SCOPE OF DESIRED INVESTMENT GRADE ELECTRICAL ENERGY AUDIT

Objective: To carryout Investment Grade Electrical Energy Audit of the Facility and other industrial operation, 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. Electrical Audit

1. Electrical supply and distribution system analysis
2. Harmonic Study
3. Thermography
4. Electrical Motors and Drives
5. CPP & DG Sets
6. Pumping Systems including performance evaluation of distribution networks
7. Fan & Blowers
8. Compressed Air Systems
9. Cooling Towers
10. Air Conditioning Systems (HVAC)
11. Refrigeration Systems (Process Operations and Distribution)
12. Lighting system analysis

3. Facility Energy Bills Analysis

a. Objective:

i. Tariff audit to estimate the opportunities for peak load savings as well opportunities for Power Saving during the Evening Peak Load hours.

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 (KWH, Rs, Rs/KWH) 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 are taken throughout the post-retrofit period. If felt necessary, Energy Meters can be provided on certain Load Centers also.

4. Electrical Supply and Distribution System

a. Objective:

i. Transformer loss reduction projects by optimum transformer loading.
ii. Distribution loss reduction.

b. Methodology / Data Collection:

i. Peak load on daily basis for last 1-2 years.
ii. Single line diagram (SLD) of the electrical supply and distribution
iii. To develop Load Curve of the facility (Voltage, Power in kW. and P.F.) with 2 – 5 minutes intervals.
iv. Maintenance expenses on monthly basis for last 3 years.

c. Analysis:

i. Transformer loading profile for optimizing the loading for transformer loss reduction
ii. Variable capacitor application
iii. Distribution loss reduction
iv. Savings are determined by field measurements of the energy use of the systems to which the ECM was applied. Separate from the energy use of the facility. Short term or continuous measurements are taken throughout the post – retrofit period.

5. Harmonic Study

a. Objective:

i. Identification of losses caused by Harmonic Distortion.
ii. Analysis of Electric Power Quality.

b. Methodology/Data Collection:

i. Preparation of Measurement plan based on single line diagram and operating load at facility.
ii. Evaluation of measurement time at each point of measurement based on operating load.
iii. Measurement of Voltage, Current Harmonics up to 51st Harmonic.
iv. Estimation of Total Harmonic Distortion (THD)
v. Maintenance Expenses due to failure of equipments because of poor power quality.

c. Analysis:

i. THD, Voltage & Current Harmonics Profiles
ii. Identification of area of high harmonic distortion and suggestion to improve power quality.
iii. Identification of Voltage Sags, Swells, Imbalance and its effect to operating systems.

6. Thermography (Non Destructive Test)

a. Objective:

i. Identification of early warnings on equipments / component failure and to avoid excessive preventive maintenance.
ii. Optimization of maintenance cost and minimization of break downs.

b. Applicable Areas:

i. Electrical Appliances:
    1. High Voltage Aerial electrical inspection for transmission lines.
    2. Power generation generator inspections
    3. Fuse boxes
    4. Cables and relays
    5. Switches
    6. Insulators
    7. Circuit breakers
    8. Motors
    9. Battery banks

10. Power connections and controllers and many more applications.

ii. Process Applications
    1. Boiler flue gas leak detection
    2. Storage tanks sludge level inspections
    3. Flame propagation explosion analysis
    4. Heat exchanger quality and efficiency analysis
    5. Flow of products, fluids, steam, chemicals, hot gases, or solids through any system typically display a particular thermal signature.
    6. Process evolution like distillation column, reaction vessel, drying operation etc.
    7. Many more process applications.

iii. Mechanical Applications
    1. Motor racing suspension and tire contact diagnostics.
    2. Brake and engine system evaluation of performance and cooling efficiency.
    3. HVAC system evaluation.
    4. Pipe inspection, leak detections, stress corrosion cracking areas.
    5. Measurement of pressures and vibrations
    6. Pumps, compressors, Fans, Hydraulics, Drives, Conveyors, couplings, gears, pulleys, shafts, turbines etc.
    7. Shutoff, throttling, and relief Valves

iv. Building Inspection applications
    1. Thermal heat loss inspection
    2. Moisture contamination evaluations.
    3. Concrete Integrity Inspections
    4. Flat roof leak detection
    5. Solar loading
    6. Air leakages
    7. Pipe leakages
    8. Cold storage cooling loss
    9. Mould growth, Façade delaminations
    10. Crack diagnosis

v. Miscellaneous applications.
    1. Design proto type evaluation
    2. Fire mapping

3. Airborne application
4. Covert surveillance
5. Environmental inspection, pollution dumping, thermal dumping of waste water.
6. Medical injury examinations
7. Many more applications.

