Energy Management Principles as applied for Energy Audit of Air-conditioning Systems

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Abstract- *The energy management is an important activity in all sectors of economy including domestic, agricultural, commercial and industrial sectors. It involves managing energy requirements in such a way that the least amount of energy is needed to complete a task while using the right quality of energy. There are certain common basic principles which are applied to ensure that these objectives are met. The author has tried to apply these principles for conducting the energy audit of air-conditioning systems to achieve the objectives of energy management.*

Keywords: Energy Audit, Air Conditioning systems, Energy Management.

I. Principles of Energy Management

The energy management involves the utilization of the minimum quantity of energy required for the task at an appropriate quality, neither better nor worse than needed. At the most elementary level, energy management may be thought of as **'task energy use' e.g. the provision of as much energy as is needed, when it is needed, where it is needed, and with the right quality.**

There are certain basic approaches or general principles which can be applied in a wide variety of applications.

Table 1 summarizes some general principles which experience has shown are applicable to a wide variety of situations.

Table 1: Fundamental Principles of Energy Management [1-2]

Sl. No	Principle
1	Review historical energy use (review of historical data and current practices)
2	Housekeeping and maintenance
3	Analysis of energy use (engineering analysis, computer simulation)
4	More efficient equipment
5	More efficient process
6	Energy containment (heat recovery and waste reduction)
7	Material substitution
8	Material and resources economy (scrap recovery, salvage and recycle)
9	Material quality selection (material purity and properties)
10	Aggregation of energy uses
11	Cascade of energy use
12	Renewable energy sources (energy from or fuel substitution)
13	Energy conversion
14	Energy storage
15	Economic evaluation (cost benefit, rate of return, life-cycle costing)

II. AIR-CONDITIONING SYSTEMS

Air-conditioning involves simultaneous control of Air purity and filtration, Air movement, Dry-bulb temperature and Relative humidity while ensuring low Noise and vibration, highest Energy efficiency, and Fire safety. There are different types of systems as shown in the Figure 1 to achieve the above performance.

