The Need for Energy Management in Health Facilities

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Abstract

In the public sector where most hospitals belong, it is unlikely to find trained energy personnel despite the fact that consumption is huge. With escalating energy prices, walk-through energy audits are now becoming common-place in our industries. They are generally followed with recommendations for implementing one-off projects referred to as system-specific audits. These have enabled 5 – 20% savings on energy bills. By this simple process in energy management, as contrasted to increasing productivity by a similar margin, industries have realized savings on energy worth millions of shillings.

A tremendous amount of our invaluable finite energy resource sinks to oblivion day in day out. This paper explains the role of efficient energy management in health facilities with the aim of introducing it in Kenyan Hospitals. This will be achieved through creating awareness within the top decision makers on the value of systematic energy management.

The essence of energy management is that the data provided for analysis must be reliable and consistently dependable. This is only possible when there is an energy monitoring and targeting program in place. In our attempt to search for dependable data from health facilities, a number of hurdles were insurmountable. These, from informal conversation with plant engineers in these facilities, ranged from 'data protection' tag to improper methods used in data collection.

This paper therefore outlines the need for establishment of an Energy Department in every health facility and its crucial role. One role is to apply simple techniques to save energies in hospitals. Success stories of similar facilities elsewhere shall be cited.

Key Words

Energy management, walkthrough, audit, monitoring and targeting, Energy Department, energy saving.

1 Introduction

Demand for global energy services to support economic growth has grown by 50 percent since 1980 and is projected to grow another 50 percent by 2030, or nearly to 250 exa-joules. Global oil consumption is projected to rise by about 300,000 barrels per day (bbl/d) in 2008 and by almost 800,000 bbl/d in 2009 compared with year-earlier levels[1]. In order to cope with this increasing demand for energy, two options are available: increase supply or improve energy end-use and supply efficiencies. As appreciated in the recent ever first National Energy Conference in Kenya, both approaches are needed. But of the two, only energy efficiency can generate nearly immediate results with existing technology and proven policies and do so while generating strong financial returns that exceed those from investments in conventional energy supply[2].

There are four core concepts in energy management technique: the energy survey, energy audit and energy balance; monitoring and targeting (M&T). All these have very close relationships. There is yet minimal standardisation hence non-uniformity in the definition of terms such as "audit", "survey" and "monitoring and targeting" and there are widespread differences in the meaning people give to these terms. Nevertheless, there are agreed procedures that make the energy management profession both a managerial and a scientific discipline. It is a scientific quantification and control of energy supply and use plus management of people and equipment that use the energy resource.

Inefficient use of the non-renewable energy resource is a contributor to environmental degradation, pollution and resource depletion. Despite the fact that energy efficiency is not a new concept, its urgency has now been brought to the forefront by underlying factors that have some of their roots in the oil-shocks or energy crisis of the 1970's. This triggered high energy prices, sense of insecurity of energy supplies, concerns on adverse environmental impacts, consequences on human health and security of future generations. The same spirit of energy insecurity is echoing in the now-generation so that governments have no other choice but to ensure strict decisive measures are taken to avoid the historic dark crises recurring. It is therefore paramount that effective energy policies be set up to reduce our consumption while meeting our present needs of life but without compromising the ability of the future generations to meet their own needs[3].

Research, development and deployment of symbiotic technologies – generically meaning activities satisfying our needs yet caring for the environment[4] – coupled with energy efficient practices, form the effective two-pronged tool for energy management. To address the present-age impediment on development yet curtail environmental degradation, sustainable energy and energy management policies must be embraced.

The primary objective of energy management is to produce goods and render services with minimal energy consumption. Such a path will not only be of least cost but will also be environment-friendly. The term energy management therefore may be defined as below:

- Energy management is the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of

[1] Global Energy Industry Outlook 2009. At www.EnergyBusinessReports.com [Last accessed 31/10/08]

[2] Expert Group on Energy Efficiency 2007: Realizing the Potential of Energy Efficiency: Targets, Policies, and Measures for G8 Countries. United Nations Foundation, Washington, DC, 72 pp.