7. Electrical Motors and Drives

a. Objective:

i. Identification overloading and under loading of motors.
ii. Saving Evaluation w.r.t. motor operation criterion.

b. Methodology/Data Collection:

i. Measurement of various parameters like V, A, PF, kVA, kW, RPM and frequency during normal operation of motors
ii. Rewind motors use details and Nos of rewinding for same motors.
iii. Motor burning incidences of last 2 years.
iv. Maintenance Expenses on monthly basis for last 3 years.

c. Analysis

i. Motor Loading Analysis
ii. Drive Matching
iii. Regression Analysis for use of rewind motors
iv. Saving evaluation from motor management analysis

8. CPP & DG Sets

a. Objective:

i. CPP or DG set efficiency evaluation
ii. Identification of specific energy consumption.

b. Methodology/Data Collection:

i. Measurement of fuel consumption for specified period
ii. Measurement of Units generation for same period.
iii. Measurement of auxiliary drives consumption
iv. Measurement of other losses like flue gas etc.
v. Study of Operational criterion.
vi. Maintenance Expenses on monthly basis for last 3 years.

c. Analysis

i. Calculation of specific out put in terms of power based on specific input based on fuel used.
ii. Comparison of same with design values.
iii. Identification of opportunity to reuse or recycle various looses for other purpose.

9. Pumping System

a. Objective:

i. Pumping system efficiency improvement
ii. Piping layout.

b. Methodology / Data Collection:

i. Parameters Measures and Observed
ii. Pump pipeline layout (for pressure drop estimation)
iii. Pump discharge flow
iv. Suction head
v. Discharge head
vi. Operating hour on year basis
vii. Maintenance expenses on monthly basis for last 3 years

c. Analysis :

i. Pumping efficiency
ii. Pumping power consumption
iii. Piping pressure drop estimation

10. Fans and Blowers

a. Objective:

i. Fan and Blower System Efficiency improvement
ii. Ducting layout and air flow distribution assessment

b. Methodology/Data Collection:

i. Parameters Measures and Observed
ii. Fan/Blower Ducting layout (for pressure drop estimation)
iii. Fan/Blower discharge flow
iv. Static and Velocity head
v. Operating hour on year basis
vi. Maintenance expenses on monthly basis for last 3 years

c. Analysis :

i. Fan/Blower efficiency
ii. Fan/Blower power consumption
iii. Ducting pressure drop estimation

iv. Saving evaluation based on reducing efficiency gaps as well as supply demand characteristics.

11. 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 analysis 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.

12. 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. 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

c. Analysis

i. Cooling tower effectiveness.
ii. Estimation of evaporation and drift losses.

iii. Suitable measures to improve effectiveness of cooling tower.

13. 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.

14. Lighting System analysis

a. Objectives:

i. Energy savings by application of energy efficient lighting system.
ii. Providing optimum comfort level lighting to the occupants.

b. Methodology / Data Collection:

i. Inventory of lighting fixtures (type and number of fixtures)
ii. Zone or space or room wise Lux measurement (day time and evening time) and type of activity
iii. Hours of operation
iv. Isolation the lighting circuits and measure power consumption for lighting
v. Floor plan
vi. Maintenance expenses on monthly basis for last 3 years.

c. Analysis:

i. Calculation of zone wise lux
ii. Lighting power consumption in terms of Watt /Fixture and watt /M^2 (Lighted Space)
iii. Projected lighting consumption for the year in kWh.
iv. **Retrofit Isolation:** Savings are determined by field measurement of the energy use of the system to which the ECM was applied. Separate from the energy use of the rest of the facility short-termed or continuous measurements are taken throughout the post-retrofit period.
v. **Partially Measured Retrofit Isolation:** Savings are determined by partial field measurement of the energy use of the system (s) to which an EMC was supplied. Separate from the Energy use of the facility. Measurements may be either short term or continuous.

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.