LECTURE NOTES

ON

ENERGY AUDIT AND MANAGEMENT

B.Tech VI Sem (IARE-R16)

By

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UNIT – I
GENERAL ASPECTS

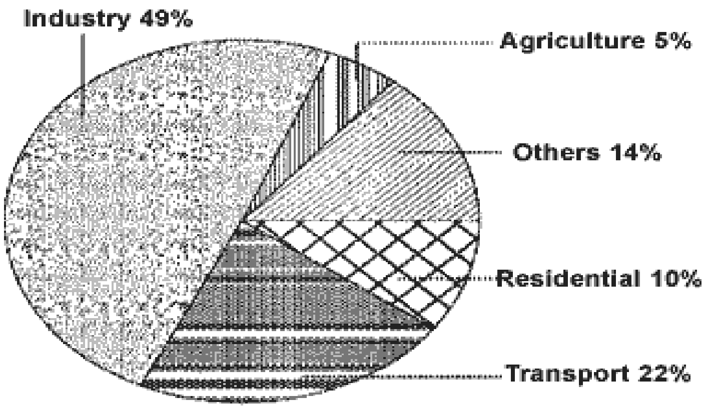
ENERGY MANAGEMENT AND AUDIT

ENERGY MANAGEMENT: AN OVERVIEW

Energy is an integral part of today's modern life. It has become the blood of our day to day life. But it is not free. It comes at a monetary price but more than that it comes at environment cost too.

It is very difficult to think about our modern life without energy. But the generation of energy requires natural resources which are depleting day by day. On the other side, use of energy is increasing exponentially. In developing nation like India, about 49% of total commercial energy is consumed in industries and utilities like Compressed Air, Air Conditioning, Steam, Hot water, Electrical systems, fuel, water system consumes substantial part of total energy in these industries.. Figure Number 1.1 shows, sector wise energy consumption for the year 1999-2000.

Figure No 1.1: Sector wise Energy Consumption (1999-2000)



Source: Bureau of Energy Efficiency, India.

Thus the need to improve and maintain energy efficiency in industrial utilities is strongly felt to survive in present scenario of rising energy costs and volatile energy markets and to gain competitive advantage. On the other side, consumption of energy resources in industries leads to atmospheric pollution and damages environment. Application of energy efficient technologies to improve energy efficiency (i.e., reductions in energy per unit of output) in industries are often suggested as a means of reducing carbon emissions. In many cases where climate change is not a concern; improvements in energy efficiency will pay for themselves through reductions in energy costs.

In India, per capita Energy Consumption is very low. Being a developing country, it needs to achieve Economic Growth by increasing its pace of development through industrialization. There are two options to match the pace of industrial development. First one is to produce more and more industrial energy which is quite difficult considering depleting natural resources and second one is to reduce the consumption of energy by improving energy efficiency in industries especially in utilities. The research focuses on reducing energy consumption of industrial utilities through energy efficient technologies. It also focuses on barriers to energy efficiency in industries and training needs of the employees for the effective energy management in industries.

Pune is a hub of automobile industries in India and one of the most polluted city in the state. This study deals with the energy management in utilities of automobile industries in Pune manufacturing passenger cars. The researcher studied the status of energy management in these industries with respect to energy efficient technologies adopted and barriers in their adoption, performance assessment of utility equipment, utility costing, and training needs of employees on energy management.

We have limited fuels available on earth. Our demand for energy is increasing day-by- day. It is possible that someday, most of fuels will be exhausted, and we will have to switch over to alternate energy. At present consumption levels (world) are - Crude oil will last only for 45 years. Gas will last for 65 years. Coal will be finished in nearly 2001.

It is estimated that Industrial energy use in developing countries constitutes about 45-50 % of the total commercial energy consumption. Much of this energy is converted from imported oil, the price of which has increased tremendously so much so that most of developing countries spent more than 50 % of their foreign exchange earnings. Not with standing these fiscal constraints, developing countries need to expand its industrial base like us if it has to generate the resources to improve the quality of life of its people. The expansion of industrial base does require additional energy inputs which become more & more difficult in the present scenario.

In response to the wave of challenges related to energy use, some industries around the world have reduced energy intensities by adopting and developing energy efficient technologies and management strategies. This is a justification for their high energy end-use and high contribution to energy related environmental problems. By doing so, industries have not only gained improvement in environmental protection, but also gained economic and social dividends. Numerous studies have highlighted the tremendous gains of implementing industrial energy efficiency and management measures. Notably, some of these studies reveal that greater savings can be realized in developing countries.

Considerable untapped potential exists for curbing wasteful use of energy estimated to be of the order nearly 30 per cent of the total consumption of commercial energy. The size of energy efficiency markets growing @ 10% annually in India is estimated to be in the range of Rs. 200 to Rs. 300 billion. In spite of many efforts and benefits of energy efficiency, several technical, financial market and policy barriers have constrained the implementation of energy efficiency projects.

Indian industry uses energy more intensively than is the norm in industrialized countries. While selected modern Indian units often display very high efficiency that approaches world best practice levels, the average intensity lags world best levels. Indian industry has undergone a transformation since 1991, the year the economy was opened to foreign investment and competition. Energy per unit of valued added in the industrial sector has declined since then. However, there still remains considerable scope for continued improvement of energy efficiency in Indian industry, and for learning from both worldwide and Indian best practices.

Considering potential for energy savings especially in industries, fastly depleting energy resources and the harmful effects of energy consumption on environment, researcher has taken this study to understand the energy efficient measures adopted by the industries and barriers in their adoption. This study incorporates the investigation of barriers for the implementation of energy efficient technologies in Industrial utilities to shed light on the rationale for non-adoption of cost effective industrial energy efficient technologies.

India is one of the fastest growing modern economies of the world today. With economic growth rates ranging between 8% and 9% in the last 6 years and a double digit growth rate target for next decade, the Indian economy has become an energy guzzler. As per the global environment facility (GEF), industry remains the largest consumer of energy in the Indian economy; accounting for over 50% of total primary energy consumption in the country. There are estimated 13 million Micro, Small, and Medium-sized Enterprises (MSME) contributing to around 45% of manufacturing output, and employing more than 40 million people. Most of energy intensive MSMEs depend on inefficient equipment, technology and operating practices, leading to high energy consumption and significant CO2 emissions.[5]

Indian industries are lagging in application of Energy Efficient technologies for improving energy efficiency because of the various reasons. Specific energy consumption is very high in

Indian industries.

The main reasons for higher specific energy consumption in Indian industries are:

1) Obsolete technology
2) Lower capacity utilization
3) Causal metering and monitoring of energy consumption
4) Lower automation
5) Raw material quality and poor handling
6) Operating and maintenance practices
7) Lack of knowledge/awareness among the employees

So, the technology upgrades, Re-engineering and continuous evaluation, Self- knowledge & Awareness among the masses is basic step towards energy conservation program in any industry. It is strongly required to monitor energy utilization on continuous basis and relate it to specific energy consumption. This research analyses the status of training programs on energy management conducted in the organization and needs of the employees to improve their technical capabilities and awareness about energy management in passenger car manufacturing automobile industries in Pune. It provides comprehensive information about the industrial energy culture of these industries derived from both primary and secondary data sources.

Since, the substantial share of energy resources is consumed in generation, distribution and utilization of electrical and thermal utilities, improving energy efficiency in industrial utilities is the very first step in Energy Management. Hence it calls "Management of Energy in industrial utilities".

These electrical and thermal utilities are not only energy intensive utilities but the least energy efficient systems too. Over a period of time, both performance of these utility equipment and utility system reduces drastically. The causes are many such as poor maintenance, wear and tear etc. All these lead to additional utility Equipment installations leading to more inefficiency. Therefore, a periodic performance assessment of these utility Equipment with a standard procedure is essential to minimize the cost of energy. This doctoral study also deals with the status of performance assessment of major utility equipment at a periodic intervals with standard procedure.

Definition & Objectives of Energy Management

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect.

The term energy management means many things to many people. One definition of energy management is:

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance

competitive positions"

(Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997)

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

- To minimize energy costs / waste without affecting production & quality
- To minimize environmental effects.

Energy Audit: Types And Methodology

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management program..

As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Need for Energy Audit

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labor and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control program which are vital for production and utility activities. Such an audit program will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a " bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

Principles of Energy Audit :

. Eliminate un necessary energy usage.

. Improve efficiency of energy usage.

. Buying energy at low cost.

. Adjusting operations to allow purchasing energy at low prices.

. Control the cost of energy not the BTU.

. Control energy as a product cost.
. For same energy higher production.
. Energy saved is the money earned which can be used in the other productive means.

2 Type of Energy Audit

The type of Energy Audit to be performed depends on:
- Function and type of industry
- Depth to which final audit is needed, and
- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types. i) Preliminary Audit ii) Detailed Audit

Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:
- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement

Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.
This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.
In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.
Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase Phase II - Audit Phase Phase III - Post Audit Phase

A Guide for Conducting Energy Audit at a Glance

Industry-to-industry, the methodology of Energy Audits needs to be flexible.
A comprehensive ten-step methodology for conduct of Energy Audit at field level is pre- sented below.

Phase I -Pre Audit Phase Activities

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important.

Initial Site Visit and Preparation Required for Detailed Auditing

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit.

