# Energy Management and Cost Saving Opportunities for the Pharmaceutical Company

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**ABSTRACT-**
Our lives depend heavily on energy since it gives us comfort, boosts our productivity, and lets us live the way we want. Since the dawn of time, humans have heated their homes and powered their devices with wood, water and fossil fuels. We use one type of energy or another for almost all of our actions.One of the leading healthcare corporations in the world manufactures a variety of vaccination products. As of right now, only their manufacturing and production site has examined the measurement, evaluation, and conservation of utilities along the production process. The heating, ventilation, and air conditioning (HVAC) systems are responsible for the majority of the energy utilized on – site. The Cleanliness Zoning Policy for the manufactures of sterile drug products and the respective (sterile) drug substances stringent standards are too responsible for this production areas are controlled for Temperature, Relative humidity and differential pressure to comply Good Manufacturing practices. To maintain environmental conditions (RH) hot water is used in air handling units. Hot water generated by steam generation from boiler is consuming high energy and fuel consumption is increasing and Chillers are used to meet chilled water requirement of the plantfor meeting the process requirements and controlling the %RH of air in AHU. It is also increasing $CO_2$ emission which causing global carbon footprint warming. Particularly in light of the current state of the world economy and the growing demand for factories to operate in a more ecologically responsible manner, reducing energy usage is essential to keeping the business competitive.The goal of energy management is to achieve and maintain optimal energy acquisition and the secret to a systematic strategy for accountability in the field of energy management is an energy audit.  Reducing the quantity of energy andeasy-to-use energy model developed they would consider lighting, pumps, chillers, and HVAC Systems.

**Index Terms**- Energy Management, Cost Benefit Analysis, Boiler, Chiller, Heat Pump and Motor.
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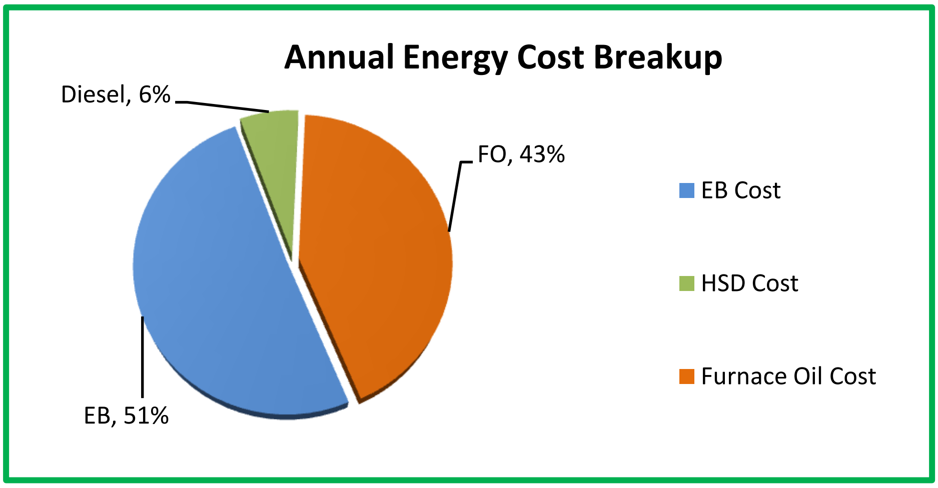
## INTRODCTION

While nothing is flawless, perfection is attainable with consistent efforts. This is what an energy audit accomplishes. It is described as the verification, monitoring, and analysis of energy use, as well as the production of the technical report with recommendations for increasing energy efficiency, together with a cost benefit analysis and an action plan to cut back on energy use. In order to limit the quantity of energy input into a system without adversely affecting output, energy flow is inspected, surveyed, and analysed.

