An Energy Saving System by Replacing Window & Split Air-Conditioning By Centralized Air-Conditioning

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Abstract – This paper concentrates on the energy management side of the implementation of energy saving measures in the Jabalpur hospital and research center. This paper consist of audit of a hospital in which various electrical and thermal utilities are considered such as transformer, lighting, air conditioning system, pumps etc. audit was conducted and various measurements and calculation was done on the basis of the data collected and performance assessment was done of the equipments installed in the hospital. In this paper the main concern on air conditioning system, the total load of window and split air conditioning system in tonnage is 159.5 kW and total cooling is 526.6 kW. In case we replace the window and split air conditioning system by centralized air conditioning system with considering 20% duct losses [2] then we gets annual saving in electricity is 2,99,592 kWh and their respective cost 15,27,326 /-Rs. are annually savings. In order to benefit from energy-saving measures there are a number of steps that should be taken to ensure maximum effect.

Keywords - Energy conservation, energy management, energy saving, loads, losses

I. INTRODUCTION

Air-conditioning System consists of a group of components or equipment connected in series to control the environmental parameters. An air-conditioning system, by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) definition is a system that must accomplish four objectives simultaneously. These objectives are to: control air temperature; control air humidity; control air circulation; and control air quality. The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used, commonly for comfort cooling in buildings and motor vehicles. In construction, a complete system of heating, ventilation and air conditioning is referred to as "HVAC". Air conditioning is needed in different sections and units for efficiently cool room air during Operating Room, Delivery Rooms, Treatment Rooms, Patient Care Rooms, Nurseries Intensive Care Units, Diagnostic and related areas, laboratories and Sterile Storage. Air conditionings used in hospital for efficiently remove from the air micro-organisms, dust, soot, and other foreign bodies.

II. TYPES OF AIR CONDITIONING SYSTEM

1. Window Air Conditioner - This system is technically called a "unitary" air conditioning system and consists of a self contained air conditioning unit that is placed in a window or through a hole in an exterior wall. Since adding holes in your homes outside walls are not a really good idea, these units are almost always placed in a window. The unitary system has all the refrigeration components on one compact box. It ejects heat out one end and blows cooled air out the other end.

2. Portable Air Conditioner - This system is another flavor of the unitary air conditioning system. The portable air conditioner consists of a mobile self contained air conditioning unit that is placed on the floor inside a room and discharges exhaust heat using a hose vent through an exterior wall. Portable air conditioning units are a bit noisier than other types of units and can typically cool rooms under 500 Sq.ft. These units are a solution to those stubborn hot rooms that may exist even with central air conditioning. Like the window air conditioner, the portable unitary system has all the refrigeration components on one compact box. It also ejects heat out one end and blow cooled air out the other end.

3. Split Air Conditioner - In a split-system, an outdoor metal cabinet contains the condenser and compressor, and an indoor cabinet contains the evaporator. In many split-system air conditioners, this indoor cabinet also contains a furnace or the indoor part of a heat pump. The air conditioner’s evaporator coil is installed in the cabinet or main supply duct of this furnace or heat pump. If your home already has a furnace but no air conditioner, a split-system is the most economical central air conditioner to install.

4. Central Air Conditioner - In a central air conditioner, the evaporator, condenser, and compressor are all located in one cabinet, which usually is placed on a roof or on a concrete slab next to the house’s foundation. This type of air conditioner also is used in small commercial buildings.
Air supply and return ducts come from indoors through the home’s exterior wall or roof to connect with the packaged air conditioner, which is usually located outdoors. Packaged air conditioners often include electric heating coils or a natural gas furnace. This combination of air conditioner and central heater eliminates the need for a separate furnace indoors.

III. OBJECTIVES OF ENERGY AUDIT

The energy audit provides the vital information base for overall energy conservation program covering essentially energy utilization analysis and evaluation of energy conservation measures. It aims at:

- Identifying the quality and cost of various energy inputs.
- Relating energy inputs and production output.
- Assessing present pattern of energy consumption in different cost centers of operations.
- Identifying potential areas of thermal and electrical energy economy.
- Highlights wastages in major areas.
- Fixing of energy saving potential targets for individual cost centers.

- Implementation of measures for energy conservation & realization of savings.
- The analysis of building and utility data, including study of the installed equipment and analysis of energy bills.
- The survey of the real operating conditions.
- The understanding of the building behavior and of the interactions with weather, occupancy and operating schedules.
- The selection and the evaluation of energy conservation measures.
- The estimation of energy saving potential.
- The identification of customer concerns and needs.