During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

- Discuss with the site's senior management the aims of the energy audit.
- Discuss economic guidelines associated with the recommendations of the audit.
- Analyse the major energy consumption data with the relevant personnel.
- Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.
- Tour the site accompanied by engineering/production

The main aims of this visit are: -

- To finalise Energy Audit team
- To identify the main energy consuming areas/plant items to be surveyed during the audit.
- To identify any existing instrumentation/ additional metering required.
- To decide whether any meters will have to be installed prior to the audit eg. kWh, steam, oil or gas meters.
- To identify the instrumentation required for carrying out the audit.
- To plan with time frame
- To collect macro data on plant energy resources, major energy consuming centers
- To create awareness through meetings/ program.

Phase II- Detailed Energy Audit Activities

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.
The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected pay- back on any capital investment needed.

The information to be collected during the detailed audit includes: -

1.Energy consumption by type of energy, by department, by major items of process equipment, by end-use
2.Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)
3. Energy cost and tariff data
4. Process and material flow diagrams
5. Generation and distribution of site services (e.g. compressed air, steam).
6. Sources of energy supply (e.g. electricity from the grid or self-generation)
7.Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).
8.Energy Management procedures and energy awareness training programs within the establishment.

Existing baseline information and reports are useful to get consumption pattern, production cost and productivity levels in terms of product per raw material inputs. The audit team should collect the following baseline data:

- Technology, processes used and equipment details

- Capacity utilization
- Amount & type of input materials used
- Water consumption
- Fuel Consumption
- Electrical energy consumption
- Steam consumption
- Other inputs such as compressed air, cooling water etc
- Quantity & type of wastes generated
- Percentage rejection / reprocessing
- Efficiencies / yield

Draw process flow diagram and list process steps; identify waste streams and obvious energy wastage

An overview of unit operations, important process steps, areas of material and energy use and sources of waste generation should be gathered and should be represented in a flowchart as shown in the figure below. Existing drawings, records and shop floor walk through will help in making this flow chart. Simultaneously the team should identify the various inputs & output streams at each process step.

Example: A flowchart of Penicillin-G manufacturing is given in the figure3.1 below. Note that waste stream (Mycelium) and obvious energy wastes such as condensate drained and steam leakages have been identified in this flow chart

The audit focus area depends on several issues like consumption of input resources, energy efficiency potential, impact of process step on entire process or intensity of waste generation / energy consumption. In the above process, the unit operations such as germinator, pre-fermentor, fermentor, and extraction are the major conservation potential areas identified.

Identification of Energy Conservation Opportunities

Fuel substitution: Identifying the appropriate fuel for efficient energy conversion

Energy generation : Identifying Efficiency opportunities in energy conversion equipment/utility such as captive power generation, steam generation in boilers, thermic fluid heating, optimal loading of DG sets, minimum excess air combustion with boilers/thermic fluid heating, optimissing existing efficiencies, efficient energy conversion equipment, biomass gasifiers, Cogeneration, high efficiency DG sets, etc.

Energy distribution: Identifying Efficiency opportunities network such as transformers, cables, switchgears and power factor improvement in electrical systems and chilled water, cooling water, hot water, compressed air, Etc.

Energy usage by processes: This is where the major opportunity for improvement and many of them are hidden. Process analysis is useful tool for process integration measures.

Technical and Economic feasibility

The technical feasibility should address the following issues

- Technology availability, space, skilled manpower, reliability, service etc
- The impact of energy efficiency measure on safety, quality, production or process.
- The maintenance requirements and spares availability

The Economic viability often becomes the key parameter for the management acceptance. The economic analysis can be conducted by using a variety of methods. Example: Pay back method, Internal Rate of Return method, Net Present Value method etc. For low investment short duration measures, which have attractive economic viability, simplest of the methods, payback is usually sufficient. A sample worksheet for assessing economic feasibility is provided below:

Classification Of Energy Conservation Methods

1. Low cost – High return.
2. Medium cost- medium return.
3. High cost –high return.

Energy Audit Reporting Format

After successfully carried out energy audit energy manager/energy auditor should report to the top management for effective communication and implementation. A typical energy audit reporting contents and format are given below. The following format is applicable for most of the industries.

Understanding Energy Costs

Understanding energy cost is vital factor for awareness creation and saving calculation. In many industries sufficient meters may not be available to measure all the energy used. In such cases, invoices for fuels and electricity will be useful. The annual company balance sheet is the other sources where fuel cost and power are given with production related information.

Energy invoices can be used for the following purposes:

•They provide a record of energy purchased in a given year, which gives a base-line for future reference

•Energy invoices may indicate the potential for savings when related to production requirements or to air conditioning requirements/space heating etc.

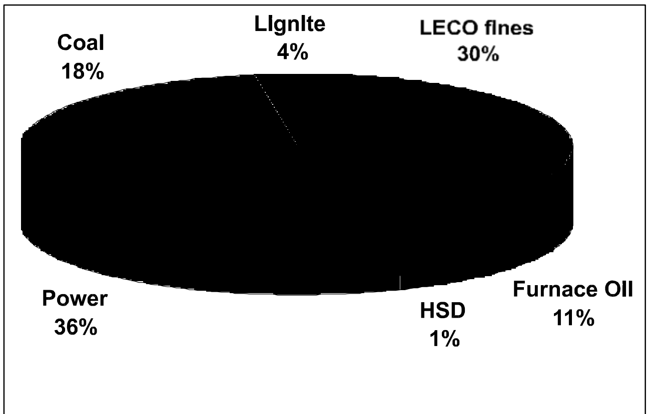
•When electricity is purchased on the basis of maximum demand tariff

•They can suggest where savings are most likely to be made.

•In later years invoices can be used to quantify the energy and cost savings made through energy conservation measures

A wide variety of fuels are available for thermal energy supply. Few are listed below:

- Fuel oil
- Low Sulphur Heavy Stock (LSHS)
- Light Diesel Oil (LDO)
- Liquefied Petroleum Gas (LPG)
- COAL
- LIGNITE
- WOOD ETC.



Total Energy Bill - Rs. 6 Crores/annum

Understanding fuel cost is fairly simple and it is purchased in Tons or Kiloliters. Availability, cost and quality are the main three factors that should be considered.

The following factors should be taken into account during procurement of fuels for energy efficiency and economics.

- Price at source, transport charge, type of transport
- Quality of fuel (contaminations, moisture etc)
- Energy content (calorific value)

Electricity price in India not only varies from State to State, but also city to city and consumer to consumer though it does the same work everywhere. Many factors are involved in deciding final cost of purchased electricity such as:

- Maximum demand charges, kVA
- Energy Charges, kWh

(i.e., How much electricity is consumed?)

- TOD Charges, Peak/Non-peak period

(i.e. When electricity is utilized ?)

- Power factor Charge, P.F

(i.e., Real power use versus Apparent power use factor)

- Other incentives and penalties applied from time to time
- High tension tariff and low tension tariff rate changes
- Slab rate cost and its variation
- Type of tariff clause and rate for various categories such as commercial, residential, industrial, Government, agricultural, etc.
- Tariff rate for developed and underdeveloped area/States
- Tax holiday for new projects

Benchmarking and Energy Performance

Benchmarking of energy consumption internally (historical / trend analysis) and externally (across similar industries) are two powerful tools for performance assessment and logical evo- lution of avenues for improvement. Historical data well documented helps to bring out energy consumption and cost trends month-wise / day-wise. Trend analysis of energy consumption, cost, relevant production features, specific energy consumption, help to understand effects of capacity utilization on energy use efficiency and costs on a broader scale.

External benchmarking relates to inter-unit comparison across a group of similar units. However, it would be important to ascertain misleading. Few comparative factors, which need to be looked into while benchmarking exter- nally are:

- Scale of operation
- Vintage of technology
- Raw material specifications and quality
- Product specifications and quality

Benchmarking energy performance permits

- Quantification of fixed and variable energy consumption trends vis-à-vis production levels
- Comparison of the industry energy performance with respect to various production levels (capacity utilization)
- Identification of best practices (based on the external benchmarking data)
- Scope and margin available for energy consumption and cost reduction
- Basis for monitoring and target setting exercises. The benchmark parameters can be:
- Gross production related

e.g. kWh/MT clinker or cement produced (cement plant)

e.g. kWh/kg yarn produced (Textile unit) e.g. kWh/MT, kCal/kg, paper produced (Paper plant)

e.g. kCal/kWh Power produced (Heat rate of a power plant) e.g. Million kilocals/MT Urea or Ammonia (Fertilizer plant) e.g. kWh/MT of liquid metal output (in a foundry)

- Equipment / utility related

e.g. kW/ton of refrigeration (on Air conditioning plant)

e.g. % thermal efficiency of a boiler plant

e.g. % cooling tower effectiveness in a cooling tower e.g. kWh/NM^3 of compressed air generated

e.g. kWh /litre in a diesel power generation plant.

While such benchmarks are referred to, related crucial process parameters need mentioning for meaningful comparison among peers. For instance, in the above case:

•For a cement plant - type of cement, blaine number (fineness) i.e. Portland and process used (wet/dry) are to be reported alongside kWh/MT figure.

•For a textile unit - average count, type of yarn i.e. polyester/cotton, is to be reported along side kWh/square meter.

•For a paper plant - paper type, raw material (recycling extent), GSM quality is some important factors to be reported along with kWh/MT, kCal/Kg figures.

•For a power plant / cogeneration plant - plant % loading, condenser vacuum, inlet cool ing water temperature, would be important factors to be mentioned alongside heat rate (kCal/kWh).