Because Pharmaceutical business must maintain a clean atmosphere to prevent contamination of the items they are creating, the HVAC systems account for the majority of the energy utilized in these facilities. Regardless of whether the clean rooms ate actively being used or not, the systems are functioning nonstop day and night. When these clean rooms aren't in use, which is typically at night and on weekends, we want to limit the amount of air changes that occur in them. The number of air changes can be decreased while the system is not in use because there is a considerably lower chance of contaminants being introduced into the environment when there are no people present in the clean room. Due to pressure differences between the various rooms, the HVAC systems cannot be entirely shut down, but we want to look at drastically lowering the amount of air changes. When there are workers at the facility, the lighting systems are required. A few options include turning off the lights after the last person leaves the room, trying to install motion sensors that turn the system on when motion is detected, installing fully automated timers throughout an entire facility, swapping out the current bulbs for more energy efficient ones, or combining any of the aforementioned options.

Some facility uses energy an examination of potential alternatives to lower expenses is conducted. The utilities team must work together to gather information on energy costs and usage, and senior management must support this effort by providing the resources required to put the most cost-effective solutions into practise. Reducing energy usage without sacrificing productivity, quality, or user comfort is relevant and significant in this day as manufacturing facilities seek for leaner and more environmentally friendly operations. As a result, an energy audit should be carried out on regular basis and be taken into account as part of the business's efforts to drive operational improvement, which is consistent with six – sigma management approach that many organizations have adopted today. When doing this audit, the three processes are to first review the energy billing and visit the facilities, then generate a complete breakdown of energy use on the entire site, and an analysis of the changes that can be made to reduce energy and utility usage, hence lowering the overall cost of the manufacturing process. The analysis and identification of more efficient energy use methods should come next. Examples include enhancing operational procedures and spending money on new, energy efficient machinery and technology. Finally, and economic analysis of those potential solutions need to be done. The energy saving tactics that are worthwhile continuing ate identified after totaling all investment costs and projecting returns. The major goals of an audit are resource protection, climate protection, and ensuring that users have constant access to the energy they require.

A pharmaceutical production facility's floor is divided into three categories: white, grey, and black. The production processes and direct material handling, such as chemical reactions, separation, crystallization, purification, and drying, are carried out in the white area (also known as the white sanitary zone). Potential open product exposure exits (meaning the products are not packaged and thus open to contamination) in the white area. The non-production part of building is known as the "black area" or "black hygiene zone". Electrical rooms, mechanical rooms, and BMS control rooms are a few examples. The transitional or balancing area between the white and the black, such as goods lift and the gowning room, is known as the grey area (or the grey hygiene zone). On site energy conservation efforts have primarily concentrated on improving the efficiency of utility equipment like chillers and boiler. The electrical bill, FO consumption by boiler, and DG energy generation information provided by the plant are used to analyses the breakdown of energy consumption.




- Annual electrical energy cost for electricity from EB is 51% of the total energy cost of the plant.
- FO play a major in the total energy cost of the plant. FO takes 43% in the total energy cost of the plant. This makes furnace very significant when compared to electrical energy.

# I. LITERATURE REVIEW

The key factor in reducing carbon emissions is energy management, which directly affects the quantity of fuel needed to generate power. The actual status of energy management in Lebanon was made possible. Despite the significant potential for energy saving in all consuming factors, it has been determined that energy management in Lebanon remains rather small. Quickly implemented a capable energy management plan.

Several challenges must be solved if increasing an industrial process system's energy efficiency by integrating energy-saving technologiesproves to be an effective strategy: The best technological insertion must be evaluated globally, taking into account any potential synergy or mutual exclusion of the many technologies to be inserted at a specific industrial production site. R&D efforts to produce new, intensified energy-saving technologies have increased the number of technologies available on the market. Size standardization of the technologies on the market has increased the challenge of choosing the best technological insertion.

The key obstacle impeding the development and application of carbon capture and storage (CCS) is the high energy consumption of $CO_2$ separation. CCS plays a significant role in combating global warming. This research aims to determine the possible energy savings of various $CO_2$ separation technical techniques at the level of thermodynamic principles. Through study of energy consumption and energy destruction distributions and further disclosure using the Energy Utilization Diagram (EUD) approach, the energy-saving mechanisms of these two technical methods are examined. The findings show that for emission sources with various $CO_2$ concentrations, the relative impact of absorbent innovation and process upgrade will fluctuate.

