CHAPTER 2

ENERGY MANAGEMENT

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1. Introduction

Chapter 1, titled ***"Energy Conservation"***, dealt with the meaning, purpose and means of energy conservation. The following 5 measures were stated for achieving energy conservation in an organization:

(a) Spread awareness and sensitize all energy users in the organization
(b) Stop wastage of energy in the organization
(c) Improve energy efficiency in the organization
(d) Carry out systematic energy management in the organization
(e) Generate renewable energy on-site, if feasible.

Details of all the measures, except the energy management mentioned at (d), were covered in Chapter 1. The present chapter (Chapter 2) is devoted mainly to ***energy management in an organization***.

It was stated in Chapter 1 that to assess the potential of energy conservation, the organization should begin with a technical ***energy audit*** of the organization. The energy audit will also serve the purpose of assessing the feasibility of ***generating renewable energy on-site*** for the measure listed at (e). Details of energy audit (meaning, types and the process) are also covered in the present chapter.

2. Meaning and Objectives of Energy Management

To give a simple definition, ***"energy management means monitoring and controlling energy consumption and generation (if present) in an organization".***

The primary objective of energy management is saving or conserving energy. But, generally it has many additional objectives. So, we can in general state the following objectives of energy management in an organization:

(a) Energy conservation: Conservation of energy is the basic objective of energy management in any organization.

(b) Environmental protection: In case on-site generation of electricity becomes necessary in order to meet the power demand of the organization, only renewable energy generation should be considered to ensure protection of the environment. Diesel generators must be avoided as they are the most polluting type of electricity generators.

(c) Resource conservation: The process of energy management should ensure that the various resources of the organization, including the energy distribution infrastructure, energy generation facilities (if present), equipment and machinery, human resources etc., are optimally utilized and none of them is wasted.

(d) Cost savings: Energy management should aim at achieving maximum savings in the overall cost of energy, but this should not adversely affect the productivity of the organization.

(e) Uninterrupted access to energy: The actual users of electricity in the organization should get electricity whenever they need it. This is necessary to ensure comfort of the users as well as their productivity.

3. Energy Management Process

The process of energy management ***involves broadly four types of activities:***

(a) Planning
(b) Action
(c) Monitoring
(d) Correction

The process is ***iterative*** and carried out in the following ***ten steps:***

(i) Measure or assess energy consumption and collect energy data
(ii) Find out and quantify opportunities of saving energy
(iii) Necessity and feasibility of on-site energy generation
(iv) Implement energy-saving opportunities
(v) Set-up energy generation (if required)
(vi) Control the loads
(vii) Control the on-site renewable energy generation (if present)
(viii) Control charging and discharging of storage batteries (if present)
(ix) Monitor the energy generation, consumption and savings on a regular basis
(x) Make corrections in the processes (iii) to (vi), as and if necessary.

It may be noted that:
Steps (i) to (iii) together constitute ***planning***.

Steps (iv) and (v) are ***one-time actions.***
Steps (vi) to (viii) are ***continuous actions.***
Step (ix) is the ***monitoring*** meant to check effectiveness of the actions taken.
Step (x) is meant to make necessary ***correction*** in the actions being taken, so as to improve the effectiveness of these actions.
After necessary corrections are made, steps (vi) to (x) will be continued on regular basis.

4. Energy Auditing

Energy auditing is an exercise undertaken prior to instituting any energy conservation program or energy management process in an organization. The exercise is carried out with all or some of the following ***objectives***:

(i) Measuring or assessing energy consumption and collecting energy data
(ii) Finding out and quantifying opportunities of saving energy
(iii) Assessing the necessity and feasibility of on-site energy generation.

There are ***two types of the energy audit:***
(a) Preliminary energy audit
(b) Detailed or comprehensive energy audit

These two types of energy audit are described in Sub-sections 4.1 and 4.2, respectively.

4.1 Preliminary Energy Audit

A preliminary energy audit is often undertaken before taking up a detailed or comprehensive audit for the simple reason that the former type can be completed in a short time, whereas the latter type takes quite a long time to complete.

The preliminary audit begins with a walk-through survey by an energy expert (called as ***energy auditor***) and relies on the readily available information/data pertaining to:

(a) Source or sources of energy used by the organization
(b) Internal power distribution system of the organization
(c) Nature of loads, and
(d) Energy consumption pattern over a year.

The energy auditor uses certain rules of thumb to ***indicate roughly*** the following:

(a) Extent of energy wastage occurring in the organization
(b) Extent of energy conservation feasible, both practically and economically.

A preliminary energy audit is ***not sufficient*** for finding out the ***exact opportunities*** of energy conservation or assessing the necessity and feasibility of on-site energy generation. In other words, preliminary energy audit can only partly serve the objective (ii) of energy audit and cannot serve the objective (iii).

4.2 Detailed or Comprehensive Energy Audit

A detailed or comprehensive energy audit aims to find out the ***exact opportunities*** of energy conservation and ***quantify*** such opportunities. It is also possible to assess the necessity and feasibility of on-site energy generation. This type of energy audit of course involves considerable amounts of money and time, but its outcome can save much more money every year and for many-many years to come. So, the exercise is highly beneficial to almost every organization.