[3] Thijs De La Court (1990): *Beyond Brundtland – Green Development in the 1990s.* London: Zed Books Ltd.

[4] Bellamy, D., Elkington, J., Mayer, M., Warren, A., O'Riordan, T. (1986): *Healthier Profits: Business Success and the Green Factor*. The Environment Foundation. ISBN No. 0951118315

output while holding constant or reducing total costs of producing the output from these systems.

- Energy management system is that part of the overall management system, which is dedicated to the continual energy performance improvement.

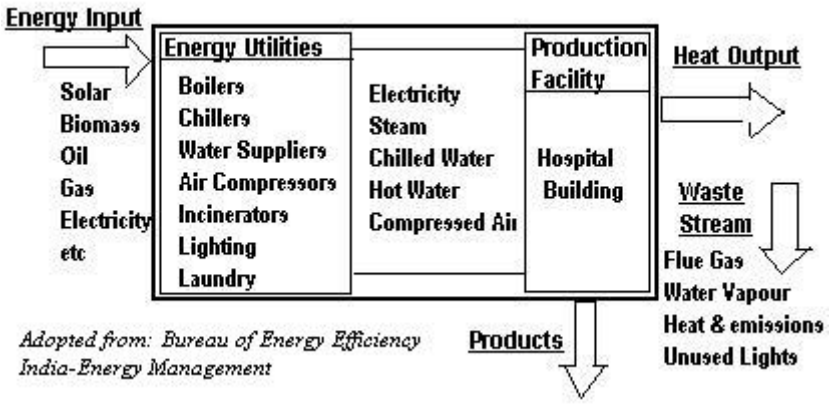
2 Analytical and Presentation Methods Available

Analytical methods used in Energy Management include *Material and Energy Balance, Forced Field, Financial, Sensitivity and Data and Information Analyses.* These are coupled with information presentation techniques like control, bar/column, contour and pie charts and company energy profiles derived from the Energy Matrix (a tool formulated according to the six management principles namely Policy, Organisation, Marketing, Motivation, Information systems and Investment).

Material and Energy Balance

An overview of unit operations, important process steps, areas of material and energy use and sources of waste generation should be gathered and should be presented in a flow chart that can be refined into a Sanky Diagram. Also identification of the various inputs and out put streams at each process step is required.

Figure 1: Hospital 'Sanky' Diagram Generally Indicating Inflows, Outflows and Wastage: A Material and Energy System.

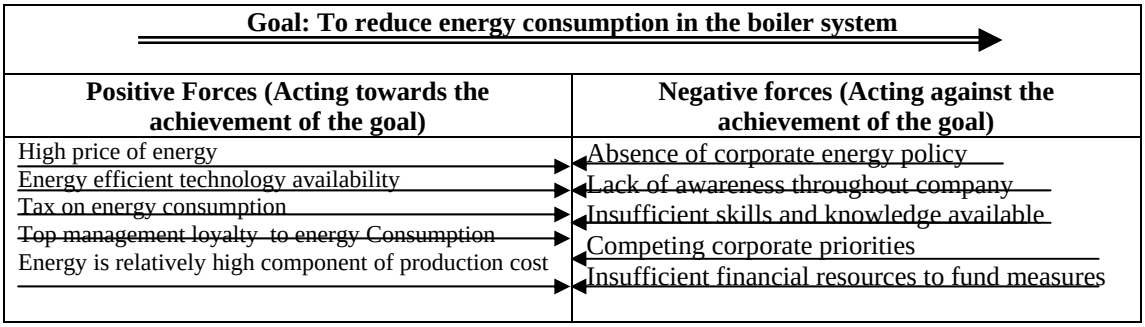


Forced Field

Before creating an action plan, it is useful to clarify the goal to be achieved, and assess what barriers must be overcome and what influences exist in the organisation that works towards the achievement of the goal. These barriers and influences can be thought of as negative and positive forces respectively.