IV. ENERGY CONSERVATION MEASURE & METHODOLOGY

The energy management includes planning and operation of energy related production and consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environment management, production management, logistics and other established business functions. Table 1 shows that different load condition in Jabalpur Hospital.

### Table 1
Type of loads

<table>
<thead>
<tr>
<th>TYPE OF LOAD</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>31.67</td>
</tr>
<tr>
<td>AC load</td>
<td>184.03</td>
</tr>
<tr>
<td>Fan</td>
<td>20.135</td>
</tr>
<tr>
<td>Pumps</td>
<td>15.666</td>
</tr>
<tr>
<td>Sterilizer &amp; autoclaves</td>
<td>18</td>
</tr>
<tr>
<td>Medical equipments</td>
<td>116.49</td>
</tr>
<tr>
<td>Computing equipments</td>
<td>10.375</td>
</tr>
<tr>
<td>UPS &amp; Inverter</td>
<td>18</td>
</tr>
<tr>
<td>Miscellaneous load</td>
<td>7.255</td>
</tr>
<tr>
<td>Geyser (Hot Water)</td>
<td>20</td>
</tr>
<tr>
<td>Lifts</td>
<td>31.8</td>
</tr>
</tbody>
</table>
We are replacing the presently used window and split air conditioning system by centralized air conditioning system.

Sun is the major cause of generation of heat during the summer seasons and it is also the major source of heat generation inside the room. The rays of the sun enter the room via windows, walls and roof of the room, partitions etc. This is the major cause of heat production inside the room. This heat increases the temperature inside the room and we feel uncomfortable.

The total amount of heat generated inside the room due to sun depends largely on the direction or alignment of the room with respect to the sun. In the morning maximum amount of heat is absorbed from the walls and windows in the east direction. During noon the maximum amount of heat is absorbed by the walls and windows in the south direction and in late noon the maximum heat comes inside the room from walls and windows in the western direction.

Table 2 shows that the hospital is having total air conditioning load is 184.03 kW.

But we are working presently first four type of air conditioning system, removing the centralized air conditioning system. Table 3 shows that the total load of hospital by using window and split air conditioning system is 182.77 kW.

### Table 2: An inventory of the air conditioning load

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Ton</th>
<th>Type</th>
<th>Quantity</th>
<th>Total Tonnage</th>
<th>Cooling (watt)</th>
<th>Total Cooling (kW)</th>
<th>Power Input (Watts)</th>
<th>Total Power Input (kW)</th>
<th>Cost in Rupees</th>
<th>Total Cost in Rupees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1 T</td>
<td>Window AC</td>
<td>43</td>
<td>43</td>
<td>3457</td>
<td>148.6</td>
<td>1235</td>
<td>53.105</td>
<td>18,990</td>
<td>8,16,570</td>
</tr>
<tr>
<td>2.</td>
<td>1 T</td>
<td>Split AC</td>
<td>10</td>
<td>10</td>
<td>3350</td>
<td>33.5</td>
<td>1130</td>
<td>11.3</td>
<td>22,000</td>
<td>2,20,000</td>
</tr>
<tr>
<td>3.</td>
<td>1.5 T</td>
<td>Split AC</td>
<td>19</td>
<td>28.5</td>
<td>5200</td>
<td>98.8</td>
<td>1735</td>
<td>32.965</td>
<td>29,790</td>
<td>5,66,010</td>
</tr>
<tr>
<td>4.</td>
<td>2 T</td>
<td>Split AC</td>
<td>39</td>
<td>78</td>
<td>6300</td>
<td>245.7</td>
<td>2190</td>
<td>85.41</td>
<td>39,173</td>
<td>15,27,747</td>
</tr>
<tr>
<td>5.</td>
<td>2 T</td>
<td>Centralized AC</td>
<td>2</td>
<td>4</td>
<td>7000</td>
<td>14</td>
<td>627</td>
<td>1.252</td>
<td>70,915</td>
<td>1,41,830</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>163.5</td>
<td>-</td>
<td>540.6</td>
<td>-</td>
<td>184.03</td>
<td>-</td>
<td>32,72,157</td>
</tr>
</tbody>
</table>
Figure 3: Graph between Different Months & Bill Payable In Rupees

Figure 3 shows that the maximum load in the month of April’12, May’12, June’12. So, we can say that, this load is mainly generated by using the Air-conditioner System in this duration.