•For a fertilizer plant - capacity utilization(%) and on-stream factor are two inputs worth comparing while mentioning specific energy consumption

similarities, as otherwise findings can be grossly misleading. Few comparative factors, which need to be looked into while benchmarking extern- nally are:

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- For a fertilizer plant - capacity utilization(%) and on-stream factor are two inputs worth comparing while mentioning specific energy consumption ating parameters to be reported while mentioning specific energy consumption data.
- For an Air conditioning (A/c) plant - Chilled water temperature level and refrigeration load (TR) are crucial for comparing kW/TR.
- For a boiler plant - fuel quality, type, steam pressure, temperature, flow, are useful com parators alongside thermal efficiency and more importantly, whether thermal efficiency is on gross calorific value basis or net calorific value basis or whether the computation is by direct method or indirect heat loss method, may mean a lot in benchmarking exer cise for meaningful comparison.
- Cooling tower effectiveness - ambient air wet/dry bulb temperature, relative humidity, air and circulating water flows are required to be reported to make meaningful sense.
- Compressed air specific power consumption - is to be compared at similar inlet air temperature and pressure of generation.
- Diesel power plant performance - is to be compared at similar loading %, steady run condition etc.

Plant Energy Performance

Plant energy performance (PEP) is the measure of whether a plant is now using more or less energy to manufacture its products than it did in the past: a measure of how well the energy management programme is doing. It compares the change in energy consumption from one year to the other considering production output. Plant energy performance monitoring compares plant energy use at a reference year with the subsequent years to determine the improvement that has been made.

However, a plant production output may vary from year to year and the output has a significant bearing on plant energy use. For a meaningful comparison, it is necessary to determine the energy that would have been required to produce this year production output, if the plant had operated in the same way as it did during the reference year. This calculated value can then be compared with the actual value to determine the improvement or deterioration that has taken place since the reference year.

Production factor

Production factor is used to determine the energy that would have been required to produce this year's production output if the plant had operated in the same way as it did in the reference year. It is the ratio of production in the current year to that in the reference year.

Reference Year Equivalent Energy Use

The reference year's energy use that would have been used to produce the current year's production output may be called the "reference year energy use equivalent" or "reference year equivalent" for short. The reference year equivalent is obtained by multiplying the reference year energy use by the production factor (obtained above)

Reference year equivalent = Reference year energy use x Production factor.

Matching Energy Usage to Requirement

Mismatch between equipment capacity and user requirement often leads to inefficiencies due to part load operations, wastages etc. Worst case design, is a designer's characteristic, while optimization is the energy manager's mandate and many situations present themselves towards an exercise involving graceful matching of energy equipment capacity to end-use needs. Some examples being:

- Eliminate throttling of a pump by impeller trimming, resizing pump, installing variable speed drives
- Eliminate damper operations in fans by impeller trimming, installing variable speed drives, pulley diameter modification for belt drives, fan resizing for better efficiency.
- Moderation of chilled water temperature for process chilling needs
- Recovery of energy lost in control valve pressure drops by back pressure/turbine adoption
- Adoption of task lighting in place of less effective area lighting.

Maximising System Efficiency

Once the energy usage and sources are matched properly, the next step is to operate the equipment efficiently through best practices in operation and maintenance as well as judicious technology adoption. Some illustrations in this context are:

- Eliminate steam leakages by trap improvements
- Maximize condensate recovery
- Adopt combustion controls for maximizing combustion efficiency
- Replace pumps, fans, air compressors, refrigeration compressors, boilers, furnaces, heaters and other energy consuming equipment, wherever significant energy efficiency margins exist.

Optimizing the Input Energy Requirements

Consequent upon fine-tuning the energy use practices, attention is accorded to considerations for minimizing energy input requirements. The range of measures could include:

- Shuffling of compressors to match needs.
- Periodic review of insulation thickness
- Identify potential for heat exchanger networking and process integration.
- Optimization of transformer operation with respect to load.

Fuel and Energy Substitution

Fuel substitution: Substituting existing fossil fuel with more efficient and less cost/less polluting fuel such as natural gas, biogas and locally available agro-residues.

Energy is an important input in the production. There are two ways to reduce energy dependency; energy conservation and substitution.

Fuel substitution has taken place in all the major sectors of the Indian economy. Kerosene and Liquefied Petroleum Gas (LPG) have substituted soft coke in residential use.

Few examples of fuel substitution

- Natural gas is increasingly the fuel of choice as fuel and feedstock in the fertilizer, petro chemicals, power and sponge iron industries.
- Replacement of coal by coconut shells, rice husk etc.
- Replacement of LDO by LSHS Few examples of energy substitution

Replacement of electric heaters by steam heaters
Replacement of steam based hot water by solar systems

Case Study: Example on Fuel Substitution

A textile process industry replaced old fuel oil fired thermic fluid heater with agro fuel fired heater. The economics of the project are given below:

A: Title of Recommendation : Use of Agro Fuel (coconut chips) in place of Furnace oil in a Boiler
B: Description of Existing System and its operation : A thermic fluid heater with furnace oil currently.
In the same plant a coconut chip fired boiler is operating continuously with good performance.

C: Description of Proposed system and its operation : It was suggested to replace the oil fired thermic fluid heater with coconut chip fired boiler as the company has the facilities for handling coconut chip fired system.

D: Energy Saving Calculations
<u>Old System</u>
Type of fuel Firing : Furnace Oil fired heater
GCV : 10,200 kCal/kg
Avg. Thermal Efficiency : 82%
Heat Duty : 15 lakh kCal / hour
Operating Hours : 25 days x 12 month x 24 hours = 7,200 hrs.
Annual Fuel Cost : Rs.130 lakh (7200 x 1800 Rs./hr.)

Modified System

Type of fuel saving = Coconut chips fired Heater
GCV = 4200 kCal/kg
Average Thermal Efficiency = 72 %
Heat Duty = 15 lakh kCal / hour
Annual Operating Cost = 7200 x 700 Rs./hr = 50 lakh
Annual Savings = 130 - 50 = Rs.80 lakh .
Additional Auxiliary Power +
Manpower Cost = Rs. 10 lakh
Net Annual Saving = Rs. 70 lakh Investment for New Coconut Fired heater = Rs. 35 lakh

Simple pay back period = 6 months

UNIT - II

PROCEDURES AND TECHNIQUES, EVALUATION OF SAVING OPPORTUNITIES AND ENERGY AUDIT REPORTING

Different Sources of Energy:

Different sources of energy are used primarily to produce electricity. The world runs on a series of electrical reactions – whether you are talking about the car you are driving or the light you are turning on. All of these different sources of energy add to the store of electrical power that is then sent out to different locations via high powered lines.

1. Solar Energy: Solar power harvests the energy of the sun through using collector panels to create conditions that can then be turned into a kind of power. Large solar panel fields are often used in desert to gather enough power to charge small substations, and many homes use solar systems to provide for hot water, cooling and supplement their electricity. The issue with solar is that while there is plentiful amounts of sun available, only certain geographical ranges of the world get enough of the direct power of the sun for long enough to generate usable power from this source.

2. **Wind Energy:** Wind power is becoming more and more common. The new innovations that are allowing wind farms to appear are making them a more common sight. By using large turbines to take available wind as the power to turn, the turbine can then turn a generator to produce electricity. While this seemed like an ideal solution to many, the reality of the wind farms is starting to reveal an unforeseen ecological impact that may not make it an ideal choice.

3**. Geothermal Energy:**

Geothermal energy is the energy that is produced from beneath the earth. It is clean, sustainable and environment friendly. High temperatures are produced continuously inside the earth's crust by the slow delay of radioactive particles. Hot rocks present below the earth heats up the water that produces steam. The steam is then captured that helps to move turbines. The rotating turbines then power the generators. Geothermal energy can be used by a residential unit or on a large scale by a industrial application. It was used during ancient times for bathing and space heating. The biggest disadvantage with geothermal energy is that it can only be produced at selected sites throughout the world. The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California, United States.

4**. Hydrogen Energy:**

Hydrogen is available with water(H2O) and is most common element available on earth. Water contains two-thirds of hydrogen and can be found in combination with other elements. Once it is separated, it can be used as a fuel for generating electricity. Hydrogen is a tremendous source of energy and can be used as a source of fuel to power ships, vehicles, homes, industries and rockets. It is completely renewable, can be produced on demand and does not leave any toxic emissions in the atmosphere.

5. **Tidal Energy:**

Tidal energy uses rise and fall of tides to convert kinetic energy of incoming and outgoing tides into electrical energy. The generation of energy through tidal power is mostly prevalent in coastal areas. Huge investment and limited availability of sites are few of the drawbacks of tidal energy. When there is increased height of water levels in the ocean, tides are produced which rush back and forth in the ocean. Tidal energy is one of the renewable source of energy and produce large energy even when the tides are at low speed.

6. **Wave Energy:**

Wave energy is produced from the waves that are produced in the oceans. Wave energy is renewable, environment friendly and causes no harm to atmosphere. It can be harnessed along coastal regions of many countries and can help a country to reduce its dependence on foreign countries for fuel. Producing wave energy can damage marine ecosystem and can also be a source of disturbance to private and commercial vessels. It is highly dependent on wavelength and can also be a source of visual and noise pollution.