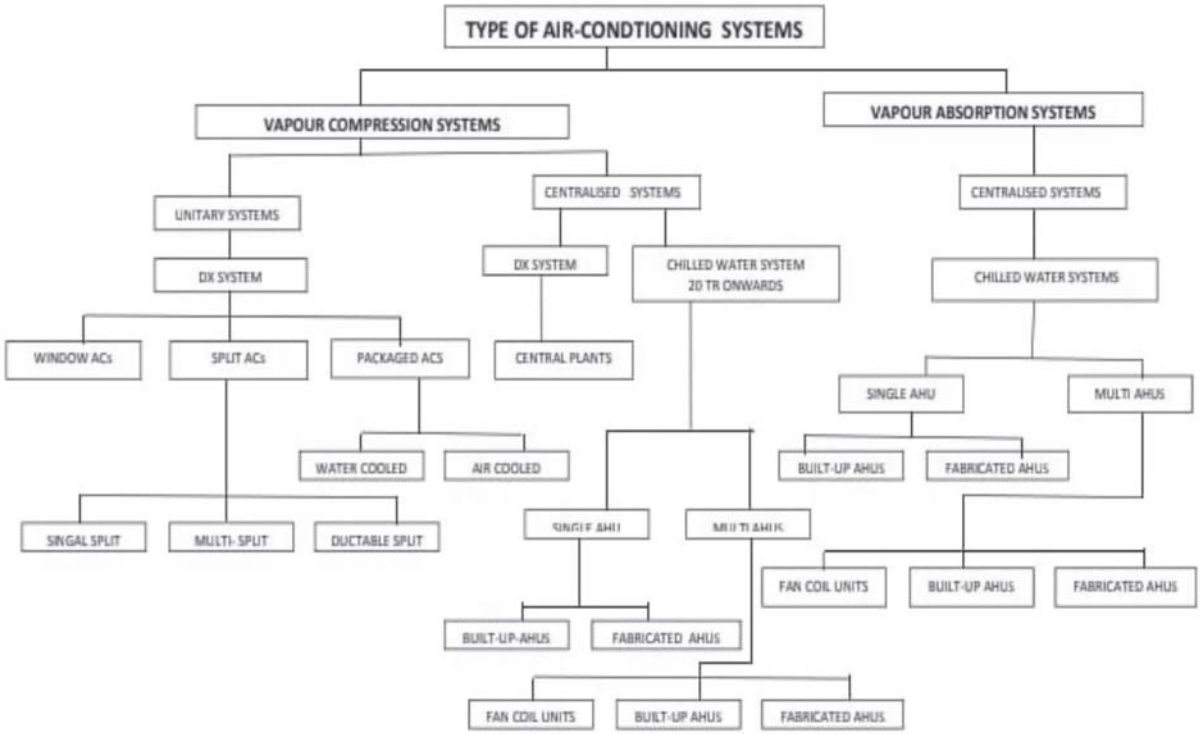

Fig. 1 Types of Air Conditioning Systems

III. APPLICATION OF ENERGY MANAGEMENT PRINCIPLES IN AIR-CONDITIONING SYSTEMS

(a) Review of Historical Use & Current Practices

The first principle is to review historical energy use.

Applying this principle, we could identify many energy saving measures while conducting the energy audit of Air-conditioning Systems. One example is given below:

CASE STUDY: *Air-conditioning system of a BSNL Telephone Exchange Building*

The building located at Bhopal had many systems of different types including Window ACs, Split ACs, Direct Expansion (DX) systems and a Chilled Water System purchased at different times. All were under use independent of each other catering to different office rooms, telephone exchange equipment, and different sections within the building premises.

We did the heat load calculations and found that the Chilled Water System had extra capacity as it was highly over-designed. The extra capacity was good enough for the part of the building which was provided with a DX system.

Thus, an energy saving idea emerged that the DX coil of the Air-Handling Unit (AHU) could be replaced with a Chilled Water Coil. After evaluating the parameters related to coil selection, it was concluded that there was no technical hitch. This way, we could discontinue the use of the DX plant. An overall saving achieved was more than 65,000 kWh per year and needed net capital investment.

(b) Improvement of Housekeeping and Maintenance

In many places, it is a common sight to find that the housekeeping and maintenance points being neglected or not attended well. The energy savings achievable through these measures can be 5-10 % of the total energy consumption of the AC system. For Air-conditioning systems, it involves regular cleaning of filters, coils, ducts, and functioning of controls.

(c) Analysis of Energy Use

Analysis of energy use is done to establish what happens if a parameter change (reduce flow by 50%), or to simulate operations (computer models of building or process energy use).

CASE STUDY: Analysis of energy use in *Walk-in coolers*

There was a small-scale dairy unit having a few Walk-in coolers provided to keep basic raw ingredients like 'Mawa' stored at certain temperature ranges. Once, the temperature reaches, the compressor was to trip however, the circulating fan inside the cooler meant for circulation of air was designed to continue running for uniform cooling of the stored products.

This was not only causing electricity consumption by the circulating fans but was also adding heat load inside. Thus, the compressor was getting-ON more frequently.

We did an analysis and came to the conclusion that considering the size of the cooler, the natural convection current would suffice. We then arranged to ensure that the fans also get switched off when the compressor trips and observed for few days. There was no adverse effect on the raw materials as the temperature was being still quite uniform. The cycle time increased and the total time for which the compressor was running reduced by 30%. Thus, the energy was saved without affecting the performance.

(d) More energy efficient equipment

Many types of industrial and residential/commercial equipment are now rated or labeled in terms of their efficiency. However, there are wide variations among different manufacturers depending on size, quality, capacity and initial cost.

Replacement of existing inefficient equipment like fans, pumps, lighting systems, ACs, Transformers etc. is very common. We need to do it judiciously after establishing the efficiency of the existing system correctly and considering the system as a whole and not the equipment in isolation. The overall system design should be energy efficient.

The standalone equipment or appliances like fans, ACs, Refrigerators, can be replaced with latest super energy efficient equipment /appliances. These incorporate not only the full load efficiency but also provide flexibility of part load efficient operations.