Table 3: An inventory of the air conditioning load without centralized air conditioning

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Ton</th>
<th>Type</th>
<th>Quantity</th>
<th>Total Tonnage</th>
<th>Cooling (watt)</th>
<th>Total Power Input (Watts)</th>
<th>Total Cooling (kW)</th>
<th>Power Input (Watts)</th>
<th>Total Power Input (kW)</th>
<th>Cost in Rupees</th>
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<td>43</td>
<td>3457</td>
<td>1235</td>
<td>148.6</td>
<td>53.105</td>
<td>18,990</td>
<td>8,16,570</td>
<td></td>
</tr>
<tr>
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<td>1 T</td>
<td>Split AC</td>
<td>10</td>
<td>10</td>
<td>3350</td>
<td>1130</td>
<td>33.5</td>
<td>11.3</td>
<td>22,000</td>
<td>2,20,000</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>1.5 T</td>
<td>Split AC</td>
<td>19</td>
<td>28.5</td>
<td>5200</td>
<td>1735</td>
<td>98.8</td>
<td>32.965</td>
<td>29,790</td>
<td>5,66,010</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>2 T</td>
<td>Split AC</td>
<td>39</td>
<td>78</td>
<td>6300</td>
<td>2190</td>
<td>245.7</td>
<td>85.41</td>
<td>39,173</td>
<td>15,27,747</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>-</td>
<td>-</td>
<td>159.5</td>
<td>-</td>
<td>526.6</td>
<td>-</td>
<td>182.77</td>
<td>-</td>
<td>31,30,357</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V. EQUIVALENT MONEY SAVING AND ANNUAL ENERGY SAVINGS

In centralized air conditioning system efficiency refers to the amount of energy converted into cool air compared to the amount of energy lost.

This is the most important factor in an air conditioner because it dictates long-term savings. Efficiency is expressed as Seasonal Energy Efficiency
Ratio, or SEER. The higher the rating, the more energy efficient the unit is. The higher the SEER, the less you’ll pay in utility costs to operate your air conditioner. In any centralized air conditioning system having SEER ratings range from 13 to 23. In my research work, the total load of window and split air conditioning system is 39%.

In case we maintain the cooling level as existing system and replace the window and split air conditioning system by centralized air conditioning system with considering 20% duct losses [2] then 29% power gets reduced to 10% annually savings.

Table 4: Difference between present air conditioning and installation of centralized AC

<table>
<thead>
<tr>
<th>Parameters</th>
<th>At present used window/ split air conditioning</th>
<th>For Installation of centralized air conditioning</th>
<th>For Installation of centralized AC with 20% duct losses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For 31 units</td>
<td>For 36 units</td>
</tr>
<tr>
<td>Total Tonnage</td>
<td>159.5</td>
<td>155 = (5*31)</td>
<td>180 = (5*36)</td>
</tr>
<tr>
<td>Total Cooling (kW)</td>
<td>526.6</td>
<td>542.5</td>
<td>630</td>
</tr>
<tr>
<td>Total Power Input (kW)</td>
<td>182.77</td>
<td>117.8</td>
<td>136.8</td>
</tr>
<tr>
<td>Total Cost in Rupees</td>
<td>31,30,327</td>
<td>57,76,985</td>
<td>67,08,780</td>
</tr>
</tbody>
</table>

A study has been done separately for presently used window and split air conditioning system and centralized air conditioning system. Table 5 shows that the total load of window and split air conditioning system in tonnage is 159.5 kW and total cooling is 526.6 kW. In case we replace the window and split air conditioning system by centralized air conditioning system (considering 20% duct losses) [2] then we gets annual saving in electricity is 2,99,592 kWh and their respective cost 15,27,326 /Rs. are annually savings. The payback period of centralized air conditioning system is 4.39 years. If we consider the salvage value of existing system, then we reduced the cost of centralized air conditioning system as well as their payback period is also reduced.