# II. COST BENEFIT ANALYSIS FOR OVERALL EQUIPMENTS

### Use Energy Efficient Water-Cooled Chillers to Replace the Existing Water-Cooled Chillers:

***Background:***
Chillers are installed in the facility to meet the chilled water requirement of the plant. There are four water cooled chillers. For meeting the process requirements and controlling the %RH of air in AHU, hot water is also generated in the plant.

***Findings:***
The SEC of the chillers are very high (above design SEC). This situation leads to high chilled water energy cost. Currently, cooling towers are used to reject heat from the chiller into the atmosphere.

***Recommendation:***
A Boiler and multiple hot water generation systems are used for generating the hot water required in the facility. Hot water generator supplies hot water with temperature ranging between 50-55$^0$C. This means there is simultaneous requirement of chilled water and hot water in the plant.
These chillers have the ability to run in heat recovery mode when hot water and chilled water are required at the same time. Reusing the recovered heat for diverse heating requirements reduces energy consumption while maintaining design parameters.

### Install heat pump to recover the heat available in the water-cooled chiller:

***Background:***
Chillers are installed in the facility to meet the chilled water requirement of the plant. There are four water cooled chillers. For meeting the process requirements and controlling the %RH of air in AHU, hot water is also generated in the plant.

***Findings:***
There are four hot water generators in the plant to supply hot water to the AHUs. Hot water is generated with the help of steam generated by the boiler

***Recommendation:***
To reduce the cost of hot water generation the heat available in the chillers can be utilized to generated hot water. The plant's chilled water and hot water systems can use this energy to operate more efficiently.
Install heat pump in the chiller system to recover the waste and use it for generating hot water. Heat pump can be installed in the chilled water return side. This will help to take the available heat in the return chilled water and generate hot water. The reject water of the heat pump (at a lower temperature, approx. 10$^0$C) will reduce the work which the compressor needs to do. Since we get chilled water at a lower temperature at the inlet of

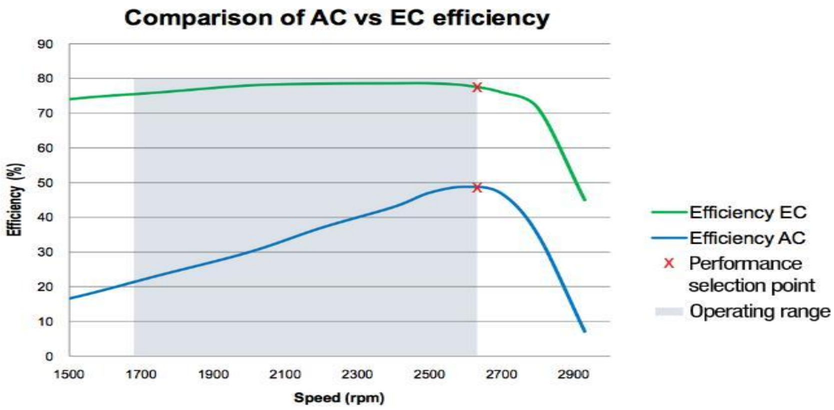
evaporator the energy consumption of the chiller will reduce. Thus, installing a heat pump will give additional of generating chilled water at a lower temperature. Moreover, the heat load of the cooling tower will also come down after providing automatic feedback for the cooling tower fan. This will reduce the cooling tower energy consumption.

**Replace existing ahu fans with energy efficient fans:**

***Background:***
AHUs are among the major energy consumers in the facility. Majority of the AHU fans used are belt driven systems which are less efficient in operation.
***Findings:***
The operating efficiency of the existing fans are at the lower side. Ordinary AC fan consumed more power compared to BLDC fans which can operate with much lower power consumption.

