SCOPE OF DESIRED INVESTMENT GRADE THERMAL ENERGY AUDIT

Objective: To carryout Investment Grade Thermal Energy Audit of the Facility and other industrial operations, so that various Options for Energy Saving measures can be straight away implemented on Performance – Contracting basis. As such, in addition to Energy Audit, "Base Line" for Energy Consumption as well as "Protocol for Measuring and Verification" must be worked out so that after the necessary implementation, actual quantum of Energy Saved can be quantified in very well acceptable level by the Client. (Any audit area as mentioned above is termed as "facility")

1. **Energy Audit Scope**
    - **a.** Energy Audit activities, in general will include:
        i. The activity starts at the utility meters, locating all energy sources coming into a facility.
        ii. Identification of energy streams for each fuel as well as electricity including own electricity generation facility.
        iii. Quantification of energy streams into discrete functions (Systems / equipments / appliances etc.)
        iv. Evaluation of the efficiency of each of those functions (Systems / equipments / appliances etc.)
        v. Identification of Energy and cost savings opportunities and analyze the impact of improvements.
    - **b.** Preparation of 'Energy Audit Report' that documents the use and occupancy of the facility and facility systems equipment.
    - **c.** The report also recommends ways to improve and implement on performance contracting basis the efficiency improvements in operation / maintenance/ housekeeping measures, and through installation of Energy Conservation Measures (ECM).

2. **Facility Details**
    - **a.** To develop the key details of facility with specific reference
        i. Facility structural details
        ii. Use & Occupancy of the facility
        iii. Energy supply features

iv. Details of Systems / Equipments /Appliances etc.

b. Methodology adopted for the Facility Energy Audit

c. The 'Energy Audit Structure' for developing energy efficiency projects to be implemented under performance contracting is given below. The facility energy system data collection and analysis can be conducted in modular way.

i. Facility Energy bills analysis

ii. Thermal Audits

1. Compressed Air System
2. Cooling Tower System
3. Air Conditioning and Refrigeration System
4. Steam Generation (Boilers)
5. Steam Distribution
6. Furnaces
7. Thermic Fluid Heaters
8. Insulation Study
9. Hot Water/Oil Systems
10. Drying Operations

iii. Process and Other Energy Consuming Equipments

3. Facility Energy Bills Analysis

a. Objective:

i. Tariff audit to estimate the impact of savings as well opportunities for fuel saving during the particular time frame as well as contribution of energy cost to the products.

ii. **Base line for Energy Consumption**: - Energy Consumption trends for developing baseline for gross metering (whole facility) for implementing multifaceted energy efficiency projects in a facility.

b. Methodology / Data Collection:

i. Energy bills (Liter, kg, lb, Rs/kg, MT, KL etc) on monthly basis for last 3 years.

ii. Peak load on daily basis for last 1-2 years.

iii. Weather Bins: dry bulb and wet bulb temperature for last 3 years

iv. Occupancy data: attendance and visitors record on monthly basis for last 5 years.

v. Energy system maintenance expenses on monthly basis for last 3 years.

c. Analysis

i. Identification of variables affecting energy consumption
ii. Regression analysis of energy consumption and development of correlations with identified variables.
iii. Databank management for regular energy bill analysis.
iv. Savings are determined by measuring energy use at the whole facility level. Short term or continuous measurements shall be taken throughout the post-retrofit period. If felt necessary, Energy Meters can be provided on certain Load Centers also.

4. Compressed Air Systems

a. Objective:

i. Estimation of specific energy consumption
ii. Quantification of compressed air leakages

b. Methodology/Data Collection:

i. Assessment of free air delivery
ii. Distribution network details for pressure drop analysis.
iii. Compressor Loading Pattern and capacity control mechanism
iv. End-use application study
v. Maintenance expenses on monthly basis for last 3 years

c. Analysis

i. Air compressor volumetric efficiency evaluation
ii. Elimination of poor application of compressed air.
iii. Optimization of operating pressure.

5. Cooling Towers

a. Objective:

i. Exploring suitable measures to improve approach and reduce power as well as water consumption.

b. Methodology/Data Collection:

i. Measurement of Cooling Water Flow
ii. Cooling Water - Inlet & Outlet temperatures
iii. Dry bulb and Wet bulb temperatures at Cooling tower inlet and outlet.
iv. Measurement of electrical energy for all cooling tower drives

v. Measurements of cooling water blow down and make up rates.
vi. Estimation of quality (TDS level) of cooling water.
vii. Maintenance expenses on monthly basis for last 3 years
viii. Disinfection process for cooling water

c. Analysis

i. Cooling tower effectiveness.
ii. Estimation of evaporation and drift losses.
iii. Suitable measures to improve effectiveness of cooling tower
iv. Identification of disinfection as per new technology which eliminates microbiological & scaling problems and improves heat transfer.