7. Hydroelectric Energy

What many people are not aware of is that most of the cities and towns in the world rely on hydropower, and have for the past century. Every time you see a major dam, it is providing hydropower to an electrical station somewhere. The power of the water is used to turn generators to produce the electricity that is then used. The problems faced with hydropower right now have to do with the aging of the dams. Many of them need major restoration work to remain functional and safe, and that costs enormous sums of money. The drain on the world's drinkable water supply is also causing issues as townships may wind up needing to consume the water that provides them power too.

8. Biomass Energy:

Biomass energy is produced from organic material and is commonly used throughout the world. Chlorophyll present in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates through the process of photosynthesis. When the plants are burned, the water and carbon dioxide is again released back into the atmosphere. Biomass generally include crops, plants, trees, yard clippings, wood chips and animal wastes. Biomass energy is used for heating and cooking in homes and as a fuel in industrial production. This type of energy produces large amount of carbon dioxide into the atmosphere.

9. Nuclear Power:

While nuclear power remains a great subject of debate as to how safe it is to use, and whether or not it is really energy efficient when you take into account the waste it produces – the fact is it remains one of the major renewable sources of energy available to the world. The energy is created through a specific nuclear reaction, which is then collected and used to power generators. While almost every country has nuclear generators, there are moratoriums on their use or construction as scientists try to resolve safety and disposal issues for waste.

10. Fossil Fuels (Coal, Oil and Natural Gas):

When most people talk about the different sources of energy they list natural gas, coal and oil as the options – these are all considered to be just one source of energy from fossil fuels. Fossil fuels provide the power for most of the world, primarily using coal and oil. Oil is converted into many products, the most used of which is gasoline. Natural gas is starting to become more common, but is used mostly for heating applications although there are more and more natural gas powered vehicles appearing on the streets. The issue with fossil fuels is twofold. To get to the fossil fuel and convert it to use there has to be a heavy destruction and pollution of the environment. The fossil fuel reserves are also limited, expecting to last only another 100 years given are basic rate of consumption.

The Different Uses of Energy in our Daily lives:

When we talk about energy saving, most of you remember being care free children at home and the adults being in a constant need to urge you to switch off the lights or the television or the washing machine. Now that you are an adult, you understand why it was important to actually do things such as switching off the lights when you leave a room.

Energy saving has been an elusive quest for many of us living in urban developed cities. We need energy for everything in our household and it is one of the earmarks of modern living and convenience. We use energy for everything in the home and in the office and basically to perform daily tasks.

Energy use can be divided many different ways but the most common is through the the end product -- either electricity; thermal energy, which is heating/cooling (including hot water); or transportation. You can also break down energy into its end-users, which are described below.

1. **Residential uses of energy:**

When we talk about residential uses of energy, these are the most basic uses of energy. They include watching television, washing clothes, heating and lighting the home, taking a shower, working from home on your laptop or computer, running appliances and cooking. Residential uses of energy account for almost forty percent of total energy use globally.

Waste in this category of use is also the highest globally. This can be attributed to the lack of education offered to the public on how to conserve the energy they use daily, or to the lack of energy conservation products available in the market. Most people are ignorant to the fact that there are avenues or companies and innovations available that can help them monitor and reduce the amount of energy they use.

2. Commercial uses of energy:

Commercial use of energy is what energy is used for in the commercial sector. This includes heating, cooling and lighting of commercial buildings and spaces, power used by companies and business throughout our cities for computers, fax machines, workstations, copiers just to name but a few.

The uses of energy in the commercial space is more or less similar to the uses in the industrial space save for personal uses. Energy saving here though, is targeted at the corporate world rather than at individuals. Players in the sector of energy conservation should introduce energy saving campaigns in order to curb the culture of waste present at our places of work.

3. Transportation:

Transportation is one hundred percent dependent on energy. Over seventy percent of petroleum used goes into the transport sector. The transport sector includes all vehicles from personal cars to trucks to buses and motorcycles. It also includes aircrafts, trains, ship and pipelines.

The transportation sector can be very vital in the overall quest for energy conservation. Innovations such as the introduction of more fuel efficient vehicles and development of alternative sources of energy for our transport system can greatly help in the saving of energy

Efforts at energy conservation can be made on a global scale if we factor in the uses and deal with them one by one. If we focus on them as individual uses rather than trying to find a solution as a whole, we will make much bigger strides in conservation.

4. Industry uses many energy sources:

The U.S. industrial sector uses a variety of energy sources including

- Natural gas
- Petroleum, such as distillate and residual fuel oils and hydrocarbon gas liquids
- Electricity
- Renewable sources, mainly biomass such as pulping liquids (called*black liquor*) and other residues from paper making and residues from agriculture, forestry, and lumber milling operations
- Coal and coal coke

Most industries purchase electricity from electric utilities or independent power producers. Some industrial facilities generate electricity for use at their plants using fuels that they purchase or the residues from their industrial processes. A few produce electricity with solar photovoltaic systems located on their properties. Some of them sell some of the electricity that they generate.

Industry uses fossil fuels and renewable energy sources for

- Heat in industrial processes and space heating in buildings
- Boiler fuel to generate steam or hot water for process heating and generating electricity
- Feedstock's (raw materials) to make products such as plastics and chemicals

The industrial sector uses electricity for operating industrial motors and machinery, lights, computers, and office equipment and for facility heating, cooling, and ventilation equipment.

Energy use by type of industry

Every industry uses energy, but three industries account for most of the total U.S. industrial sector energy consumption. The U.S. Energy Information Administration estimates that in 2017, the bulk chemical industry was the largest industrial consumer of energy, followed by the refining industry and the mining industry. These three industries combined accounted for about 58% of total U.S. industrial sector energy consumption.

Interesting Facts about Energy

- Only 10% of energy in a light bulb is used to create light. Ninety percent of a light bulb's energy creates heat. Compact fluorescent light bulbs (CFLs), on the other hand, use about 80% less electricity than conventional bulbs and last up to 12 times as long.
- Refrigerators in the U.S. consume about the same energy as 25 large power plants produce each year.
- The amount of energy Americans use doubles every 20 years.
- About 5,000 years ago, the energy people consumed for their survival averaged about 12,000 kilocalories per person each day. In AD 1400, each person was consuming about twice as much energy (26,000 kilocalories). After the Industrial Revolution, the demand almost tripled to an average of 77,000 kilocalories per person in 1875. By 1975, it had tripled again to 230,000 kilocalories per person.
- The world's biggest blackout occurred on August 14, 2004, when a massive power outage occurred across the northeastern U.S. and throughout Ontario, Canada, affecting 50 million people.
- 6.From 2008 to 2030, world energy consumption is expected to increase more than 55%**.**
- Google accounts for roughly 0.013% of the world's energy use. It uses enough energy to continuously power 200,000 homes.
- According to Google, the energy it takes to conduct 100 searches on its site is equivalent to a 60-watt light bulb burning for 28 minutes. Google uses about 0.0003 kWh of energy to answer the avenge search query, which translates into about 0.2 g of carbon dioxide released.
- The United States produces half of its electricity from coal. China uses coal to generate more than three-fourths of its electricity. Australia, Poland, and South Africa produce an even greater percentage. Overall, coal makes up 2/5 of the world's electricity generation.
- Ten countries produce 2/3 of the world's oil and hold the same percentage of known reserves. Saudi Arabia tops both lists.
- Ten countries produce 2/3 of the world's natural gas and hold about the same percentage of known reserves.
- The United States produces more nuclear-generated electricity than any other country, nearly 1/3 of the world's total. The second largest producer is France, which generates more than 3/4 of its electricity in nuclear reactors.
- Electric utilities are the largest source of greenhouse gas in America**.**

Questionnaire

A questionnaire is a research instrument consisting of a series of questions (or other types of prompts) for the purpose of gathering information from respondents. The questionnaire was invented by the Statistical Society of London in 1838.

Although questionnaires are often designed for statistical analysis of the responses, this is not always the case.

Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile data. However, such standardized answers may frustrate users. Questionnaires are also sharply limited by the fact that respondents must be able to read the questions and respond to them. Thus, for some demographic groups conducting a survey by questionnaire may not be concrete.

Question type

Usually, a questionnaire consists of a number of questions that the respondent has to answer in a set format. A distinction is made between open-ended and closed-ended questions. An open-ended question asks the respondent to formulate his own answer, whereas a closed-ended question has the respondent pick an answer from a given number of options. The response options for a closed-ended question should be exhaustive and mutually exclusive. Four types of response scales for closed-ended questions are distinguished:

- Dichotomous, where the respondent has two options
- Nominal-polytomous, where the respondent has more than two unordered options
- Ordinal-polytomous, where the respondent has more than two ordered options
- (Bounded)Continuous, where the respondent is presented with a continuous scale

A respondent's answer to an open-ended question is coded into a response scale afterwards. An example of an open-ended question is a question where the testie has to complete a sentence (sentence completion item).

Question sequence

In general, questions should flow logically from one to the next. To achieve the best response rates, questions should flow from the least sensitive to the most sensitive, from the factual and behavioral to the attitudinal, and from the more general to the more specific.

There typically is a flow that should be followed when constructing a questionnaire in regards to the order that the questions are asked. The order is as follows:

1. Screens
2. Warm-ups
3. Transitions
4. Skips
5. Difficult
6. Classification

Screens are used as a screening method to find out early whether or not someone should complete the questionnaire. **Warm-ups** are simple to answer, help capture interest in the survey, and may not even pertain to research objectives. **Transition** questions are used to make different areas flow well together. **Skips** include questions similar to "If yes, then answer question 3. If no, then continue to question 5." **Difficult** questions are towards the end because the respondent is in "response mode." Also, when completing an online questionnaire, the progress bars lets the respondent know that they are almost done so they are more willing to answer more difficult questions. **Classification**, or demographic question should be at the end because typically they can feel like personal questions which will make respondents uncomfortable and not willing to finish survey.