***Recommendation:***
Replace the existing AHU fans with energy efficient EC fans.Any sensor that can offer a 0-10V/PWM or 4-20mA input can be directly linked to a motor, depending on the motor type, to enable closed loop control for temperature, pressure, or any other parameter we choose to measure.
Compared to traditional AC fans, an EC fan produces the same amount of output with substantially less energy. A certain position on the performance curve that corresponds with the peak efficiency is where AC motors are intended to operate. Efficiency may decline sharply on either side of this operating point. As opposed to AC motors, which are constrained by synchronous speeds and more sensitive to voltage variations, EC motors have a nearly flat efficiency curve that varies relatively little over the speed range.



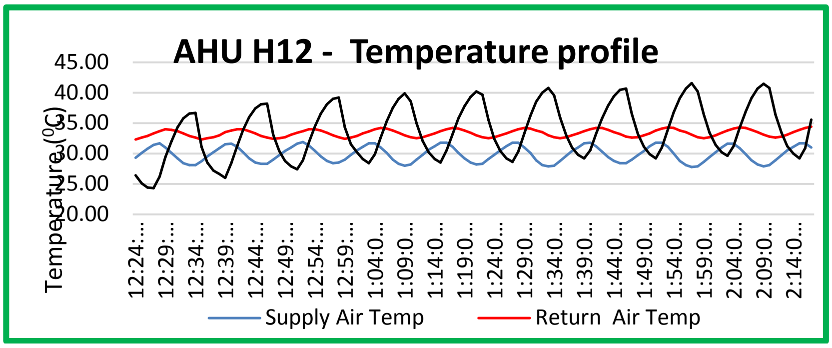



The advantages of EC fans over conventional belt driven systems are given below.

- Energy efficient- Gives minimum25% energy savings and used BLDC motors.
- Speed control without installing external VFD.
- Reduction in noise levels.

**Costbenefit analysis for avoiding excess heating ahu's:**

***Background:***
AHUs are among the major energy consumers in the facility. Majority of the AHU fans used are belt driven systems which are less efficient in operation.
***Findings:***
The temperature and humidity requirement are met presently by controlling the chilled water and hot water supply manually. The temperature requirement is 24±2$^{0}$C and relative humidity should be maintained less than 60%. The room temperature and relative humidity is continuously monitored and the chilled water supply and hot water supply to individual AHUs ae controlled manually.






***Recommendation:***
Rectify and optimize temperature and humidity control in AHU.

**Steam and hot water generation system:**

***Background:***
Boiler is used in the facility to generate hot water required for HVAC and Process applications. Presently about 70-80% is the condensate water recovery and 30-20% is the makeup water usage. The FO is heated from 30-600C in the storage tank with the help of steam. Before firing FO is heated to 1200C again with the help of steam.

***Findings***
The flue gas temperature is 253oC. Presently the flue gas is not utilized to heat FO or feed water. The heat energy available in the flu gas is sent to atmosphere without effective utilization.

- For FO heating, 0.5 TPD of steam is consumed in a day. Since steam is very costly, the heat energy available in the flue gas can be utilized to preheat FO.
- The makeup water is supplied at room temperature to the boiler along the condensate. Finally, the feed water temperature is coming around 800C. The feed water at 800C can also be heated with the heat available in flue gas.

***Recommendation:***
Preheat FO and Feed Water with the heat energy available in the flue gas. This will help to reduce the steam consumption and finally the energy cost for FO consumption will be reduced.

**Provide insulation for steam lines to avoid heat loss:**

***Background:***
Steam is used in the plant to generate hot water required for the AHUs and to meet the process requirements

***Findings:***
Steam lines with damaged insulation was found for lines near the cooling towers at the roof top. The temperature of the steam line was nearly 1700, which leads to heat loss.