The steps involved in using it include, state the organisational goal, identify barriers, identify positive influences, estimate the relative strength and then prioritize.

Figure 2: Typical force field analysis chart



Financial

In most respects, investment in energy efficiency is no different from any other area of financial management. However given the need to support sustainable national development, investment efficiency offers the most financially favourable returns. Relatively small efficiency investment generates significant additional benefits in improved business productivity and reduced consumer bills.

The basic criteria for financial investment appraisal include:

i) *The payback* period is the minimum time required for net revenues associated with an investment to return the cost of the investment. A simple payback period is computed without accounting for the time value of money. The payback period for an energy system is calculated as the total investment cost divided by the first year's revenues from energy saved, displaced, or produced.

In payback analysis, the unit of measurement is the number of years to .pay back the investment cost. Simple payback analysis takes into account only first costs and energy savings at present cost.

ii) *Present Value:* Present value is the value of a future transaction discounted to some base date. It reflects a time value for money. The present day equivalent of a future cost, i.e. the present value, can be thought of as the of amount money that would be invested today, at an interest rate equal to the discount rate, in order to have the money available to meet the future cost at the time when it was predicted to occur.

iii) *Savings/Investment or Benefit/cost Ratio* can be used to compare savings to costs of one energy system relative to an alternative energy system.
For positive net savings, the SIR must be greater than one. The higher the ratio, the greater the savings realized relative to the investment.

iv) *Net Benefit Analysis* can be used to express the net difference between the benefits and costs of one energy system relative to an alternative in present or annual value shillings. Net benefits, also called net present values (NPV), represent the difference between the present value of benefits (revenue or savings) and the present value of costs of the alternative. A system is cost-effective if the net saving or net benefit is positive.

$$NPV = -C + \sum_{t-1}^{n} \frac{(1+a)^t}{(1+r)^t} \times S$$

Where the term $\sum_{t-1}^{n} \left(\frac{1+a}{1+r} \right)^t$ represents PWF (a, r, n), the present worth factor for a series of regular savings or payments. It is also called the Net Present Cost Factor whose value may be determined from tables or from the formula:

$$PWF(a,r,n) = \frac{1-\left(\frac{1+a}{1+r}\right)^n}{\left(\frac{1+r}{1+a}\right)-1}$$

v) *Internal Rate of Return:* in addition to the net present value and benefit-cost ratio tests, investment evaluation also relies on the use of an internal rate of return. In this case, rather than use a prior specified rate of discount, one derives that rate of discount which yields a net present value of zero, or what is equivalent, a benefit-cost ratio of one.
IRR is an iterative procedure (easily obtained using excel) which computes the yield on original investment and involves selecting compound interest rates and discounting the cash flows until a rate is found for which the net value of the investment is *zero.*

vi) *Retrofit Investment:* At times when retrofitting is into an existing system or new alterations are done and can be contrasted with the previous case, a short evaluation method is used. Only an estimated budget is needed to show proof of anticipated returns in comparison to the investment cost. The following formula quantifies the returns:

$$(S_m + PC_{avd}) - (C_m + PB_{fgon})$$

Where
S_m = Marginal savings or returns anticipated
C_m = Marginal costs incurred
PC_{avd} = Present costs avoided
PB_{fgon} = Present income or benefit forgone

vii) Life-cycle cost (LCC) – The sum of time-equivalent costs of acquiring, owning, operating and maintaining a building, system, or equipment over a designated study period. Comparing LCCs of alternative building designs, systems, or equipment that equally satisfy functional requirements is one way of choosing among them on economic grounds.

A comparison between the LCC of the energy system to an alternative determines if the system in question is cost-effective. If the LCC is lower than that for the base case and in other aspects is equal, and the project meets the investor's objectives and budget constraints, it is considered cost effective and the preferred investment[5].

Sensitivity

Sensitivity analysis is an assessment of risk. Because of the uncertainty in assigning values to the analysis, it is recommended that a sensitivity analysis be carried out – particularly on projects where feasibility is marginal.

