equipment information into the existing body of knowledge. The solid arrows in figure 6.2 indicate internal operation and the dotted arrows indicate operations that occur with the other areas-of-activity as previously illustrated in figures 2.4, 2.5 and 2.6.

6.4 PLANNING

The first part of the Energy Maintenance Management area-of-activity relies on the input of faults from the Energy Diagnosis activity area. These faults will have been noticed during building the auditing phase of Energy Diagnosis activity area and identified as contributors towards high electricity cost and poor benchmark performance.

Once the fault has been received, the solution needs to be found. The maintenance body of knowledge provides input into this planning stage in terms of equipment maintenance specifications and recommended maintenance procedures. At the conclusion of the planning stage a solution to the problem must be put forward, in the form of a job card, that includes all the relevant information. This includes recommended replacement parts, method of replacement and even quotations from external maintenance contractors in the case of specialist equipment such as lifts and escalators.

Occasionally the problem might not only require maintenance but may also require the upgrade of the electrical equipment. The problem in section 2.6.2 is an example of this where a cost-effective plan is implemented in order to maintain the condition of the lighting in a building by soliciting action from both the Energy Maintenance Management and Energy Load Management areas-of-activity.

Once the plan has been formulated, it is not only passed onto the scheduling phase but the plan itself is also forwarded to the Energy Awareness and Education area-of-activity in order for it to be used as marketing material. This will help to generate awareness and where necessary can provide fair warning time to building occupants regarding work that is about to be done.

Naturally, other than those received from the Energy Diagnosis activity area, other faults with electrical equipment will also be received from the building occupants through a customer care-line operated by the facilities management department. These customer faults will run their normal course in the breakdown maintenance schedule of the facilities management department.

6.5 SCHEDULING

From the planning stage, a series of job cards will arrive at the scheduling phase of the Energy Maintenance Management activity area. Here these jobs need to be incorporated into the existing maintenance schedules of the University (both preventive and breakdown).

For example, the cleaning of electrical lamps might be submitted as a job card but this activity is already scheduled to take place anyhow as part of the existing preventive maintenance schedule and that no place need to be found immediately. The existing schedule can be rearranged if it is felt that the task on hand should be fast-tracked but respect must always be paid to the other maintenance requirements on campus.

6.6 IMPLEMENTATION

Once all of the jobs, from faults identified as part of the energy management programme and those as part of the existing preventive and breakdown maintenance programme of the institution, have been prioritised, the next step involves their implementation. The implementation is fairly simple as all of the planning has been completed based on the maintenance body of knowledge.

The final step of the implementation phase is the export of all of the important documentation to the maintenance body of knowledge. Information will also be continually received from the Energy Load Management activity area where new electrical equipment upgrades and installations will have taken place and all maintenance procedures, specifications, system drawings and equipment numbers and ratings will be required in order to update the body of knowledge. This information is then used to ammend the preventive maintenance schedule in order to incorporate any new equipment.

On completion of each maintenance task, the energy benchmark can be re-evaluated in the Energy Diagnosis activity area in order to determine the impact on the energy benchmark.

6.7 MAINTENANCE EXAMPLES

Regular maintenance not only has a positive effect on the electricity benchmarks but on the reliability and sustainability of the electricity reticulation system in general. This will be highlighted in the following 3 examples of where maintenance can play a positive role, or the absence thereof can have disastrous effects.

6.7.1 Building Preventive Maintenance

From the definition of preventive maintenance in section 6.2, it was mentioned that regular maintenance helps to extend the useful life of an asset or piece of equipment. Maintenance that becomes deferred could lead to assets, including electricity reticulation systems, being degraded to a point that is beyond their financial viability whereby the sum of all of the maintenance costs required to render the asset operational is greater than the value of that asset. The effect of preventive maintenance on a building that is conducted in a pro-active manner is illustrated in figure 6.3. This illustration holds true for the electricity reticulation system, and associated costs, too.