Basic rules for questionnaire item construction

- Use statements which are interpreted in the same way by members of different subpopulations of the population of interest.
- Use statements where persons that have different opinions or traits will give different answers.
- Think of having an "open" answer category after a list of possible answers.
- Use only one aspect of the construct you are interested in per item.
- Use positive statements and avoid negatives or double negatives.
- Do not make assumptions about the respondent.
- Use clear and comprehensible wording, easily understandable for all educational levels
- Use correct spelling, grammar and punctuation.
- Avoid items that contain more than one question per item (e.g. Do you like strawberries and potatoes?).
- Question should not be biased or even leading the participant towards an answer.

Multi-item scales

- Multiple statements or questions (minimum ≥3; usually ≥5) are presented for each variablebeing examined.
- Each statement or question has an accompanying set of equidistant response-points (usually 5-7).
- Each response point has an accompanying verbal anchor (e.g., "strongly agree") ascending from left to right.
- Verbal anchors should be balanced to reflect equal intervals between response-points.
- Collectively, a set of response-points and accompanying verbal anchors are referred to as a rating scale. One very frequently-used rating scale is a Likert scale.
- Usually, for clarity and efficiency, a single set of anchors is presented for multiple rating scales in a questionnaire.
- Collectively, a statement or question with an accompanying rating scale is referred to as an item.
- When multiple items measure the same variable in a reliable and valid way, they are collectively referred to as a multi-item scale, or a psychometric scale.
- The following types of reliability and validity should be established for a multi-item scale: internal reliability, test-retest reliability (if the variable is expected to be stable over time), content validity, construct validity, and criterion validity.
- Factor analysis is used in the scale development process.
- Questionnaires used to collect quantitative data usually comprise several multi-item scales, together with an introductory and concluding section.

Main modes of questionnaire administration

- Face-to-face questionnaire administration, where an interviewer presents the items orally.
- Paper-and-pencil questionnaire administration, where the items are presented on paper.
- Computerized questionnaire administration, where the items are presented on the computer.
- Adaptive computerized questionnaire administration, where a selection of items is presented on the computer, and based on the answers on those items, the computer selects following items optimized for the testee's estimated ability or trait.

Concerns with questionnaire

While questionnaires are inexpensive, quick, and easy to analyze, often the questionnaire can have more problems than benefits. For example, unlike interviews, the people conducting the research may never know if the respondent understood the question that was being asked. Also, because the questions are so specific to what the researchers are asking, the information gained can be minimal. Often, questionnaires such as the Myers-Briggs Type Indicator, give too few options to answer; respondents can answer either option but must choose only one response. Questionnaires also produce very low return rates, whether they are mail or online questionnaires. The other problem associated with return rates is that often the people who do return the questionnaire are those who have a really positive or a really negative viewpoint and want their opinion heard. The people who are most likely unbiased either way typically don't respond because it is not worth their time.

One key concern with questionnaires is that there may contain quite large measurement errors . These errors can be random or systematic. Random errors are caused by unintended mistakes by respondents, interviewers and/or coders. Systematic error can occur if there is a systematic reaction of the respondents to the scale used to formulate the survey question. Thus, the exact formulation of a survey question and its scale are crucial, since they affect the level of measurement error . Different tools are available for the researchers to help them decide about this exact formulation of their questions, for instance estimating the quality of a question using MTMM experiments or predicting this quality using the Survey Quality Predictor software (SQP). This information about the quality can also be used in order to correct for measurement errors.

Further, if the questionnaires are not collected using sound sampling techniques, often the results can be non-representative of the population—as such a good sample is critical to getting representative results based on questionnaires.

Incremental Cost

Production activities, such as sales, machine hours or productive area dimensions, incur expenses. As these activities increase or decrease, total expenses to the company also change. For example, if a company responded to greater demand for its widgets by increasing production from 9,000 units to 10,000 units, it will incur additional costs to make the extra 1,000 widgets. If the total production cost for 9,000 widgets was $45,000, and the total cost after adding the additional 1,000 units increased to $50,000, the incremental cost for the additional 1,000 units is $5,000.

Usefulness of Incremental Costs

Incremental costs are relevant in making short-term decisions or choosing between two alternatives, such as whether to accept a special order. If a reduced price is established for a special order, it is critical the revenue received from the special order at least covers the incremental costs, or the special order results in a net loss. Incremental costs are also useful for decisions on whether to manufacture a good or purchase it elsewhere. Only the additional costs associated with the manufacturing of the good should be considered and compared to the retail price in this scenario.

Incremental Cost Analysis

Incremental cost analysis is utilized to analyze business segments with the intent of determining the profitability of the segment. All fixed costs, such as rent, are omitted from incremental cost analysis because they do not change and are generally not specifically attributable to any one business segment. Only the relevant incremental costs that can be directly tied to the business segment, such as variable wages, utilities and materials, should be considered in evaluating the profitability of a business segment.

Mass and Energy Balances

A **mass balance**, also called a **material balance**, is an application of conservation of mass to the analysis of physical systems. By accounting for material entering and leaving a system, mass flows can be identified which might have been unknown, or difficult to measure without this technique. The exact conservation law used in the analysis of the system depends on the context of the problem, but all revolve around mass conservation, i.e. that matter cannot disappear or be created spontaneously.

Therefore, mass balances are used widely in engineering and environmental analyses. For example, mass balance theory is used to design chemical reactors, to analyze alternative processes to produce chemicals, as well as to model pollution dispersion and other processes of physical systems.

Closely related and complementary analysis techniques include the population balance, energy balance and the somewhat more complex entropy balance. These techniques are required for thorough design and analysis of systems such as the refrigeration cycle.

In environmental monitoring the term **budget calculations** is used to describe mass balance equations where they are used to evaluate the monitoring data (comparing input and output, etc.) In biology the dynamic energy budget theory for metabolic organization makes explicit use of mass and energy balance.

The general form quoted for a mass balance is *The mass that enters a system must, by conservation of mass, either leave the system or accumulate within the system* .

Mathematically the mass balance for a system without a chemical reaction is as follows

Strictly speaking the above equation holds also for systems with chemical reactions if the terms in the balance equation are taken to refer to total mass, i.e. the sum of all the chemical species of the system. In the absence of a chemical reaction the amount of any chemical species flowing in and out will be the same; this gives rise to an equation for each species present in the system. However, if this is not the case then the mass balance equation must be amended to allow for the generation or depletion (consumption) of each chemical species. Some use one term in this equation to account for chemical reactions, which will be negative for depletion and positive for generation. However, the conventional form of this equation is written to account for both a positive generation term (i.e. product of reaction) and a negative consumption term (the reactants used to produce the products). Although overall one term will account for the total balance on the system, if this balance equation is to be applied to an individual species and then the entire process, both terms are necessary. This modified equation can be used not only for reactive systems, but for population balances such as arise in mechanics problems. The equation is given below; note that it simplifies to the earlier equation in the case that the generation term is zero. In the absence of a nuclear reaction the number of atoms flowing in and out must remain the same, even in the presence of a chemical reaction.

- For a balance to be formed, the boundaries of the system must be clearly defined.
- Mass balances can be taken over physical systems at multiple scales.
- Mass balances can be simplified with the assumption of steady state, in which the accumulation term is zero.

A simple example can illustrate the concept. Consider the situation in which a slurry is flowing into a settling tank to remove the solids in the tank. Solids are collected at the bottom by means of a conveyor belt partially submerged in the tank, and water exits via an overflow outlet.

In this example, there are two substances: solids and water. The water overflow outlet carries an increased concentration of water relative to solids, as compared to the slurry inlet, and the exit of the conveyor belt carries an increased concentration of solids relative to water.

Assumptions

- Steady state
- Non-reactive system

Analysis

Suppose that the slurry inlet composition (by mass) is 50% solid and 50% water, with a mass flow of 100 kg/min. The tank is assumed to be operating at steady state, and as such accumulation is zero, so input and output must be equal for both the solids and water. If we know that the removal efficiency for the slurry tank is 60%, then the water outlet will contain 20 kg/min of solids (40% times 100 kg/min times 50% solids). If we measure the flow rate of the combined solids and water, and the water outlet is shown to be 65 kg/min, then the amount of water exiting via the conveyor belt must be 5 kg/min. This allows us to completely determine how the mass has been distributed in the system with only limited information and using the mass balance relations across the system boundaries.

Plant Energy Performance Improvement Study

Service Description

Process energy usage is one of the largest and most controllable operating costs in most plants. In today's environment, an energy conservation program is essential to remaining competitive. Automation improvements provide some of the most effective and easily implemented energy conservation programs available.

A Plant Energy Performance Improvement Study is a proven methodology used to identify potential process energy savings and develop economically justified automation investment programs.

Studies are conducted by senior consultants with in-depth industry and process expertise and extensive experience in saving energy through enhanced automation.

Service Objectives

- Identify process energy savings that can be attained through enhanced automation.
- Develop plans and project costs of possible automation investments
- Provide the business case and financial basis for project implementation

Typical Situations

- Interest in evaluating automation improvements toward reducing plant energy usage.
- Wish to optimize energy usage or improve energy efficiency of targeted process units.
- Need for assistance in defining an energy conservation automation investment program.