Table 5: Annual savings in Electricity

<table>
<thead>
<tr>
<th>Model (Ton)</th>
<th>180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of a centralized air conditioning for 36 units</td>
<td>67,08,780/-</td>
</tr>
<tr>
<td>Cost of window/ split air conditioning</td>
<td>31,30,327/-</td>
</tr>
<tr>
<td>Annual saving in electricity kWh</td>
<td>2,99,592</td>
</tr>
<tr>
<td>Rs.</td>
<td>15,27,326 /-</td>
</tr>
<tr>
<td>Pay back period</td>
<td>4.39 years</td>
</tr>
</tbody>
</table>
The various advantages by using centralized air conditioning system in place of window and split air conditioning system can be summarized as follows:

- **Indoor comfort during warm weather** - Central air conditioning helps keep your home cool and reduces humidity levels.
- **Cleaner air** - As your central air conditioning system draws air out of various rooms in the house through return air ducts, the air is pulled through an air filter, which removes airborne particles such as dust and lint. Sophisticated filters may remove microscopic pollutants, as well. The filtered air is then routed to air supply duct work that carries it back to rooms.
- **Quieter operation** - Because the compressor bearing unit is located outside the home, the indoor noise level from its operation is much lower than that of a free-standing air conditioning unit.

### VI. ENERGY SAVING APPROACHES

In each of the key end use areas, there are three basic approaches to save energy.

- **Switching off** – All energy consuming equipment should be switched off when not in use. This can be done manually by hospital staff or automatically with special devices.
- **Maintancence** – A number of energy efficiency measures can be carried out as part of routine maintenance procedures at no extra cost.
- **Refurbishment** – Energy saving measures can be extremely cost effective when planning for refurbishment in the hospital.

### VII. CALCULATION

**Energy Cost of presently used window and split air conditioning system** –

- Suppose 6 hours air conditioning system used for 182.77 kW. Then Energy consumed for 6 h = 182.77 x 6 = 1097 kWh
- Assuming usage of air conditioning for 365 days/year. Then Energy consumed for 6 h Daily = 1097 x 365 = 4,00,405 kWh/year
- Calculate at tariff rate of Rupees 5.10/kWh. Then Energy cost = 4,00,405 x 5.10 = Rs. 20,42,065.5 /-

**Energy cost for 1 month = Total Energy Cost / Total Months**

\[
= \frac{20,42,065.5}{12} = Rs. 1,70,172.125 /-
\]

**Replace Window and Split air conditioning system by Centralized Air Conditioning System**

- Suppose 6 hours air conditioning used for 136.8 kW. Then Energy consumed for 6 h = 136.8 x 6 = 820.8 kWh
- Assuming usage of air conditioning for 365 days/year. Then Energy consumed for 6 h Daily = 820.8 x 365 = 2,99,592 kWh/year
- Calculate at tariff rate of Rupees 5.10/kWh. Then Energy cost = 2,99,592 x 5.10 = Rs. 15,27,919 /

- **Energy cost for 1 month = (Total energy cost) / (Total months)**

\[
= \frac{15,27,919}{12} = Rs. 1,27,326 /-
\]

- **Pay back period = (Investment) / (money saving)**

\[
= \frac{67,08,780}{15,27,919} = 4.39 \text{ years}
\]

### VIII. CONCLUSIONS

To implement energy-efficiency measures cost-effectively, they are best installed in new or retrofitted buildings, or when replacing old equipments. It is generally cheaper to introduce additional energy-saving measures when retrofitting work is already being carried out on a building than at other times when the hospital is operating normally. If an installation or item of equipment has to be replaced anyway, it is only the extra cost (the over-cost compared to a conventional system) which needs to be taken into consideration when calculating the payback period for a new, more energy-efficient installation. By using centralized air conditioning system with 20% duct losses considered [2] then we gets annual saving in electricity is 2,99,592 kWh and their respective cost 15,27,326 /-Rs. are annually savings. The payback period of centralized air conditioning system is 4.39 years. If we consider the salvage value of existing air conditioning system, then we reduced the cost of centralized air conditioning system as well as their payback period is also reduced.
REFERENCES

[1] Audit of an air conditioning system André Philippe, Hannay Cleide, Hannay Jules, Lebrun Jean University of Liège, Belgium


[7] A. Bhatia, Centralized Vs Decentralized Air Conditioning Systems


[9] HVAC Calculations and Duct Sizing by Gary D. Beckfeld, P.E.

[10] Joshua Energy Audit Analysis of Residential Air-Conditioning Systems in Austin, Texas by Rhodes, Brent Stephens, Michael E. Webber, PhD


[12] HVAC Design Manual for New, Replacement, Addition, and Renovation of Existing VA Facilities, Department of Veterans Affairs


[19] Analysis of energy use for Ontario Hospital, Fin project 13March 2009


[22] Bureau of Energy Efficiency, Govt. of India, www.beeindia.nic.in