6. Air conditioning system (Refrigeration):

a. Localized System: Window/Split AC's

i. **Objective:**
   1. Energy Savings by optimum use of air conditioners (central or zone wise package).
   2. Providing optimum comfort level to the occupants.

ii. **Methodology / Data Collection**:
   1. Inventory of Air Conditioners (type, numbers and age)
   2. Sample size selection for Testing for power consumption and also output delivered in TR under the existing weather conditions (kW, Air Flow, Inside Air Temperature & Humidity, Outside Air Temperature and Humidity)
   3. Typical temperatures maintained in the rooms.
   4. Air conditioner control operation – Time Cycle bases Control or Temperature Control
   5. Hours of operation
   6. Air conditioned floor area
   7. AC ventilation floor area
   8. Weather bins for last 2-3 years
   9. Maintenance expenses on monthly basis for last 4 years.

iii. **Analysis**

1. Calculation of zone wise tons/sq.meters.
2. Calculation of individual AC power consumption kW/TR.
3. Application of zone wise package air conditioners or central air conditioning systems
4. Projected air conditioners consumptions for the year in kWh.

b. Central Air Conditioning System

i. **Objective:**

1. Energy savings by retrofits/replacement of chilling plants/system components for reduction in specific power (kW/TR) consumption.
2. Energy savings by retrofits/replacement of chilling plant Auxiliaries such as condenser pumps, chiller pumps, cooling towers, Air Handling units.

ii. **Methodology/Data Collection:**

1. Inventory of chilling plant & auxiliaries
2. Performance evaluation of VAM and other compressor Machines.
3. Performance evaluation of chilled water distribution.
4. Performance testing of chillers for power consumption and Output TR delivered to derive specific power consumption (KW/TR).
5. Size selection and testing for power consumption, CFM delivered and efficiency of Air Handling Units.
6. Typical temperatures maintained in the rooms. Chiller capacity control mechanism loading/unloading or vane control
7. Hours of operations for chilling plant, AHU's and other auxiliaries
8. Performance testing of condenser/chiller pumps to derive operating efficiency.
9. Air conditioned floor area
10. Weather bins for last 2-3 years
11. Maintenance expenses on monthly basis for last 4 years.

iii. **Analysis**

1. Calculation of zone wise TR/sq. meters.

2. Calculation of individual chiller specific power consumption kW/TR.
3. Calculation of operating efficiency for Condenser/Chiller pumps, AHU's etc.
4. Optimization of end use of chilling requirements.
5. Projected consumption of chilling plants and auxiliaries for year in KWH.

7. Steam Generation (Boilers)

a. Objective:

i. Evaluation and optimization of combustion efficiency of Boiler

b. Methodology/Data Collection:

i. Quantification of fuel consumption
ii. Quantification of Steam Generation
iii. Operating parameters for boiler operation
iv. Estimation of boiler feed water and blow down quantity and quality.
v. Estimation of various heat losses in the boiler
vi. Preparation of Boiler heat balance and Sankey diagrams.

c. Analysis

i. Estimation of Boiler efficiency by direct and indirect methods.
ii. Estimation of potential heat recovery from boiler heat losses.
iii. Identification of various energy conservation measures to increase the boiler efficiency.

8. Steam Distribution

a. Objective:

i. Identification of unjustified use and various losses of steam and condensate in distribution system.

b. Methodology/Data Collection:

i. Steam and condensate piping layout details
ii. Operating parameters like temperatures, pressures, duration of process etc. of steam consuming equipments.
iii. Details of other steam consumption, which can be returned back in terms of condensate.

iv. Details of steam traps (Type, size and quantities) at various locations.
v. Operation status of steam traps.
vi. Estimation of steam distribution quantity
vii. Estimation of Condensate return Quantity
viii. Material balance for condensate returns and steam distribution.
ix. Heat balance for condensate return and steam distribution (If process details are available)

c. Analysis

i. Maximizing the opportunity of condensate recycle.
ii. Identification of faulty steam traps and estimation of losses for same.
iii. Estimation of overall steam balance and optimization of steam requirement. (If process details are available)
iv. Identification of other steam and condensate losses.