Scope of Service

- Establishment of business, operations, and energy performance goals.
- Review and audit of overall site energy balance for fuel, power, and steam.
- Survey of current processes, systems, and process equipment.
- Identification and quantification of energy savings that can be expected with improved automation.
- Estimation of automation equipment, systems, and implementation costs (±50%)
- Development of a financial return-on-investment analysis.
- Preparation of a multi-year energy conservation automation investment program.

Deliverables

- Onsite consulting and formal assessment by a senior Emerson Process Management consultant
- Detailed report documenting results, analyses, project estimates, and recommendations
- Management presentation or meeting to review and discuss results and recommendations

Service Activities

- Information gathering—Prior to onsite work, an Emerson consultant will request and review a list of base plant, process, product, and systems information for preliminary analysis.
- Business driver and site survey—An evaluation of process operations, operating objectives, constraints, cost drivers, and existing automation performance will be conducted.
- Opportunity identification—An investigation to identify potential energy improvement sources and quantify projected economic gains will be performed.
- Offsite analysis and report—A detailed report to document results, analyses, automation plans, and recommendations will be generated.
- Report transmittal and follow up—A final report will be delivered and follow-up meeting scheduled to review and discuss the report.

Service Duration

A typical Plant Energy Performance Improvement Study can take one week onsite and one month for the completion of a final report. However, as each study will be customized to specific needs and situations, the duration will vary depending on scope and complexity. Service Ordering Please contact your local Emerson sales office to retain this service. Prior to order acceptance, Emerson will issue a written proposal for your review and approval to ensure that scope, deliverables, timing, and
budget meet your needs and expectations.

UNIT – III

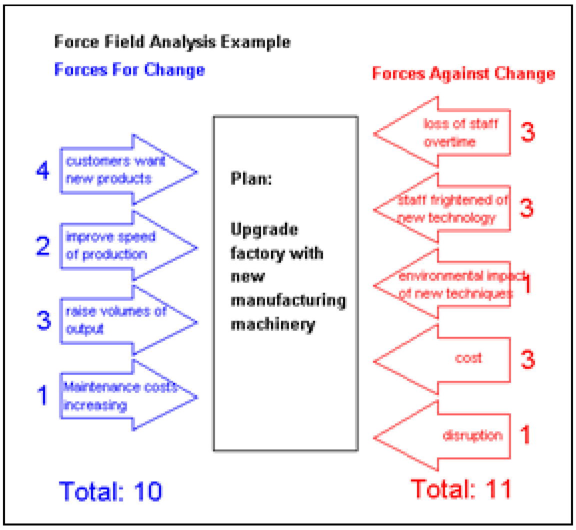
ENERGY POLICY PLANNING AND IMPLEMENTATION

Force Field Analysis

Force Field Analysis was developed by Kurt Lewin (1951) and is widely used to inform decision making, particularly in planning and implementing change management programmes in organisations. It is a powerful method of gaining a comprehensive overview of the different forces acting on a potential organisational change issue, and for assessing their source and strength.

Detailed description of the process

Force field analysis is best carried out in small group of about six to eight people using flipchart paper or overhead transparencies so that everyone can see what is going on. The first step is to agree the area of change to be discussed. This might be written as a desired policy goal or objective. All the forces in support of the change are then listed in a column to the left (driving the change forward), whereas all forces working against the change are listed in a column to the right (holding it back). The driving and restraining forces should be sorted around common themes and then be scored according to their 'magnitude', ranging from one (weak) to five (strong). The score may well not balance on either side. The resulting table might look like the example above.



Throughout the process, rich discussion, debate and dialogue should emerge. This is an important part of the exercise and key issues should be allowed time. Findings and ideas may well come up to do with concerns, problems, symptoms and solutions. It is useful to record these and review where there is consensus on an action or a way forward. In policy influencing, the aim is to find ways to reduce the restraining forces and to capitalise on the driving forces.

Example: Food and Agriculture Organization of the United Nations

The Food and Agriculture Organization of the United Nations (FAO) adapted force field analysis, adding an extra element of the organisation's control over a situation. For example, in an attempt to improve success in afforestation and reforestation programmes, the agency in question might list all the driving forces and restraining forces. It then rates each force by its importance and by the degree of control it exerts over that force. The totals are then calculated and a table developed. This means that for each force, the higher the total of importance and control, the more impact the agency should have in trying to address that force. In addition, if the agency can find some forces that explain others, the effectiveness of its actions will be greater. For example, suppose that 'improved operational planning' can reduce 'losses to fires and grazing' as well as 'poor procedures for hiring and paying field workers'. Because it has these cross-impacts, in this example, the agency decided to give special attention to 'operational planning'.

Energy Policy

Energy policies are the actions governments take to affect the demand for energy as well as the supply of it. These actions include the ways in which governments cope with energy supply disruptions and their efforts to influence energy consumption and economic growth.

The energy policies of the United States government have often worked at cross purposes, both stimulating and suppressing demand. Taxes are perhaps the most important kind of energy policy, and **energy taxes** are much lower in the U. S. than in other countries. This is partially responsible for the fact that energy consumption per capita is higher than elsewhere, and there is less incentive to invest in **conservation** or alternative technologies. Following the 1973 Arab **oil embargo** , the federal government instituted price controls which kept energy prices lower than they would otherwise have been, thereby stimulating consumption. Yet the government also instituted policies at the same time, such as fuel-economy standards for automobiles, which were designed to increase conservation and lower energy use. Thus, policies in the period after the embargo were contradictory: what one set of policies encouraged, the other discouraged**.**

The United States government has a long history of different types of interference in energy markets. The **Natural Gas** Act of 1938 gave the **Federal Power Commission** the right to control prices and limit new pipelines from entering the market. In 1954 The Supreme Court extended price controls to field production. Before 1970, the Texas Railroad Commission effectively controlled oil output (in the United States) through prorationing regulations that provided multiple owners with the rights to underground pools. The federal government provided tax breaks in the form of intangible drilling expenses and gave the oil companies a depletion allowance. A program was also in place from 1959 to 1973 which limited oil imports and protected domestic producers from cheap foreign oil. The ostensible purpose of this policy was maintaining national security, but it contributed to the depletion of national reserves.

Organizational Structure for Energy Management

The placement of responsibility for energy management within the organizational structure is an important decision. However, there is no one right answer to this question; rather, there are some guiding principles—energy accountability centers being an example—that can be taken from successful energy managing organizations. This Module develops those principles based on the style of organization and the nature of its business.

Organizing for Energy Management

Energy management impacts on the whole organisation; to be effective as an energy manager, you need access to all parts of the organisation. But energy management has to be located somewhere. How this is resolved depends on the structure of the
organisation and its maturity in terms of energy management practices.
Some points to consider are:

♦ Whether responsibility should be concentrated or distributed.
♦ Energy management is more than a technical function—it is management too.
♦ All managers are responsible in some way for energy
♦ Accountability for energy use should be distributed to those who control it.

The critical issue in organising for energy management is its integration into the overall management structure and process. While leadership may be placed in the hands of an individual or group of individuals, just like other management functions, energy management needs to be incorporated into the roles and responsibilities of all line managers.

Location of Energy Management Leadership

The energy management function, whether vested in one "energy manager or co-ordinator" or distributed among a number of middle managers, usually resides somewhere in the organisation between senior management and those who control the end-use of energy.
Exactly how and where that function is placed is a decision that needs to be made in view of the existing corporate structure.

Saving energy has tended to be seen as a technical activity and you may now find yourself located in a technical section within your organisation. This may be a good base for gaining control in Phase 1 of an energy management programme but it is less appropriate for training or energy information activities.
Human Resources may be a suitable location for the motivation and training activities and a finance section may, in the long term, be a good base from which to operate the financial control and accounting

procedures required in Phase 3. But both locations have disadvantages in terms of technical support and credibility.

The chief executive's office may provide the high profile and access required to kick-start energy management initially. But, in the longer term, if you want energy management to be integrated into mainstream management throughout the organisation, then this may not be the best location.

Another option is to employ outside consultants who can provide wide experience and expertise. This may be the best option in technical situations when consultants can be used to support internal personnel but it lacks the network of relationships and day-to-day contact that is crucial for informing and motivating staff.

In practice, there may be no single ideal home for all energy management activities and the optimum location may need to reflect this, altering over time as the organisation moves from one phase of its energy management programme to the next.

Each option has its own advantages and shortcomings. An important question concerns the concentration of the energy management function:

♦ Should all energy staff be kept together in a combined unit?

♦ Or is it more appropriate for them to be dispersed across the organisation?

A single unit within a particular section of the organisation has the shortest chain of command and it may also offer esprit de corps and economies of scale. But dispersed locations with responsibilities delegated between sections may be more useful in the longer term as a way of integrating energy management across the organisation’s activities.

Which of these options will prove to be best, not just in the short term but in the long run, will depend on the organisation’s specific circumstances. If energy management is based in a technical section, then there is a danger that 'saving energy' may be marginalized as a specialized technical activity. Energy is an organisation-wide management issue, not a technical specialty.

It is essential that:

♦ all managers understand that controlling energy consumption is one of their managerial responsibilities.

♦ they accept and act on this 'new' understanding and are made accountable for their own energy consumption.

Top Management Support

The status and authority of the person charged with energy management responsibility is often limited. To achieve corporate objectives, those in positions of authority need to be persuaded of the need to change the ways in which their units operate. The backing of top management is needed to accomplish this.