Suppose, for example that a feasible project is based on an energy cost saving that escalates at 10% per year, but a sensitivity analysis shows the break-even is at 9% (i.e. the project becomes unviable if the inflation of energy cost falls below 9%). There is high degree of risk associated with this project – much greater than if the break even value was at 2%.

[5] Ruegg, R.T. and Marshall, H.E. (1990). *Building Economics: Theory and Practice.* New York: Van Nostrand Reinhold.

Data and Information

Electricity bills and other fuel bills should be collected periodically and analysed. This is done in the most simplified format in the form of a data-collection table to allow easier interpretation and information display. Information can then be presented graphically and related; for instance energy consumption per unit production, Normalised Performance Index, specific energy consumption, CuSum etc.

Cumulative Sum (CuSum) represents the difference between the base line (expected or standard consumption) and the actual consumption points over the baseline period of time. This useful technique not only provides a trend line, it also calculates savings/losses to date and shows when the performance changes.

3 The **Strategy**

Energy management, defined as a strategy in the introduction, should be a comprehensive overview of where company decisions affect energy saving. The company therefore needs to consider implementing the following:

1) Publish a corporate policy
2) Establish an energy management responsibility structure
3) Monitor and evaluate performance
4) Set performance improvement targets
5) Improve the awareness of energy conservation amongst staff
6) Hold regular reviews
7) Report performance change and improvements to employees and shareholders

Unlike energy audits, whereby energy consumption is identified and energy conservation opportunities (ECOs) that may lead to appropriate efficiency practices are determined, energy management must be seen as a continuous process. Energy audits alone oft-times result in one-off projects that raise quick profits from energy savings and then laxity comes in. High standards basically involve good housekeeping procedures in energy management and result in a win-win situation where monetary gains are reaped from energy efficiency or conservation in addition to pro-ecological benefits.

Consider a Corporate Approach

The starting point in energy management is to identify a strategic corporate approach to energy management. Clear accountability for energy management needs to be established, appropriate financial and staffing resources must be allocated, and reporting procedures initiated. The full potential for energy saving improvements may not be realised unless all staff are working together towards the success of the project. Since *lack of knowledge of the benefits* of energy saving has been recognised as a major *non-technical barrier* the awareness of ALL staff needs to be raised. This is achieved through staff campaigns, by clearly identifying the benefits of the improved efficiency to each individual employee.

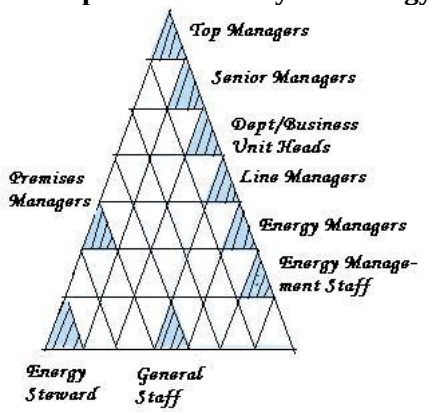
Formalize an Energy Management Policy Statement

A written energy management policy will guide efforts to improve energy efficiency, and represents a commitment to saving energy. It will also help to ensure that the success of the program is not dependent on particular individuals in the organization. An energy management policy statement includes a declaration of commitment from senior management, as well as general aims and specific targets relating to: energy consumption reduction, energy cost reduction, timetables, budgetary limits, energy cost centres and organisation of management resources.

Appoint Energy Manager

The Energy Manager, who should be a senior staff member, will be responsible for the overall coordination of the program and will report directly to top management. The proposed hierarchical pyramid below is a slight variation of the 'conventional' one:

Figure 3: The Proposed Hierarchy for Energy Managers



Energy management is made to be seen as a function of everybody's duties, but certain personnel are assigned to maintain an overview or coordinating role.