CASE STUDY: *Replacement of Standard Ceiling Fans with Super energy efficient ceiling fans*

i. Average power consumption by use at different speeds for existing fans= 60 Watts
ii. Average power consumption by use at different speeds for Super energy efficient fans as demonstrated for the same air quantity = 12 Watts
iii. Average hours of productive use per year = 300 days X 8 hours = 2400 hours
iv. Average hours of unproductive use (by housekeeping staff / unnecessary running or at high speeds) = 600hrs

It was proposed to replace existing fans which are used for more than 8 hours per day with Super energy efficient Fans. There were 100 such fans installed in various areas. The fans rarely used were not to be replaced. It is also proposed that the old fans may either be installed in places where these are rarely used or sold to employees to put them in places where these are used occasionally.

The super energy efficient fans consume only 5-7 W power at lowest speed and 28-35 W power at full speed as against conventional fans which consume 40-80W for the corresponding speeds and air flow. The power consumption at intermediate speeds is 9 W, 12 W and 18 W. The reduction in electricity bills is due to the use of Brushless Direct Current (BLDC) motor as well as timer and sleep mode. Investment made in purchase of Super energy efficient fans gives the buyer more than 50% returns and payback period of 2 to 3 years depending on tariff/hours of use etc. The remote provides convenience of use at different speeds while Timer and Sleep mode help in further energy savings and increased comfort as the fan automatically reduces the speed in sleep mode and stops as per pre-set timing.

Biggest energy savings are possible in Air-conditioning systems if the Super energy efficient fans are used in Air-conditioned premises by setting the thermostat at higher temperatures of 28-29 Degree C. All energy auditors must recommend this measure which is a very easily implementable low hanging fruit.

(e) More efficient processes

This idea of using more energy efficient process for Air-condoning systems include alternatives to refrigerant based cooling systems like Direct-Indirect Evaporative Cooling systems, Natural cooling systems, Hybrid systems etc. In many applications, especially for comfort cooling application systems, we can do that.

(f) Energy Containment

Energy containment seeks to confine energy, reduce losses and recover heat. For Air-conditioning applications, this principle is applied to minimize hot air ingress and cold air leakages, insulation of ducts, pipes, heat recovery etc.

(g) Material Substitution

For Air-conditioning systems, this principle is applied during manufacture of the equipment and selection of pipe/duct/insulation materials which has lowest embedded energy consumption during manufacture, installation and maintenance.

(h) Material & Resources Economy

For Air-conditioning Systems, the materials for pipes, ducts, supporting structures, cooling towers, etc. are selected in such a way that these have maximum reuse, and recyclable components with least waste and need for resources like water and land etc.

(i) Materials Quality

Materials quality selection is extremely important, since unnecessary quality almost always means higher cost and often means greater energy use. During the energy audit, this aspect may also be observed and included in the report.

(j) Aggregation of energy use

Aggregation of energy helps to save energy used for transportation of materials as well as to reduce losses.

This principle is actually applicable at the design stage; however, the energy auditor may apply it during the audit and include it in the report [3].

(k) Cascade of energy use

Proper time sequencing of operations can also reduce energy use, for example by using temperatures generated by one step of the process to provide preheating needed by another step.

This principle can be applied in Air-conditioning systems for use of waste heat from other processes, hot condense water return for reheating to maintain Relative Humidity instead of using electrical heaters.

(l) Renewable energy sources

For several applications such as low-grade heating or drying, solar thermal systems like Solar Water Heaters/ Solar Air dryers can be used for 300 days in a year. Biomass briquettes can be used for direct firing in Boilers.

Solar PV powered air-conditioners and Solar Thermal based Vapor based air-conditioning systems are the examples [4].

(m) Energy conversion

In some of the applications, the form of energy used can be changed to another form to save over all energy.

For Air-conditioning systems, this principle can be used to avoid use of high-quality energy like electricity with a lower quality energy or waste wherever possible.

(n) Energy storage

Thermal Energy Storage systems involve storing of thermal energy to meet peak demand.

The applications for air-conditioning systems include the production of ice, chilled water, or eutectic solution at night, or hot water which is then used to cool / heat environments during the day.

(o) Economic Evaluation

Economic evaluation helps in prioritizing the energy saving measures for the best overall energy efficiency gains.

IV. Conclusion

Implementation of the energy management principles can be done right from the selection of materials during manufacturing, equipment sizing and selection to system integration, operation and maintenance.

For new projects, the plant designers can incorporate these principles to ensure the most energy efficient designs for the life of the equipment and processes.

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