Without this endorsement from top management, energy management is likely to remain a low-level activity. As a result, it will not be accepted by mainstream managers and by their staff as something that needs to be treated as part of their everyday actions and activities.

The energy manager or co-ordinator, can increase his influence by building an alliance with a person within the organisation who holds a position of power and who will support energy management. However, influence acquired in this way is informal and transient. It is not an integral part of the organisation's energy management structure. If that person leaves or turns his or her attention elsewhere, then the influence is lost and the energy management effort may be in jeopardy.

Top management should be approached:

1. to get agreement for major spending on staff or energy measures
2. to provide a summary of progress
3. to gain recognition and prestige for energy management activities.

Roles and Responsibilities

Above all, energy management is a managerial function. It is for this reason that this Manual focuses almost entirely on management issues. Of course, the energy manager or co-ordinator must also be knowledgeable about technical concerns. Other workshops in this series provide that technical knowledge base.

Your tasks and responsibilities as energy manager are clearly wide ranging and may even vary over time as energy management becomes established. It may be helpful therefore to provide a sample job description for the role of energy manager.

Among the responsibilities often assigned to energy managers are:

1. Overseeing the formulation and implementation of an energy policy.
2. Introducing and maintaining cost-effective ways of providing management information about energy consumption and attendant environmental pollution.
3. Reporting such information appropriately and regularly to the staff accountable for this consumption and to senior managers.
4. Introducing and maintaining efficient and environmentally benign policies and practices for the purchase and combustion of fuels.
5. Raising and maintaining energy awareness throughout your organization.
6. Introducing and maintaining effective 'good housekeeping' and plant operating practices throughout your organization.
7. Identifying your organisation's training needs for energy-related skills and understanding.
8. Identifying cost-effective opportunities for increasing energy efficiency whether in new or existing premises.
9. Formulating an investment programme for reducing energy consumption and environmental pollution.

10. Introducing and maintaining review procedures for establishing the value for money of energy management activities, both to top management and other relevant staff.

The integration of energy management into the regular management functions involves identifying the activities that need to be carried out and determining who should be responsible for them.

Accountability

Good line management is as important as location. What is needed is:

♦ unambiguous delegation of responsibility for controlling energy consumption to appropriate budget holders in each section in the organization.

♦ one person assigned overall responsibility for co-ordinating all energy management activities and reporting regularly on how well each section is controlling the amount of energy it consumes.

♦ clear lines of reporting and accountability to that person from energy users.

♦ clear lines of reporting and accountability for energy management activities leading from that individual right up to top management.

♦ a clear inter-departmental committee structure for managing energy.

Regular reporting through the normal management structure is important. In the case of energy management reporting, some companies find it helpful to create an inter-departmental energy management committee. If this is the case in your company, the committee also would expect to receive regular reports. The advantage of such a committee is that it provides access to areas of decision-making affecting energy consumption otherwise denied you. Finally, periodic reports would normally be filed with senior management—the CEO and/or the company board.

It is also desirable to separate two key functions within energy management so that one set of individuals is responsible for making investments in energy saving measures and another for auditing the return on those investments.

Energy accountability centres

Many companies that are successful in managing energy have adopted an “energy accountability centre” (EAC) structure that places responsibility for energy budgets in the hands of line managers. The EAC structure is based in the principle that, if a

manager responsible for a department in a plant is made accountable for the energy costs of the department, and is supplied with the required information on costs and consumption, there is an incentive to find ways of improving performance.

Implementing an EAC structure involves identifying where management accountability is defined by location, installing meters on energy utilities at the point of entry to the area or department, and providing information on consumption and activity on a routine (daily, weekly or monthly) basis. Energy metering schemes are mapped on to the organisational structures.

In this way, energy consumption is managed in the same way that finances are. EACs are also integral to the implementation of energy MT&R; indeed, management responsibility for energy performance demands that the techniques associated with
MT&R be employed.

Employee Motivation

Employee motivation is a critical aspect at the workplace which leads to the performance of the department and even the company. Motivating your employees needs to be a regular routine.
There are companies that sadly fail to understand the importance of employee motivation. Research shows that many companies have disengaged employees with low motivation; only 13% of employees are engaged at work.

Importance of Employee Motivation

There are several reasons why employee motivation is important. Mainly because it allows management to meet the company's goals. Without a motivated workplace, companies could be placed in a very risky position.
Motivated employees can lead to increased productivity and allow an organisation to achieve higher levels of output. Imagine having an employee who is not motivated at work. They will probably use the time at their desk surfing the internet for personal pleasure or even looking for another job. This is a waste of your time and resources.
Note that this is based on one employee. Try picturing the majority of your employees doing the same thing. This is not a position anybody wants to be in.

Benefits of Motivated Employees

Employee motivation is highly important for every company due to the benefits that it brings to the company. Benefits include:

Increased Employee Commitment

When employees are motivated to work, they will generally put their best effort in the tasks that are assigned to them.

Improved Employee Satisfaction

Employee satisfaction is important for every company because this can lead towards a positive growth for the company.

Ongoing Employee Development

Motivation can facilitate a worker reaching his/her personal goals, and can facilitate the self-development of an individual. Once that worker meets some initial goals, they realise the clear link between effort and results, which will further motivate them to continue at a high level.

Improved Employee Efficiency

An employee's efficiency level is not only based on their abilities or qualifications. For the company to get the very best results, an employee needs to have a good balance between the ability to perform the task given and willingness to want to perform the task. This balance can lead to an increase of productivity and an improvement in efficiency.

How to Increase Employee Motivation

Communication

The easiest way to increase employee motivation is by having positive communication at the workplace. Not relying only on emails but by making sure they talk to their employees in person and even on a personal level, if possible.

Try setting aside some time each day to talk with employees or you can join them during coffee breaks instead of sitting at your desk. By doing so, you actually make employees feel as though you are part of the team; a leader instead of just the boss.

Employees also want to see the company that they are working for succeed. Many have excellent ideas, ranging from money saving to operational improvements. Management must make an effort to take some time to ask and listen to suggestions. Nothing is more worthwhile than feeling valued.

Value Individual Contributions

Management should ensure their employees on how their individual efforts and contribution plays an important part of the company's overall goals and direction. Employees will take pride and be engaged in their work if they are aware how their efforts create an impact the organisation; regardless of how big or small their contributions are.

Management does not have to reward their employees with gifts every single time they did a good job at a task. At times, a simple "Thank You" or "Great job" will suffice. These meaningful words acknowledge effort, build loyalty and encourage people to work even harder.

Positive Workplace Environment

Sometimes, the employees lack motivation because their workplace does not have a positive work environment. To fix this, management could sent out surveys and get feedback from employees in order to solve the issues that they may face.

Management could also post a positive quote or picture by the copier, coffee machine or somewhere else that is visible and that receives high foot traffic so that others can see. Flora and fauna also helps create a serene workplace environment for your employees, so why not add a couple of plants around the office.

Management could also find creative ways in which to consistently keep their employees motivated as much as possible.

Strategic Marketing Plan

10 steps to developing a strategic marketing plan:

1. Set goals and objectives. Before you create a marketing plan, you must have a purpose for it. This purpose is based on the long-term goals that guide all of your efforts. Once these long-term goals are established, break them down into specific objectives. Your objectives should be measurable over a period of time. For example, your goal may be to establish a social media marketing strategy. Meanwhile, an objective related to this goal could be to gain 100 followers on social media during the first month on the platform.

2. Analyze your situation. A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis can give you a snapshot of the situations you face as you market your business. Your strengths are what make your business unique, while your weaknesses are what you can improve on. The economy, your competitors, technology, and other external factors contribute to your opportunities and threats. By analyzing your situation this way, you can improve your marketing strategies, while overcoming challenges that may or may not be in your control. Create customer personas to help figure out who your ideal customers. This will help with your analysis. To get you started, we've created a Customer Persona Checklist.

As part of our analysis, Pulse uses a template that outlines an ideal customer persona, the tone of our content, and the benefits of our services.

3. Map your messages. Your messaging is part of your marketing strategy and your brand. To create a message map, start by writing an XYZ statement or boilerplate that contains basic information about your business. Then, center other messaging related to your products, clients, and services around the XYZ statement. These messages can then be incorporated into your mission statement, press releases, and other marketing materials. To learn how to craft messaging that creates the best image of your business, check out our Content Writing Checklist.

4. Live out your mission. Your business has a set of values that guides it. Creating a mission statement outlines these values and ensures that the people who interact with your business are aware of them. Just be sure that this message reflects your brand honestly so you can actively demonstrate the values outlined in the mission statement through your interactions with clients. This statement and how it is carried out can make or break your clients' trust.

Pulse takes pride in being your local, friendly marketing team, which is why it is our tagline. We demonstrate those values by being involved in our community.

5. Outline your tactics. A successful marketing strategy is made up of many different tactics, including both online and offline options. Your goals, target audience, and industry factor into this decision. For example, if your target audience is young, focusing on social media is more beneficial as this is primarily where this group consumes content. If your industry is product-based (for example, if you design jewelry), then using a more visual platform would better showcase your products. To be most effective, you have to choose which methods are right for your business. Once you've selected your tactics, list them in your marketing plan and determine how they'll help you reach your goals.

6. Make a timeline. Your time is precious, especially when it comes to your marketing strategies. Based on the goals and objectives you've set for your business, create a timeline that will determine what will be completed and when. Remember to allow extra time for unexpected events that may delay some of your goals.