Conduct Energy Audit

An energy audit, as discussed in the next subsection, establishes both where and how energy is being used, and the potential for energy savings. It includes a walk-through survey, a review of energy using systems, analysis of energy use and the preparation of an energy budget, and provides a baseline from which energy consumption can be compared over time. An audit can be conducted by an employee of the organization who has appropriate expertise, or by a specialist energy-auditing firm or whoever else that is registered by, according to Energy Act 2006, the Energy Regulatory Commission[6].

Energy Audit is defined as "*the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption*".

A methodical approach for decision-making in energy management calls, first, for an Energy Audit. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Hospital energy audit would be an effective tool in defining and pursuing a comprehensive energy management programme.

Benchmarks or reference points are derived from an Energy Audit for managing energy in the organization and also provides the basis for planning a more effective use of energy among different organisations that engage in similar operations. The Audit programme will help focus on the changes which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy switch and mix, identify symbiotic technologies, retrofit for energy conservation equipment etc.

[6] *The Energy Act, 2006* of Kenya. Part II – The Energy Regulatory Commission Sec 5 (c).

Energy Audit Types

Depending on the accuracy of results, some studies divide Energy Audits into 2 types: preliminary and comprehensive; others into 3: I-40%, II-20% and III–10% accuracy; while others into 4 types: walk through, preliminary, system specific and comprehensive. We adopt the latter in this paper.

i) The *Walk-Through Energy Audit* is mostly used in tertiary buildings where the energy consuming systems are quite simple and the probable areas for potential measures are known in advance.
ii) The *Preliminary Energy Audit* is used in large sites of the process industry.
It provides an overview of the present total energy consumption and defines the areas of significant energy consumption. It points out the most obvious savings and the areas where supplementary second-phase audits are needed.
iii) The *System Specific Energy Audit* concentrates on one specific energy using system (boiler, compressed air system, etc) and provides detailed technical measures for the improvement of energy efficiency, with accurate budget, energy conservation and cost savings estimations.
iv) The *Comprehensive Energy Audit* covers all energy usage of the site, including mechanical and electrical systems, process supply systems, all energy using processes, etc. Where the most important energy systems are identified, this method provides similar information to the System Specific Energy Audit.

The Need for Data

Structured data collection is fundamental to the energy audit. As a first step, only existing data sources should be used. A considerable amount of energy information is readily available to an organisation, but it often requires collating and interpreting. By simply gathering appropriate information, a clearer picture of energy use and costs will begin to emerge.

Set up an Energy Monitoring, Targeting and Information System

Having formulated a policy framework and established responsibilities, successful energy management requires that a system to collect, analyse and report on the organisation's energy consumption and costs (i.e. a monitoring and targeting system) be set up. This will enable an overview of energy use and its related costs, as well as facilitate the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy use, as well as cost information from billing data, and be capable of producing summary reports on a regular basis. This information will provide the means by which trends can be analysed and tariffs reviewed and will also act as a feedback mechanism to all staff to create awareness and motivation for more energy-saving endeavours.

Review Results Annually

Energy performance should be regularly reviewed and success stories, as in the case studies below, shared amongst all staff. As part of the review systems, the improvements in performance need to be shared not only with staff but also shareholders and, for corporal social responsibility, the general public. Such an approach has resulted in a greater awareness of energy saving at the managerial level within companies. Many companies have seen such a campaign as a motivation to staffs and have used it to *gain a marketing edge* on their competitors.

Review of energy management policy and strategies eventually form the basis for developing an implementation plan for the next evaluation period.

4 Case Studies

Due to the difficult in obtaining energy data from our local facilities for reasons in the discussion section, two case studies have been isolated the highlight the benefit of setting up and running an efficient energy management system in hospitals.

In Asia

Basic data and goal of one of the oldest and largest hospitals in south-east Asia[7] is set out in the following box. A team that was set up adopted a multi-faceted energy conservation strategy identifying effective methods and techniques to improve energy efficiency and reduce wastage.