The process of detailed or comprehensive energy audit is carried out in the following ***ten steps***:

(i) ***Conduct a walk-through survey:*** If a preliminary audit has been carried out by the same energy auditor, then this step is not needed.

(ii) ***Establish mandate of the audit:*** Means, spell out the expectations from the audit.

(iii) ***Establish scope of the audit:*** Means, spell out the areas of energy use to be covered in the audit. For example, whether the energy use in laboratories (in case of an educational institute) or in industrial machinery (in case of a factory) is to be considered or not.

(iv) ***Conduct a detailed survey and measurements:*** Prepare location-wise or space-wise tables of all electric loads, along with power rating or actual power consumption (to be measured) of each load. Assess hours/days/months of use of each load. Finally, prepare an inventory of energy usage in the organization.

(v) ***Calculate energy consumption*** for each load on the basis of the data collected in step (iv).

(vi) ***Analyse and profile the energy consumption:*** Such as space-wise energy consumption (i.e. consumption of all loads in each location/space), load-wise energy consumption (i.e. consumption of each type of load in the whole organization), facility-wise energy consumption, month-wise energy consumption, and so on.

(vii) ***Compare energy performances:*** Compare energy consumption during one period with that during another period, of one facility with that of another facility, and so on. Also, compare with best practices in other similar organizations.

(viii) ***Identify and quantify opportunities*** of:

  (a) Energy conservation, and

  (b) On-site renewable energy generation.

(ix) ***Calculate or assess the benefits:*** It includes the following:

  (a) Calculate the potential savings in energy and the cost of each energy-saving opportunity.

  (b) Prioritize these opportunities in the order of most cost-effective to least-effective ones.

(b) Spell out intangible benefits, like how much contribution will this exercise make to environmental protection and how it will boost the image of the organization in the society/country.

(x) ***Prepare audit report*** and submit to the management of the organization.

5. Energy Assessment

Energy audit of homes and residential buildings is often done less rigorously than that of the organizations. These energy audits are usually referred to as ***home energy assessment*** and ***building energy assessment,*** respectively.

6. Maximum or Peak Demand

So far, we were talking of energy, which is measured in kilo-watt-hours (kWh). A load is specified in terms of the power it draws from the power supply, and measured in watts (W) or kilo-watts (kW). When an electric load (for example, an electric heater) of 1 kW works for one hour, it consumes one kWh of electrical energy.

To understand the meaning of demand or power demand, let us assume that at a certain time a consumer is using power for 15 lamps of 20W each, two heaters of 1kW each and a water geyser of 3kW. The total power being used at a time, called as power demand, is calculated below:

Power demand = (15 × 20) W + (2 × 1) kW + 3 kW
= 0.3 kW + 2 kW + 3 kW
= 5.3 kW

The power demand of a consumer keeps changing with time depending on which loads are switched on at different times. It generally keeps fluctuating between some minimum value (which may be zero) and a maximum value (when all the loads are switched on simultaneously). The maximum or peak demand is defined as follows:

"The maximum value of the power demand of a consumer any time during a month is called as the maximum demand or peak demand during that month".

7. Electricity Tariffs

7.1 What is Electricity Tariff?

Electricity consumer has to pay for the electricity (that is, electrical energy) consumed by him against an ***electricity bill*** raised by the electricity or power supply company. The bill is generally raised on a monthly basis.

"***The rate schedule on the basis of which electricity bill is raised by the power supply company is called electricity tariff".***

Electricity tariff may be different for different consumers.

7.2 Why Different Tariffs?

The tariff is based on the costs of ***generation, transmission and distribution*** incurred by the power supply company, plus his overhead costs and profits. The tariff may, therefore, vary as under:

(a) Tariff varies with the source/type of generation, because the generation cost is different for different sources and types of power generation (thermal power, nuclear power, large hydro power, small hydro-power, photo-voltaic solar power, thermal solar power, wind power, or power generated from some other source).

(b) Tariff varies with the location of the consumer, because the cost of power transmission and distribution increases as the distance of the consumer from the power generation plant increases.

(c) ***Different tariffs are applied to small and bulk consumers,*** for the following reason: Bulk electricity consumers, like educational institutes, residential societies and industries, are supplied bulk amounts of electricity at 11kV or 33kV. To use this electricity, the bulk consumers have to install their own distribution transformers of 11kV/415V ratio or 33kV/415V ratio and distribution lines for 240V, single-phase and/or 415V, three-phase supply. On the other hand, small consumers are supplied electricity at 240V, single-phase or 415V, three-phase, which they can use directly.

