Energy Audit and benchmarking for energy saving in process and equipment operation

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Abstract

Energy cost is one of the key parameters of operating cost for most of the Industries. Hence, reduction in energy consumption (electrical, thermal – steam, waste heat or in any other form) always helps in business sustenance and growth. This article indicates some of the basic aspects related to enablers such as Energy Audit and benchmarking towards optimising energy cost.

Introduction

Energy Audits are being conducted by different industries since oil embargo of 1973. Reasons for energy audits included business bottom line relevance and Governmental schemes such as Accelerated Depreciation for Energy Efficient Equipment; financing schemes from Financial Institutions such as Equipment Finance for Energy Conservation Scheme; Energy Audit subsidy scheme, etc.

Over last few years, Energy Audits adoption gained traction with Bureau of Energy Efficiency (BEE) promoting the movement.

In a chemical plant, energy is utilised in different forms such as electricity, steam and thermal. For this, a plant typically involves generation, distribution and utilisation of different energy forms.

Over the years a plant undergoes performance degradation or operates in non-optimum conditions vis-a-vis designed conditions. This leads to sub-optimal performance of a plant. Energy Audits (including steam) and Energy Management Systems are the tool available to conserve/optimise energy. The need for energy conservation through Energy Management Systems and energy audit is gaining further importance with increasing energy cost. One of the measures of sustainability is Specific Energy Consumption.

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Any energy audit is a systematic approach for assessing the existing condition and performance of energy systems. A detailed audit involves thorough inspection of facilities to provide:

(a) Energy Mapping viz. energy use breakdown
(b) Baseline for further detailed analysis / surveys
(c) Identify energy conservation potential
(d) Prioritise from list of energy project measures

The outcome is normally presented in the form of a report with recommendations for energy efficiency improvement supported by cost benefit analysis and an action plan.

Energy Conservation Measures (ECM) are to be identified and implemented such that it should not impact: Safety, Product Quality, Productivity, Statutory Compliance and Power Quality.

The energy audit may serve as an energy management feasibility study or energy base for setting energy budgets.

Audit Methodology

An energy audit can vary in its degree of thoroughness viz. the extent of energy system verification and the accuracy of data that must be qualified.

For an effective audit following steps may define the basic methodology:

Step-1: Interaction with Plant Energy Management team

- Short description of energy audit objects, scope, agenda and work procedures
- Define the necessary initial data, where to get it and who shall provide it.

- Define arrangements of fieldwork practices (permits for entry, safety training/orientation based on plant practices and chemicals/hazards involved, measurements).
- Define project schedule.
- Clarify the availability and usability of the Equipment/System Drawings/Documents
- Define the check-up of the portable and fixed meters for the baseline definitions.

Step 2 - Interview with Key Facility Personnel (including O&M and Projects team)

Step 3 - Facility Tour (Walk-through Audit)

Step 4 - Document Review

- Some of the things covered at this point of the audit: Available records of energy costs and consumption levels, seasonal profile, purchasing arrangements review, compare energy consumption with output where appropriate, and specific energy consumption calculation)

Step 5 - Facility Inspection, Field Measurements & Special Trials

Step 6 - Utilisation Analysis (based on Energy Mapping)

Step 7 - Identify/Evaluate Feasible ECMs (energy conservation measures)

Step 8 - Economic Analysis

Step 9 - Prepare a Report Summarizing Audit Findings

Step 10 - Review Recommendations with Plant Energy Management team (for action plan)

Pre-Requisites for Energy Audit

1. Obtain detailed information on existing equipment / systems from plant team
2. Appointment of a key person from plant side to hold all field study activities together
3. For better accuracy and quicker execution, plant team shall make available the following design and historical data and operating data / parameters to audit team members prior to starting the energy audit field study:

- Overall Plot Plan
- SLD's for Electrical System
- Process Flow Diagram with Description / P&ID
- Process Operating Parameters
- Electricity Bills for Past 12 Months
- Fuel Bills for Past 12 Months
- Specifications for Process Equipment
- Piping Layout / Isometric Drawings for applicable systems - chilled water, cooling water, hot water, steam, thermic fluid/hot oil, compressed air system, etc.
- Ducting Layout (HVAC, Hot Air, Flue Gas)
- Lighting layout

Typical Audit Activities

1. Energy audits are of different extent. Accordingly these are classified as:

- Walk-Through Audit
- Detailed Energy Audit
- Energy Assessment / Evaluation

Energy Audits may be:

- Equipment Level
- System Level
- Unit Level
- Plant Level
- Entire Complex level

The team constitution, specific methodology, measuring instruments will be varied based on the type of process, offsites and utilities applicable to the Plant.

Typical utilities include steam, electricity, compressed air, thermic fluid apart from various water and HVAC related systems.

Broadly, the following are envisaged from opportunity identification perspective:

2. Process Study

(a) Present Operational Practices
(b) Process Energy Balance (steam, fuel & power)
(c) Process Material Balance
(d) Evaluation for opportunity of Heat Exchangers Networking
(e) Process Technology (Level of energy use in existing Process Technology; Level of energy saving by modifying existing process technology; Opportunities for Energy Saving investment in Process Technology)

3. Electrical Energy System

(a) Distribution System Loss
(b) Reactive Power Compensation
(c) Measurement of Harmonics Level
(d) Identification of Partly Loaded Motor
(e) Identification of Improvements in Lighting System
(f) Identification of energy saving opportunities through energy efficient measures/ techniques/ devices/ retrofit
(g) Opportunities for Automation/ Monitoring