The Goal: To devise "no- or low-cost" methods to improve energy efficiency and conserve energy through education of the users through campaigns and posters.
Occupancy: 1,352 beds.
Area coverage: 65 acres
Equipment responsible for 3/4 of energy consumption: operation theatres, high-end medical equipment, lighting, HVAC systems, water heaters, elevators, and water pumps.
Operation and maintenance (O&M): Carried out by the Public Works Department.
Power Supply bills: Too high attracting a threat for disconnection

Coordination of educational and outreach activities in energy efficiency measures targeted the management staff in each department. So the O&M department implemented an Awareness Campaign to sensitise all staff on the need to reduce energy consumption throughout the hospital campus. The low- and no-cost O&M measures implemented to achieve effective solutions to minimize energy wastage and maximize savings were:

- Catchy campaigns that made use of easy to remember slogans;
- Use of various communication tools such as posters at strategic locations to inform staff of the steps that can be taken to conserve energy and minimize wastage.

The technical measures that then followed included

- Maximizing usage of natural light during the day through passages and corridors;
- Turning off office equipment, fans and air-conditioners during unoccupied hours;
- Educating people about reasonable and efficient usage of water heaters and other electrical appliances;
- Plugging air leakages in air-conditioned rooms such as office spaces, operation theatre;
- Turning off water pumps when the tanks filled up.

Results and Lesson Learned

Through these efforts, a more responsible attitude towards the environment was cultivated among the hospital staff leading to substantial energy savings with little investment. Quality checks and analysis included use of checklists and other performance enhancement tools to record the electricity costs over the period and analyze the data to evaluate the performance of the project.

The project team quantified the electricity reduction resulting from the awareness campaign by using metered electricity data from the buildings during 2001-2004. The simple energy saving calculation and analysis was done by collecting metered monthly electricity consumption data and comparing it with the data for corresponding month of the preceding year.

[7] Promoting an Energy-Efficient Public Sector. Found at http://www.mahaurja.com/PDF/JJ%20Case%20Study.pdf [Last accessed 6/11/08]

Fiscal Year (April to March)	Energy Savings (kWh)	Cost Savings (Million Rs.)
FY2002	473,000	2.13
FY2003	229,000	0.73
FY2004	110,000	0.99
Total savings	**812,000**	**3.85 (US $ 90,000)**

Table 1: 3-year 'Profits' Accruing from low- & no- cost Energy-saving Measures.

It is important to identify one person or a group (Energy Champion) and give them responsibility so that they can play a leadership role in planning and implementing the project in an effective fashion. The fruition of the low-cost energy saving measures of the project was achieved via starting up and maintaining good housekeeping, staff-awareness and consistent O&M for equipment.

In the United Kingdom

A Health Authority in the UK embarked upon a programme aimed at reducing its annual energy bill of GBP 2.1 million by 25% over a five year period, whilst maintaining or improving on the standards of service and comfort required by the Department of Health [8]. The target savings were to be achieved by a combination of good housekeeping measures and a parallel programme of capital investment in energy cost reduction projects

Innovation

Art, publication and some humour too have their role! The gist of this is to involve all personnel. To launch the programme, posters were produced to promote ideas for reducing waste. Most of these used humour to attract attention and to create a more lasting effect. A 10-page handbook, also humorous, was produced and given to all employees. It contained many examples of wasteful practices and encouraged staff to 'Catch the Energy Bug'. An 'Ideas Scheme' was launched to encourage staff to submit further ideas for cost saving, with small awards being given to winners and runners-up in the various competitions. Colouring competitions using energy posters were introduced for children and patients. At the end of the first year posters were produced to inform staff of the programmes achievements. These were supplemented by regular features.

Within the programme, training and appreciation sessions were arranged for Departmental Managers and Energy Managers and Monitors. Initially, a policy statement set out the saving objectives and the methods to be used to achieve them. An Energy Management Group was set up for each of the three units, consisting of members of the unit management team and chaired by the unit General Manager. Energy Monitors, appointed from existing staff in each department, were given the task of maintaining a watch on the day-to-day use of energy-using equipment and identifying opportunities for savings. Allowing for changes in energy costs, the original five year target saving of 25% was laid out in the Authority's internal newspaper.

