Lesson 7-8-9: energy performance evaluation

1. What is energy performance evaluation?

Energy performance evaluation (EPE) is a systematic investigation to diagnose energy performance improvement opportunities by comparing energy performance using key statistical data and benchmarks, and calculation tools. The EPE process can be used to gain insights into how well an organization's programs, projects, and facilities are performing and how they can be improved. It can also serve as a high-level tool for understanding different components of energy management and prioritizing institutional decision-making, including technical improvements and policies.

EPE is part of management accounting, particularly cost accounting, and plays a crucial role in efficient energy management and a well-functioning energy market. It helps identify policy areas and strategic advantages, and helps assess facilities and buildings under real best practices. Small differences in performance can determine low-cost producers in the energy market.

In addition, EPE systematically assesses energy usage in systems or processes to identify potential improvements. It measures energy consumed during the operational phase and compares it against established benchmarks to evaluate performance.

2. Historical development:

The concept of energy performance evaluation has been widely used since the late 1970s, with its roots dating back to the 19th century. The first oil shortage in the mid-19th century led to the invention of electric lighting and the foundation of the electric utility industry. The basic law of energy use, or the first law of thermodynamics, states that energy cannot be consumed but can be converted into another form, or energy conservation. This idea is the foundation of today's energy auditing, which focuses on converting energy from primary energy sources to provide useful energy for goods and services.

3. Importance of EPE:

- **Economic Benefits:**
  - Reduces energy bills through optimization.
  - Improves return on investment for energy-saving projects.
- **Environmental Impact:**
  - Reduces carbon emissions by minimizing energy wastage.
  - Aligns with global and local sustainability goals.
- **Regulatory Compliance:**
  - Meets legal requirements for energy efficiency.
  - Prepares organizations for energy audits by external bodies.

4. Components of EPE:

These are elements or tools that facilitate the execution of the steps:

- **Energy audits:**
  - Frameworks for identifying inefficiencies and optimization opportunities.
  - Tools: thermal imaging cameras, data loggers, portable meters.
- **Performance metrics:**
  - Key indicators like Specific Energy Consumption SEC, energy used per unit of output (e.g., kWh per product or per square meter). Regular monitoring of SEC highlights trends and improvement opportunities. In addition to energy Utilization Index (EUI), energy used relative to a standard measure like production levels or facility size.
  - Production factor (PF): A ratio comparing the production in the current year to the reference year. It helps normalize energy data for production changes, allowing for fair comparisons between different time periods.

PF= Current Year’s Production/ Reference Year’s Production

- Reference year equivalent energy (RYEE): The amount of energy that would have been used in the current year if the plant operated at the same efficiency as in the reference year. Provides a baseline for evaluating energy performance improvements or deterioration.

RYEE=Reference Year Energy Use × Production Factor

- Plant energy performance (PEP): A percentage measure of improvement or deterioration in energy consumption compared to the reference year. Quantifies how well energy conservation measures are working.

PEP= RYEE−Current Year Energy Use/RYEE×100

Positive values indicate improvement, while negative values suggest performance deterioration.

Example:

The integrated paper plant has produced 119366MT of paper during the year 2015-16. The management has implemented various energy conservation measures and had reduced the specific energy consumption from 53GJ/tone of product to 50GJ/tone of product in the assessment year (2017-18). The corresponding production in assessment year was 124141 MT. Calculate the plant energy performance and states your inference.

Reference year production=119366MT

Reference year specific energy consumption=53GJ/tonne of product

Assessment year production=124141MT

Assessment year specific energy consumption = 50GJ/tonne of product

$Production\ Factor = Assessment\ Year\ Production / Reference\ Year\ Production$

Production factor = (124141/119366) = 1.04

$Reference\ year\ energy\ consumption,\ GJ = Reference\ year\ Specific\ Energy\ Consumption\ (GJ/MT) \times Reference\ year\ production,\ MT$ =53 x 119366 = 6326398 GJ

$Assessment\ Year\ energy\ consumption,\ GJ = Reference\ year\ Specific\ Energy\ Consumption\ (GJ/MT) \times Assessment\ Year\ Production\ ,\ MT$

=50x124141=6207050GJ

$Reference\ Year\ equivalent\ energy\ use,\ GJ = Reference\ Year\ energy\ consumption,\ GJ \times Production\ Factor$ =6326398GJx1.04=6579454 GJ

$Plant\ energy\ performance\ \% = Reference\ year\ equivalent\ energy - Assessment\ year\ energy / Reference\ year\ equivalent\ energy \times 100$