7.3 Single-Part and Two-Part Tariffs

Small consumers of electricity are generally charged as per a simple or single-part tariff, whereas bulk consumers are charged on the basis of a two-part tariff for the reason explained above. These two types of tariff structures are explained below:

(a) Simple Tariff or Single-Part Tariff

The consumer is asked to pay simply on the basis of the number of energy units (in kWh or kilo-watt-hours) consumed by him over a month. The tariff, which has just one part, is stated as follows:

"Rs. A per kWh of energy consumption"

(b) Two-Part Tariffs

In this type of tariff, the total charge to be made from the consumer is split into two components or parts. First part of the charge is based on the number of energy units (in kWh or kilo-watt-hours) consumed by him over a month, while the second part is based on the maximum or peak demand of power (in kVA or kilo-volt-amperes), any time during the same month. The tariff, which has two parts, is stated as under:

"Rs. A per kWh of energy consumption + Rs. B per kVA of peak power demand"

Part 'A' is meant basically related to the operating cost of the generation plant, which is roughly proportional to the energy generated in kWh. Part 'B' takes care of the infrastructural cost of the complete generation, transmission and distribution system. The size and cost of generating plant and transmission and distribution lines are roughly proportional to the capacity of each of them stated in kVA (and not in kW).

7.4 Power Factor / kW-kVA Relationship

The product of volts and amperes is called as ***apparent power*** and is given in VA, which is always more than or equal to the ***active or real power*** in W. The ratio of real power to apparent power is called ***power factor (PF)*** of a load***,*** and its value is less than or equal to 1.0. Thus,

"Power factor of an electric load is defined as the ratio of the active or real power to the apparent power taken by it".

Similarly,

"Power factor of an electric generator is defined as the ratio of the active or real power to the apparent power delivered by it".

Power factor can also be expressed by the following simple mathematical relationship:

$$\text{Power factor} = \frac{\text{Active or real power in watts (W)}}{\text{Apparent power in volt-amperes (VA)}}$$

We can re-arrange this equation as under to show the relationship between kW and kVA:

$$\text{Real power in kW} = \text{Apparent power in kVA} \times \text{Power factor}$$

8. Management of Maximum Demand

As explained in Sections 7.2 and 7.3, bulk consumers (which include almost all large organizations) are charged for electricity on the basis of a two-part tariff. The second part or part 'B' of the charge is based on the maximum or peak demand (defined and explained in Section 6). Therefore, such an organization should manage (minimize) not only its energy consumption, but also its maximum demand. Following methods can be used to manage (reduce or minimize) the maximum demand:

Method#1: Stop wastage of energy and improve energy efficiency in the organization. Both the measures not only reduce the energy consumption (as explained in Chapter 1), but the maximum demand also to some extent.

Method#2: Major reduction in the peak demand can be achieved by spreading out the loads in time as much as possible. This means that major loads (like air conditioners and air conditioning plants during summer, or room heaters and water geysers during winter) should be used at different times, as far as possible.

Method#3: If some power is generated on-site, it will be able to meet the maximum demand of the consumer partly. Thus, the net maximum demand to be met by the supplier is reduced by an amount equal to the on-site power generation.

Generally, the management of maximum demand is considered an integral part of energy management process described earlier.

9. Energy Management Strategies

A long-term 'energy management strategy' or 'energy strategy' should be a part of the overall strategy of any organization. Following are the potential energy strategies that may be considered for adoption by an organization. Very often, organizations combine more than one of these basic strategies.

(i) Passive Strategy
(ii) Short-Time Profit Strategy
(iii) Long-Time Profit Strategy
(iv) Proactive Strategy
(v) Pro-Environment Strategy

The above energy management strategies are explained below in Sub-sections 9.1 to 9.5., respectively.

9.1 Passive Strategy

Passive energy management strategy means that the organization has a passive attitude toward conservation of energy and protection of environment. The issues of energy management and environmental protection are not perceived as important activities. The organization only deals with the most essential subjects, and energy management is not one of them.

9.2 Short-Time Profit Strategy

In this case, the management of the organization concentrates exclusively on those energy-saving measures which have a relatively short pay-back period or a quick return. For example, it may consider replacing old conventional lamps of low-efficiency with LED lamps of high efficiency, because the payback period is less than a year. Measures with long-term low profitability, like installing a renewable energy plant, are not considered.

9.3 Long-Time Profit Strategy

In this strategy, the management of the organization considers the long-term low-profitability measures, like installing a renewable energy plant, as well as those energy-saving measures which have a relatively short pay-back period, like replacing old conventional lamps of low efficiency with LED lamps of high efficiency. In other words, this strategy has the goal to implement all the energy-saving measures that have a positive return on investment.

9.4 Proactive Strategy

Proactive energy strategy is just opposite to the passive strategy. The management of the organization/company, in this case, has a proactive approach in considering and implementing all those measures which can lead to energy conservation or environment protection. Profitability is considered secondary in this regard. The management is fully aware of the latest energy saving technologies and products, and has a concern for the environment. It also values the other (intangible) benefits of a proactive energy policy, namely, enhancement of image of the organization and greater motivation of its employees.

9.5 Pro-Environment Strategy

This energy strategy is based on the principle of restoring and preserving the environment. It applies not only to energy management but to the issue of the energy on the whole. It includes energy saving measures, green energy generation, green buildings, energy-efficient products and resource-efficient production processes of the organization/company.