For senior managers, cost reduction was seen as part of the management performance indicators used to assess performance. Energy was seen as one of the best opportunities for cost reduction. Motivation provided for departmental staff came in the form of arranging for achieved revenue savings to be re-allocated to development funds and thereby contribute towards the provision of additional equipment and facilities. This general incentive was seen by the Authority as an essential feature of their approach. In addition, there was observed a positive response by staff and users to the greening of their hospital. To take advantage of the increased levels of staff interest, brief surveys were undertaken of each department to identify all the opportunities to reduce energy through good housekeeping. These surveys also identified scope for reducing energy costs through minor capital expenditures e.g. the provision of more light switches, which would give staff better local control.

[8] *CADDET Energy Efficiency, Saving Energy with Energy Efficiency in Hospitals; 1997, UK*

Result and Lesson Learned

The outcome of the surveys reinforces the benefits of linking a good housekeeping programme to a project-based programme, to obtain the best of both worlds.
The cumulative net cost savings by the end of the third year were GBP 1,015,000, of which GBP 331,000 had come from the good housekeeping measures.

5 Discussion and Recommendations

A survey of a few hospital facilities in Kenya revealed that there is no structured data collection on energy consumption. Haphazard records are kept by different departments whose routine operations are least interrelated. For instance the engineers in charge of various sections such as electrical works, boiler and compressor plants, automotive etc may keep various data on energy consumption however, in most cases the accounts department is the custodian of all utility bills and invoices. There is a keen 'confidentiality tag' attached to most of this data that it is difficult to access it unless permission is granted by the top management. As regular financial auditing is taken to be of top-most priority in all successful business organisations, so should energy auditing. The first step toward this is establishment of energy departments in all health facilities whose core role would be to track closely financial savings that accrue from energy saving measures and guide the company management in identifying viable energy projects for seed-funding from the savings.

Structured data collection is fundamental to the energy management. As a first step, only existing data sources should be used. Sources of existing information are: invoices, outputs from measuring devices, test documents, manuals and other audit reports. A considerable amount of energy information is readily available to an organisation, but it often requires collating and interpreting. By simply gathering appropriate information, a clearer picture of energy use and costs will begin to emerge. But the exercise requires company policy that is followed by appointment of energy managers and establishment of a dedicated energy division. This approach is evident in the outlined case studies.

Hospitals have high energy use per unit of floor area and high energy bills, but a number of technologies can be employed to lower them significantly. The following are some of the recommendation on energy management systems used to do conservation in hospitals:
People: creating awareness, offering incentives and training in good house-keeping procedures such as avoiding partial loads in laundering and using cold water for washing where necessary.
Technical systems: use of condensing boilers, economisers, boiler make-up water, pre-heat air, heat recovery ventilation (from laundry/sterilisation/dishwashers), auto-control of air-handling units for demand-controlled ventilation, use of CFL fluorescents, auto-control of lights (occupancy and photo-sensors), water-use control (e.g. low-flow toilets)

None of the two procedures stated above can happen without, first, policy, then determination to wisely invest in energy efficiency and renewable energy projects. In the event of lack of dependable time series data, which may happen due to misuse of the 'confidentiality clause' in the company policy or because of outright weakness in data collection and record keeping, it becomes utterly impossible to track and control energy use. Consequently energy efficiency measures fail to be identified and hence overall investment in energy projects is overlooked.

6 Conclusion

In pursuit of vision 2030 and confronted with escalating petroleum prices, it would do this country a great common good when a paradigm change in the exploitation and use of energy is made to occur within our private and public sectors. Millions of shillings spent on oil imports, as seen in the case studies, would be saved. Megawatt hours of electricity that currently go to waste would go to boost the rural electrification programme without need for increasing electricity generation capacity. New jobs would be created in energy-poor areas since cottage industries and enterprises would flourish. Environmental degradation that contributes to climate change would be mitigated as more symbiotic energy technologies are embraced.