***Recommendation:***
Provide insulation for the damaged steam lines to reduce the heat loss.

**Electrical supply and network:**

***Background:***
The electricity bill for the 12 months (from July 2021 to June2022) was analysed and the details are tabulated as given below

Table-10: Electrical bill analysis.

| Month | Contractor Demand | Recorder Demand | Apparent Energy Consumption | Bill Amount |
|---|---|---|---|---|
| | KVA | KVA | KVAH | Lakhs |
| Jul-21 | 3300 | 3012 | 1678640 | 116 |
| Aug-21 | 3300 | 2946 | 1779880 | 122 |
| Sep-21 | 3300 | 3033 | 1839850 | 126 |
| Oct-21 | 3300 | 3303 | 1834250 | 127 |
| Nov-21 | 3300 | 2997 | 1750790 | 120 |
| Dec-21 | 3300 | 2616 | 1540010 | 106 |
| Jan-22 | 3300 | 2712 | 1568160 | 108 |
| Feb-22 | 3300 | 2805 | 1599450 | 110 |
| Mar-22 | 3300 | 2928 | 1717187 | 119 |
| Apr-22 | 3300 | 3057 | 1627700 | 99.3 |

| Month | Contractor Demand | Recorder Demand | Apparent Energy Consumption | Bill Amount |
|---|---|---|---|---|
| | KVA | KVA | KVAH | Lakhs |
| May-22 | 3300 | 3228 | 1842850 | 127 |
| Jun-22 | 3300 | 3345 | 1948810 | 134 |
| Average | 3300 | 2998.5 | 1727298 | 117.9 |
| Total | 39600 | 35982 | 20727577 | 1414.3 |
| Maximum | 3300 | 3345 | 1948810 | 134 |
| Minimum | 3300 | 2616 | 1540010 | 99.3 |



***Findings:***

- The contract demand of the facility is 3300kVA. The maximum and minimum demand recorded during the period of twelve months from July 21 - to May - 22 is 3345kVA in Jun-22, it is more than contract demand value & 2616kVA in Dec-2021.
- The average demand charges spent per month us Rs.117.9 Lakhs.
- Energy consumption was maximum during June-22, 1948.8 MWh and minimum during Dec-21, 1540MWh.

**Motor loading:**

***Background:***

Motors are designed to operate with maximum efficiency at full load. At part load, the motor efficiency and power factor come down. Some of the motors, input supply voltage is less than design voltage. This will affect characteristics of the motor.

$$\% \, Loading = \frac{Inputpowerdrawnbythemotor(kW)atexistingload * 100}{(NameplatefullloadkWrating/ Nameplatefullloadmotorefficiency\%)}$$

During our Energy Audit study, power measurement was carried out for motors using power analyzer.

***Findings & Recommendations:***

- Overall loading of motors is satisfactory, except for few motors.
- Cooling Tower Fan 6&9, Hot Water System (supplied to Suite-A, B&C) and AHU-6F have light loads lesser than 20%.
- Primary Pumps 2&4, Condenser Water Pump-4 and AHU-H15 are loaded way above 90%, but not critical

## III. CONCLUSIONS

Enhancing energy efficiency is a significant strategy to lower these expenses and boost predictable profits, particularly during periods of high energy price volatility. Numerous energy-efficient technologies and methods that can be used at the component, process, system, and organizational levels have been found by this energy audit. Based on case study data from actual industrial applications, expected reductions in energy and energy-related expenses have been offered for several energy efficiency methods. When available, references to additional material in the technical literature and typical payback times have also been included in Table.

It is commonly acknowledged that if humanity is to lessen its dependency on fossil fuels, it is imperative that efficient energy efficiency laws and programs be developed and implemented. Although there has been significant improvement in recent decades, much more needs to be done. A variety of courses to introduce energy saving principles to industrial automation and control specialists, as well as the potential to use their expertise in automation and control to create active energy management systems. This learning path starts with the fundamentals of energy efficiency, gives the professional knowledge of specific automation and control applications where active energy management solutions have been demonstrated to have a significant financial impact, and explains how to assess the financial impact of an energy management solution and the potential for savings in an industrial environment.