= ((6579454- 6207050)/6579454) x 100 =5.66%

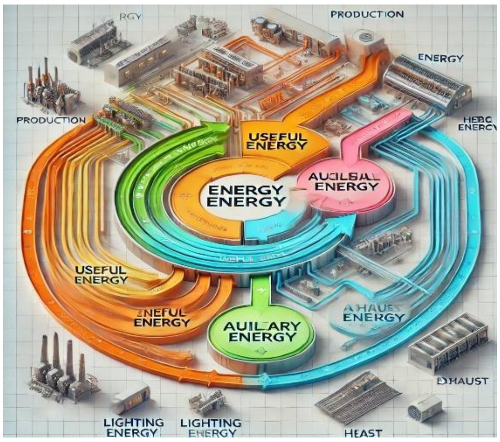
Inference:

The **PEP** is **5.66%**, indicating that the energy conservation measures implemented by the management have been successful, achieving energy savings and improving overall efficiency.

- Used for measuring and benchmarking efficiency.

– **Data analysis techniques:**

- Methods such as energy balance, regression analysis, and trend tracking.
- Visual aids like Sankey diagrams to illustrate energy flows.



– **Benchmarking:**
- Internal (past performance) or external (industry standards) comparisons. Benchmarking compares a facility's energy use to industry standards, best practices, or internal historical data to evaluate performance and identify gaps.
- Types: historical benchmarking, peer comparison, and best practice adoption.

☞ **Note:**

EPE and benchmarking are often used together. EPE identifies inefficiencies and opportunities for improvement, while benchmarking helps set realistic and competitive targets.
Example: After conducting an EPE, a company finds that its energy use per unit of production is higher than industry standards. Benchmarking helps identify the exact gap and determine how to align with or surpass peers.

– **Energy management tools:**
- Smart meters for real-time tracking.
- Energy simulation software for predictive modeling.

– **Continuous monitoring and feedback:**
- Regular review of performance metrics.
- Use feedback to refine energy-saving strategies.

5. Steps in EPE:

These are sequential actions or phases carried out to evaluate energy performance systematically:

– **Understanding energy costs:**
- Examine utility bills for consumption patterns.
- Identify cost drivers contributing to high energy use.

– **Define scope and objectives:**
- Select specific areas or processes to evaluate.
- Establish clear performance objectives (e.g., reduce SEC by 10%).

– **Energy audits:**
- Preliminary audit: Identify quick, low-cost energy-saving measures.
- Detailed audit: Conduct a comprehensive analysis of all energy systems.

– **Data collection and monitoring:**
- Install metering systems (smart meters, sub-meters).
- Collect historical and real-time data to understand usage trends.

– **Analyze and compare:**
- Use energy metrics (e.g., SEC, EUI) to assess efficiency.
- Perform regression analysis to pinpoint inefficiencies.

– **Set targets and action plans:**
- Define achievable goals based on analysis (e.g., replace inefficient HVAC).
- Create a detailed implementation plan.

- **Implement and optimize:**
  - Execute the action plan with technologies or process changes.
  - Ensure staff engagement and training in energy-efficient practices.
- **Review and improve:**
  - Regularly monitor performance post-implementation.
  - Adjust strategies as needed for continuous improvement.

6. **Techniques of EPE:**

Utilizing appropriate techniques is essential for effective energy performance evaluation and benchmarking.

- **Energy balance:**
  - Assess energy inputs, outputs, and losses within a system.
  - Use Sankey diagrams to visualize energy flows.
- **Energy simulation:**
  - Employ modeling tools to simulate energy systems and predict the impact of changes.
  - Analyze different scenarios to identify optimal solutions.
- **Life cycle cost analysis:**
  - Evaluate the total cost of ownership of energy-saving projects, including initial investment, operation, maintenance, and disposal costs.
  - Determine the economic feasibility of proposed measures.

7. **Maximizing energy efficiency:**

Maximizing energy efficiency goes beyond reducing energy usage; it aims to optimize the output-to-energy-input ratio. Effective strategies include:

- **Upgrading equipment:** Replace outdated equipment with high-efficiency alternatives. For instance, modern HVAC systems can reduce energy use by up to 30%.
- **Improving insulation and building envelope:** In buildings, improving insulation reduces heating and cooling needs, significantly lowering energy usage.
- **Implementing control systems:** Using sensors, automation, and smart meters to monitor and optimize energy consumption in real-time.
- **Reducing standby power consumption:** Ensuring that idle equipment or systems do not consume unnecessary energy.