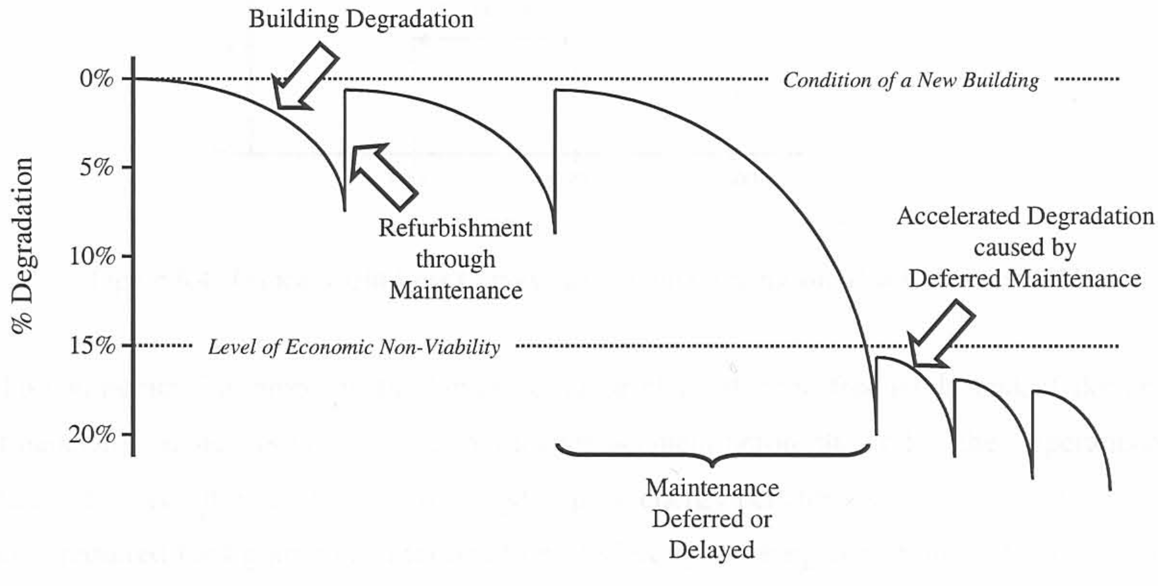

Figure 6.3: The Effect of Preventive Maintenance on a Building [7]

If the maintenance schedule is not set up correctly or is not adhered to, then the situation is reached whereby a building or other asset no longer retains any of its original value and major funding is required to restore this building to a point of economic viability. In this instance it usually makes financial sense to replace the asset altogether. Unfortunately, this is not always possible with certain assets such as buildings and is usually done at a far greater cost than the regular maintenance would have cost. Once an asset has passed a state of economic viability, the degradation occurs at a much faster rate, which in turn requires more funding.

6.7.2 Lighting Maintenance

Regular maintenance helps to ensure that the electricity benchmarks are reduced through a process of increasing the efficiency of electrical equipment. In the case of electrical lighting, the effectiveness of the lamps is affected by both the operational ageing of the lamps and the collection of dirt. The effect of this is illustrated in figure 6.4.