By using the proposed system, the present system will give us an energy efficient and cost effective.
Brief about the project outcomes and achieved outcomes are, saving of 303.86 Lacs and Energy Saving of 30,30,723 kWh /4,21,640 liters.



| S. No | Energy Conservation Measures | Annual Savings | | Investment | Simple Payback Period |
|---|---|---|---|---|---|
| | | kWh/Liters | Rs. Lakhs | Rs. Lakhs | Months |
| **0-6 Months Payback** | | | | | |
| 1 | **Optimize heating and dehumidification in AHU**<br>The supply air temperature is crossing the return sir temperature for AHU H-12. Rectify and optimize temperature and humidity control in AHU. | 19,914 | 6.77 | 3.0 | 5 |
| **6-12 Months Payback** | | | | | |
| 1 | **Reduce excess air in boiler**<br>Reduce the excess air in boiler. | 3,532 | 1.20 | 1.0 | 10 |
| 2 | **Replace the primary chilled water pumps**<br>Replace the existing pump with energy efficient pump which can operate in the existing condition. The proposed water pump can give 81% operating efficiency under the existing operating conditions. | 1,33,488 | 9.08 | 7.50 | 10 |
| 3 | **Replace the secondary chilled water pump supplying to D, E&F and provide pressure feedback system**<br>Replace the existing pump with energy efficient pump which can operate in the existing condition. The proposed water pump can give 76.5% operating efficiency under the existing operating conditions. Give pressure feedback system to the existing VFD. This will help the pumps operated based on the system conditions more effectively. | 1,78,430 | 12.13 | 11.70 | 12 |
| **12-24 Months Payback** | | | | | |

| S. No | Energy Conservation Measures | Annual Savings | | Investment | Simple Payback Period |
|---|---|---|---|---|---|
| | | kWh/Liters | Rs. Lakhs | Rs. Lakhs | Months |
| 4 | **Replace the existing water-cooled chillers energy efficient water-cooled chillers**<br>Replace the water-cooled chillers with energy efficient heat recovery chillers which can meet simultaneous chilled water hot water requirements. | 20,43,105 | 138.90 | 150.00 | 13 |
| 5 | **Preheat FO and Feed Water with heat available in Flue Gas of Boiler**<br>The flue gas temperature is 253$^{o}$C. Presently the flue gas is not utilized to heat FO or feed water. The heat energy available in the flu gas is sent to atmosphere without effective utilization. Preheat FO and Feed Water with the heat energy available in the flue gas. This will help to reduce the steam consumption and finally the energy cost for FO consumption will be reduced. | 1,08,187 | 36.80 | 40.00 | 13 |
| 6 | **Provide insulation for steam lines to avoid heat loss**<br>Provide insulation for the damaged steam lines to reduce the heat loss. | 262 | 0.08 | 0.1 | 14 |
| 7 | **Replace the secondary chilled water pump supplying to R&D and provide pressure feedback system**<br>Replace the existing pump with energy efficient pump which can operate in the existing condition. The proposed water pump can give 77% operating efficiency under the existing operating conditions. Give pressure feedback system to the existing VFD. This will help the pumps operated based on the system conditions more effectively. | 54,451 | 3.70 | 4.30 | 14 |
| | **24-36 Months Payback** | | | | |
| 8 | **Install Heat Pump to recover the heat available in the water-cooled chiller**<br>Install heat pump in the chiller system to recover the waste and use it for generating | 2,89,745 | 53.00 | 128.00 | 29 |

| S. No | Energy Conservation Measures | Annual Savings | | Investment | Simple Payback Period |
|---|---|---|---|---|---|
| | | kWh/Liters | Rs. Lakhs | Rs. Lakhs | Months |
| | hot water. A heat pump will generate water at 50-57°C based on the requirement and it reduces the SEC of the chiller by providing chilled water at a lower temperature to the evaporator. Provide feedback system for the C.T fans to operated based on the basin temperature. C.T basin temperature can be 29°C for better chiller performance. | | | | |
| **>36 Months Payback** | | | | | |
| 9 | **Replace existing AHU fans with energy efficient EC fans**<br>Replace the existing AHU fans with energy efficient EC fans. Any sensor that can offer a 0-10V/PWM or 4-20mA input can be directly linked to a motor, depending on the motor type, to enable closed loop control for temperature, pressure, or any other parameter we choose to measure. | 6,21,249 | 42.20 | 150.00 | 43 |
| Total | | 30,30,723 kWh / 4,21,640 Liters | 303.86 | 495.60 | 20 |

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