9. Furnaces

a. Objective:

i. Evaluation and optimization of combustion efficiency of Furnace

b. Methodology/Data Collection:

i. Quantification of fuel consumption
ii. Quantification of Furnace output
iii. Operating parameters for furnace operation
iv. Estimation of various heat losses in the furnace.
v. Preparation of heat balance and Sankey diagrams.

c. Analysis

i. Estimation of furnace efficiency by direct and indirect methods.
ii. Estimation of potential heat recovery from furnace heat losses.
iii. Identification of various energy conservation measures to increase the furnace efficiency.

10. Thermic Fluid Heaters

a. Objective:

i. Evaluation and optimization of combustion efficiency of Thermic Fluid Heaters

b. Methodology/Data Collection:

i. Quantification of fuel consumption
ii. Quantification of TFH output
iii. Operating parameters for TFH operation
iv. Estimation of various heat losses in the TFH.
v. Preparation of heat balance and Sankey diagrams.

c. Analysis

i. Estimation of TFH efficiency by direct and indirect methods.
ii. Estimation of potential heat recovery from TFH heat losses.
iii. Identification of various energy conservation measures to increase the TFH efficiency.

11. Insulation Study

a. Objective:

i. Identification of poor insulation area and quantification of equivalent fuel loss.

b. Methodology/Data Collection:

i. Piping layout for insulated lines.
ii. Insulated Equipment layout. Dimensions and operating parameters.
iii. Operating parameters of insulated lines like temperatures, fluid and pressures.
iv. Type and thickness of insulation used and its physical properties like thermal resistance of conductivity, effect of various pickings, bulk density, and temperature range etc.

c. Analysis

i. Estimation of uninsulated area and corresponding heat loss.

12. Hot water/Oil Systems

a. Objective:

i. Identification of unjustified use and various losses of hot water/oil in distribution system.

b. Methodology/Data Collection:

i. Hot water/oil piping layout details
ii. Operating parameters like temperatures, pressures, duration of process etc. of hot water/oil consuming equipments.

iii. Details of other Hot water consumption, which can not be returned back.
iv. Estimation of hot water distribution quantity
v. Material balance for hot water/oil distribution.
vi. Heat balance for hot water/oil distribution (If process details are available)

c. Analysis

i. Estimation of overall heat balance and optimization of hot water/oil requirement. (If process details are available)

13. Drying Operations

a. Objective:

i. Optimization of drying efficiency by reduction of various losses.

b. Methodology/Data Collection:

i. Design details of dryers
ii. Operating parameters of drying.
iii. Drying material properties details
iv. Connected load details of drying.
v. Measurement of various parameters for drying operation (minimum 3 cycles).

c. Analysis

i. Estimation of drying efficiency
ii. Estimation of specific energy consumption for drying of unit mass of product on dry base
iii. Identification of various opportunities to lower the specific energy consumption.

14. Process and Other Energy Consuming Equipments

a. Objective:

i. Overall manufacturing Process Study to evaluate theoretical and actual energy consumption.
ii. Preparation of overall as well as process wise mass balance and energy balance.

b. Methodology/Data Collection:

i. Process Flow chart
ii. Process & Instrumentation Diagrams
iii. Plant Layout

iv. Operating and design details of all equipments utilized for manufacturing process.
v. Operation timing details
vi. Cost of Raw materials, man power, maintenance, and other overheads as well as energy charges for all types of fuel used including electricity.
vii. Ideal operating hours for year.
viii. Last 3 years breakdown details with reasons.
ix. Last 3 years various optimization details with benefits / losses achieved.
x. Last 3 years weather details on hourly basis

c. Analysis

i. Preparation of material balance
ii. Preparation of energy balance
iii. Estimation of specific energy consumption theoretical and actual based on past 3 years data.
iv. Suggestion to improve specific energy consumption close to theoretical values based on Bifurcation of specific energy consumption in two parts.
    1. Fixed energy consumption: Not related with production activity and also terms as “base consumption” which will remain constant when production is zero. Reduction in base consumption can be achieved by energy conservation measures
    2. Variable energy consumption: it is related to production volume. Reduction in variable consumption can be achieved by energy efficiency measures.

The audit shall also cover the study on feasibility of incorporating renewable energy systems such as solar water heater, solar cookers, solar PV, wind energy etc.