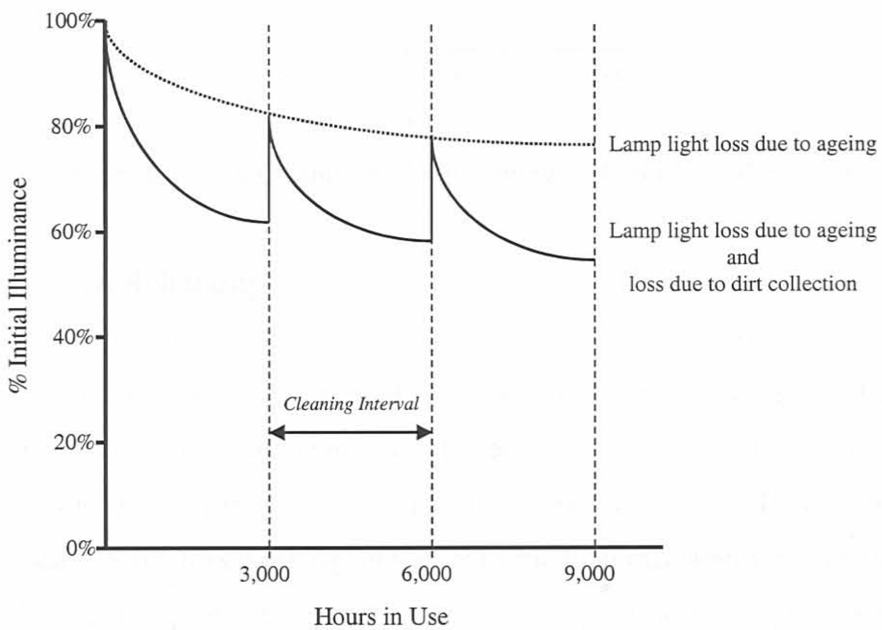

Figure 6.4: Typical Light Loss Curves due to Lamp Ageing and Dirt Collection [55]

To counteract this problem, the lamps could be cleaned more frequently and, if deemed financially viable, could be considered for replacement before the end of their operational life. This could be motivated from both a poor energy benchmark in terms of electricity cost required for lighting or in terms of unsatisfactory working conditions in terms of low illuminance. The effect of regular cleaning and lamp retrofitting is illustrated in figure 6.5.

Although cleaning lamps is not always practical, it will increase the efficiency of the lighting in terms of the amount of light that is obtained per unit of electrical energy consumed. Cleaning the lamps can be carried out with the minimum amount of disruption, requires little training on the part of maintenance personnel and ensures that the condition of the electrical lamps are visually more satisfactory.

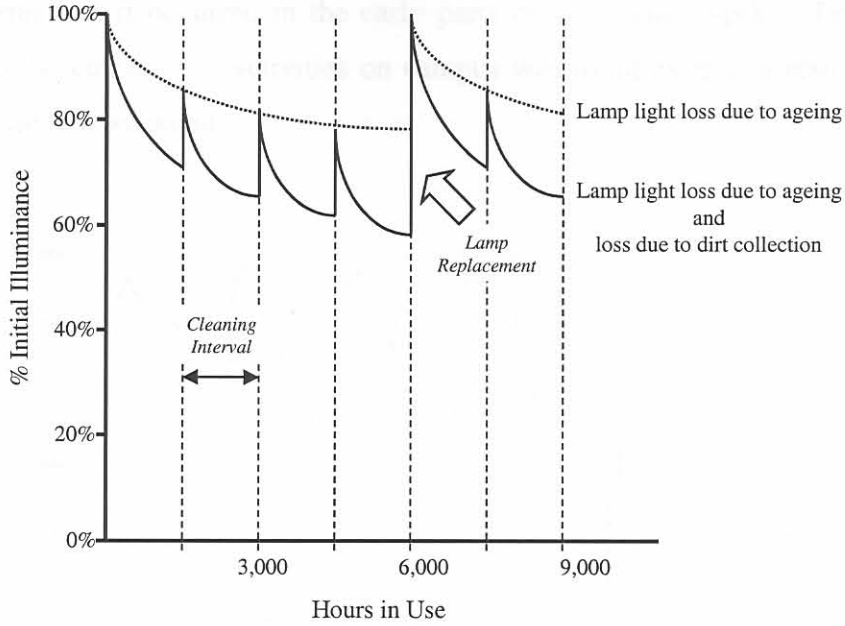

Figure 6.5: Effect of Cleaning and Retrofitting on Light Loss Curves [55]

6.7.3 Sub-Station Reliability

The final example involves a case where slow reaction to a reported suspicious fault lead to the electricity supply being interrupted to the entire main campus at the University of Pretoria. During routine maintenance of the energy measurement system, an unusual noise was noted in one of the 11kV sub-stations on main campus. This noise was noted by one of the sub-contractors working on the real-time load measurement system. Initially it was thought that the problem lay with the uninterrupted power supply (UPS) used to supply backup power to real-time load measurement equipment in this sub-station. However, after conducting the necessary investigation, the UPS was cleared and the fault ascribed to irregular corona on the busbars. In concluding his tasks, the sub-contractor reported his suspicions to the facility management personnel on campus who are responsible for the integrity of the sub-stations.