4. Electrical Energy Using System

(a) Chiller Plant Study
(b) Water Pumping System
(c) Compressed Air System
(d) Ventilation System and Dust/ Fume Extraction System
(e) Heat exchangers

5. Thermal Energy system

(a) Steam/Hot water/Hot Oil Generation / Furnace System
(b) Steam/Hot Water/ Hot Oil Distribution System
(c) Waste Heat Recovery system

6. Evaluation of Performance of Equipments forming part of various systems

(a) Boiler / Hot Water / Hot Oil Generator
(b) Gensets (DG/TG)
(c) Chillers
(d) Cooling Towers
(e) Blowers / Fans / Exhausters
(f) Water Pumps
(g) Transformers
(h) Capacitors
(i) Motors
(j) HVAC
(k) Lighting

Energy Conservation approach includes:

- Maximising Capacity Utilization
- Optimization Of Operating Procedures / Parameters
- Thrust On Recycle & Waste Minimization
- Fine Tuning Of Plants & Equipments
- Adopt Energy Efficient Methods / Equipment / Systems
- Technology Upgradation

Steps for achieving Energy Conservation include:

- Identification of Energy Conservation Projects
- Preparation of Cost Benefit Analysis Reports
- Detailed Engineering for Implementation
- Procurement Services, Inspection and Expediting
- Supervision of Erection and Commissioning and Further Monitoring

Typical contents of Audit report include:

- Executive Summary
- Objectives of the Study
- Energy Audit Methodology
- Historical Data Analysis
- Energy Efficiency Analysis (specific energy consumption)

- Comparison with Prevailing Standards & Causes for the Deviation
- List of Recommendations for Performance Improvement
- Energy Optimisation Opportunities
- First Order Cost-Benefit Analysis

Energy audit and analyses of the plant enables identification of a number of potential energy saving projects. These may be classified into three categories based on CapEx & returns:

(a) Minimal investment – high return
(b) Medium investment – medium return
(c) High investment – high return

Energy audit is steadily evolving into Energy Evaluation / Assessment studies. These have additionality of identifying the process set points for optimum performance of the Plant/Systems based on production rate and climatic conditions.

Typically, the preferred areas to be targeted, depending on the industry, for energy intensive processes are Thermal System (Burner Management System, Insulation / Refractory), Process Gas Compressors, Main Air Blowers, FD/ID fans.

Chemical industries/processes involving exother-

mic reactions provide a good opportunity for Co-Generation (Steam and Electricity).

Review of Process Flow Diagram (PFD) enables identification of operational improvement items.

Pinch Analysis is also one of the ways of identifying opportunities. Pinch Analysis involves Detailed Study on the Process Units with most potential as well as Optimisation of Process-Utility Interfaces

One of the approaches for energy efficient operation is to use Energy Efficient equipment. For this different Energy Labels / Ratings have been published such as BEE Energy Labelling Program, Energy Star Ratings, etc. However, mere use of equipment with best Energy Rating may not always lead to lowering of energy consumption but may instead lead to increased energy consumption (maybe with increased production) e.g. Use of say IE4 motors v/s. IE2 motors for Pumps & Blowers/Fans following affinity law.

The Audit findings may be further evaluated in line with best - equipment, system, technology, instrumentation, measurement, commissioning and maintenance practices.

Management Systems such as EnMS ISO 50001 enable sustainable deployment of the Energy Saving Practices.

Benchmarking

Perform, Achieve and Trade (PAT) is being driven as a benchmarking tool by BEE.

Petroleum refinery is one of the three new sectors that have been added to the List of Designated Consumers (DC) under PAT Cycle II. PAT Cycle III has been rolled out for existing DCs viz. chlor-alkali, fertilizer, aluminium, cement, iron & steel, paper & pulp, textile and thermal power plants. PAT scheme is now being implemented on a rolling cycle basis, i.e. new DCs are being notified yearly.

For PAT, calculating the specific energy consumption "gate-to-gate" approach is adopted, thereby including all energy consumption against the total production.

PAT incorporates fundamental best practices in reducing energy demand through energy efficiency

- Determination of energy intensity (SEC)
- Setting of SEC target for each sector
- Energy audits and compliance checks for all DCs
- Financial incentives linked to ESCerts trading (Energy Saving Certificates).

Some of the benchmarking references include Solomon's' Index; LEED (IGBC) – Green Factory.

Non-Plant buildings of the Industry are well covered by ECBC (Energy Conservation Building Code), IECC (International Energy Conservation Code) and Rating systems such as LEED (IGBC), WELL Building Standard®, and LEED (USGBC).

Benchmarking may alternatively be done in different ways for specialty industries:

- Self Benchmarking y-o-y
- System wise benchmarking
- Benchmarking wrt other plants of the same company
- Benchmarking across the sector at National Level
- Global Benchmarking.

Energy efficient equipment are being driven through Energy Labelling programmes.

For other levels, understanding of the system and interdependencies should be well understood and usually involves use of some simulation tools/techniques.

Conclusion

Optimal operation of a chemical plant is dependent on a variety of parameters. Every component of the system provides opportunity for energy conservation.

Energy Audits at regular intervals and Energy Management Systems enable verification of plant performance vis-a-vis design intent.

Holistically looking at the Plant/ Overall System provides real overall benefit rather than just the use of energy efficient equipment.

In India, for compliance with PAT, energy audits are mandatory.

Taking cognizance of thrust on sustainability, apart from energy audit, following may also be pursued,

(a) Identification of Renewable Energy Opportunities

(b) Identification of Water Conservation Opportunities / Water Audit

(c) Suggestions for Implementable Features from Green Building

(d) Plant Waste Emissions (esp. gases and effluents).