The fault was reported during the month of May 1999. The fault was not immediately addressed and a few months later, on Friday 16 July 1999, a general protection fault occurred and all power to the entire campus was lost. Figure 6.6 illustrates the load profile of the University load for the week of the fault.

Upon investigation, it was ascertained that some of the voltage transformation equipment had been incorrectly installed in the sub-station and this had lead to the general fault. The power from this specific sub-station was disrupted for a full 24-hours which could have been disastrous had it occurred in the early parts of a working week. Fortunately the disruption to the commercial activities on campus was minimised as a result of the fault occurring close to a weekend.

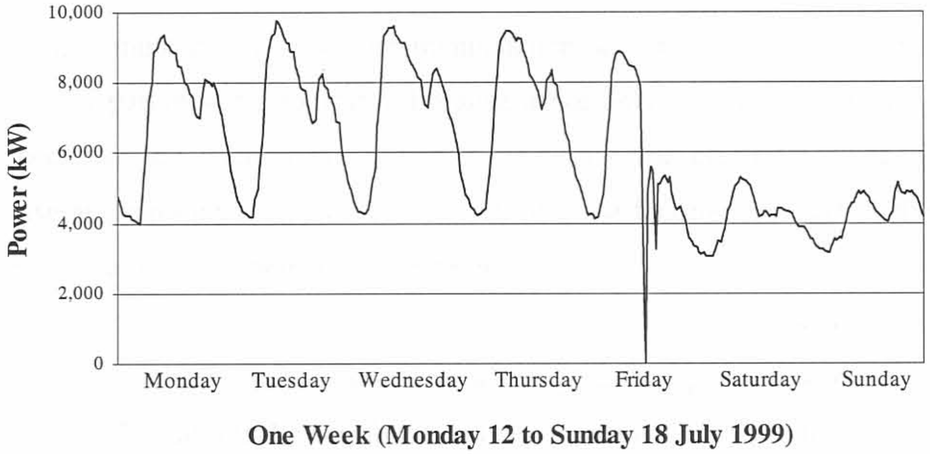

Figure 6.6: Power Outage at the University of Pretoria – Friday 16 July 1999

It can be concluded that the reaction time to reported faults must be minimised at all costs. Failure to recognise the full potential impact of reported faults could lead to major problems and increased costs. Furthermore, the facility management department must take ownership of the integrity of the electricity system and ensure that all work conforms to all certified safety standards.

6.8 CONCLUSION

By following the systematic approach to this activity area, the link between the existing maintenance on campus and the maintenance required from the energy management programme is clearly defined.

This link ensures that there is no information loss or "technology on the hoof". The capture of all of the maintenance information not only prolongs the operability of the electricity systems but ensures the sustainability of the energy management programme.

The facilities management department must take ownership of the maintenance on campus and must expand this ownership to include the electrical equipment. The maintenance of the electrical equipment can have a very positive effect on the energy management programme. On the other hand, the potential disastrous effects that poor, cumbersome maintenance could have should be also acknowledged. In this manner all maintenance and planning decisions on campus must take the energy management programme into account. The facilities management department should wear their energy management caps when approving new equipment and buildings.

In conclusion, it must be said that the maintenance activity of the energy management programme is of paramount importance because it not only ensures greater reliability and increased occupant satisfaction but it strives to reduce the electricity cost in terms of electricity use and equipment capital costs. All of these features are part of the goal of a comprehensive energy management programme.

In the next chapter, the final component of a complete energy management programme will be addressed that targets the people on campus through marketing and training.