Using project management software can help you to create a timeline. At Pulse, we use Wrike, a program that enables us to schedule projects on a timeline, as seen below.

7. Mind your budget. Creating a budget for your marketing strategies can inform your efforts by determining what you can and can't afford. Choosing the most cost-effective options for your business ensures the success of your overall marketing plan. This doesn't have to limit your options. Paid advertising on social media and search engines allows you to choose the amount you can afford to pay, making them accessible to even the smallest of budgets.

8. Divide and conquer. Once you've created a timeline for the creation and distribution of your marketing materials, assign these tasks to members of your staff. If your business is small and doesn't have the staff required to carry out your plan, you may need to consider hiring another person or a marketing agency. Ultimately, your staff's size and qualifications will determine this for you.

9. Measure up. Measuring the effectiveness of your marketing strategies will inform your current plan and your future efforts. Your website, social media, and other marketing materials are sources of this information. To help you track this , there are many free online analytics tools available. Just be sure to only track data relevant to your business so these measurements are effective.

10. Stay current. Your marketing goals and needs will change over time. Ideally, you should revisit your marketing plan once a year and make adjustments as necessary. You should write your marketing plan with this growth in mind so you can measure it. In the meantime, follow industry news and trends that you can add to your own strategies.

Establishing a marketing plan keeps your business goals organized and focused, saving valuable time and money. Even if you already have a marketing plan, you can still reap these benefits by keeping it up-to-date.

Communications training

Communications training or **communication skills training** refer to various types of training to develop necessary skills for communication. Effective communication is vital for the success in various situations. Individuals undergo communications training to develop and improve communication skills related to various roles in organizations.

In organizations, it is necessary to communicate with different sub-groups and overcome difficulties in effective communication. Since each sub-group has a unique sub-culture, an effective communications trainer may assist organizational members in improving communications between sub-groups of the organization. It is necessary to ensure that communications between individuals the various sub-cultures serve to meet the mission and goals of the organization. Communications training can assist leaders to develop the ability to perceive how various individuals and subgroups relate to each other and make appropriate interventions

Types of skill development:

- Listening skills
- Influence Skills
- Responding to conflict
- Customer service
- Assertiveness skills
- Negotiation
- Facilitation
- Report writing; business and technical writing
- Public speaking, effective presentation
- Speaking skills
- Interacting skills

Why a Communication Plan?

Employee engagement and satisfaction surveys consistently report poor communications as a leading cause of employee disenchantment. The lack of quality communication is also a major reason for project failure. If your training program is a key component of an organizational change or improvement initiative, getting the communications right will save you a lot of heartache further down the track.

A large program will involve multiple stakeholders over a considerable period of time. People who need to be involved may span departments, buildings, provinces or even countries. The duration of your program may be many weeks, months or even years. Planning for the *what*, *where*, *who*, *when* and *why*of your communications up front will achieve two key objectives. Communicating effectively will:

1. keep the relevant people informed at appropriate times of the key information that they will use to further the aims of the program, and
2. keep people onside during difficult periods by conveying the feeling that you are considering their interests

An all too common example of communications neglect occurs when human resources or training personnel invite employees to a training program without a prior discussion about why their attendance is required. In these cases, neither the employee's manager nor the trainer nor anyone else engages the employee in a dialogue about the upcoming program. The employee turns up to the session already frustrated and disenchanted. This is a sure-fire way to guarantee the program's failure.

UNIT - IV

ENERGY BALANCE AND MIS

Energy and Energy Balances

System

A “system” is an object or a collection of objects that an analysis is done on. The system has a definite boundary, called the system boundary, that is chosen and specified at the BEGINNING of the analysis. Once a system is defined, through the choice of a system boundary, everything external to it is called the surroundings. All energy and material that are transferred out of the system enter the surroundings, and vice versa. In the general case there are very few restrictions on what a system is; a system can have a nonzero velocity, a nonzero acceleration, and a system can even change in size with time.

An **isolated system** is a system that does not exchange heat, work, or material with the surroundings.
If heat and work are exchanged across a system’s boundary, but material is not, it is a closed system.
An **open system** can exchange heat, work, and material with the surroundings.
Examples. Discuss each situation below as approximating an isolated, a closed, or an open system.
(i) A river.
(ii) The interior of a closed can of soda.
(iii) The interior of a closed refrigerator that is turned on.
(iv) The interior of a closed refrigerator that is turned off.

State of a System

Once a system is defined, a certain number of variables will specify its state fully. For example, one may need to provide the temperature, pressure, composition, total amount of material, velocity, and position in order to specify a system’s “state.” The exact information that is needed to specify the state of a system depends on the type of system and the analysis to be performed.

State Functions and State Properties

The state of a system can be changed, for example by increasing its temperature or changing its composition. Properties of the system whose change depends only on the initial (before) and final states of the system, but not on the manner used to realize the change from the initial to the final state, are referred to as state properties or state functions. In other words, the change in a state function or state property X, between some final (state 2) and initial (state 1) situations, can be expressed as state 2 state1

change in X

$$\Delta X = X_{final} - X_{initial} \equiv X - X \; 1424\;434 \qquad (1)$$

In equation 1, Xfinal only depends on the final state of the system, and Xinitial only on the initial state of the system. Equation 1 does not require any information whatsoever as to how the system got from the initial to the final state, since X does not depend on the details of the path followed.

Example. Which of the below examples represent changes in state functions?

(i) Work done to climb from the bottom (state 1) to the top (state 2) of a mountain.

(ii) Change in gravitational energy of an object when it is raised from the bottom (state 1) to the top (state 2) of a mountain.

(iii) Change in density of water in a pot when it is heated from 20 oC (state 1) to 50 oC (state 2).

(iv) Amount of heat liberated from burning gas in a stove in order to realize a temperature change of the water in a pot from 20 oC (state 1) to 50 oC (state 2).

Forms of Energy: The First Law of Thermodynamics

Energy is often categorized as:

A. Kinetic Energy

B. Potential Energy

C. Internal Energy

Kinetic Energy

A system's kinetic energy is associated with directed motion (e.g. translation, rotation) of the system. Translation refers to straight line motion. The kinetic energy E_k of a moving object of mass m and travelling with speed u is given by,

$$E_k = 1/2(mu^2) \quad (2)$$

Note that u is measured relative to a frame of reference that defines what is "stationary". E_k has units of energy, m of mass, and u of length/time.

How could the kinetic energy of a system change?

Is kinetic energy a state function?

Potential Energy

Potential energy of a system is due to the position of the system in a potential field. There are various forms of potential energy, but only gravitational potential energy will be considered in this course. The gravitational potential energy of an object of mass m at an elevation z in a gravitational field, relative to its gravitational potential energy at a reference elevation z0, is given by

$$E_p = mg(z - z_o) = mgz - mgz_o \quad (3)$$

The quantity g is the gravitational acceleration that defines the strength of the gravitational field. Often, the earth's surface is used as the reference and assigned z0 = 0, in which case mgz represents the gravitational potential energy of the object relative to its potential energy if it rested on the earth's surface. Ep has units of energy, m of mass, g of length/time2 , and z of length.

How could the gravitational potential energy of a system change?

Is gravitational potential energy a state function?

Internal Energy

All the energy associated with a system that does not fall under the above definitions of kinetic or potential energy is internal energy. More specifically, internal energy is the energy due to all molecular, atomic, and subatomic motions and interactions. Usually, the complexity of these various contributions means that no simple analytical expression is available from which internal energy can be readily calculated. The internal energy will be represented by the symbol U.

What types of events would bring about a change in a system's internal energy?

Is internal energy a state function?

Enthalpy

The enthalpy H of a system is defined by

where P is the pressure and V is volume. Let's think about the PV term. We know that PA, where A is the area subjected to a pressure P, is the force acting on that area. If a fluid inside a system is displaced through a distance d by the force PA, then the resultant work W done on the system can be calculated as the product of this force times the displacement. In other words, W = PAd. Now note that Ad = V, the volume swept out by the displacement. Thus, an alternate way to write the displacement work is W = PV. This type of work, where pressure results in the displacement of a fluid, will be referred to as flow work. If an amount of fluid of volume V is inserted into a system against a pressure P, the work required to accomplish this is PV. Enthalpy, therefore, can be viewed as the sum of the internal energy of this fluid volume added to the system plus the flow work performed on the system in order to insert the fluid. Enthalpy has units of energy (e.g. J, cal, BTU).

What types of events would bring about a change in a system's enthalpy?

Is enthalpy a state function?

Specific Properties

The total internal energy, enthalpy, kinetic energy, and potential energy of a system are extensive properties. An extensive property depends on the total number of molecules present in the system and on the system's total size. Often, it is more convenient to refer to the amount of a property per mass of the system. For example, if the system is a fluid phase, one may want to express the amount of internal energy or enthalpy contained in a unit mass of the fluid. If one refers to an amount of a property per mass, one is speaking about a specific property. Specific properties are intensive. Thus, specific volume is volume per mass, specific internal energy is internal energy per mass, and specific enthalpy is enthalpy per mass. Specific properties will be identified by a "^" symbol above them; thus, Vˆ = specific volume (units: volume/mass; e.g. m3/kg, ft3/lbm), Uˆ = specific internal energy (units: energy/mass; e.g. J/kg, BTU/lbm), Hˆ = Uˆ + PVˆ = specific enthalpy (units: energy/mass; e.g. J/kg, cal/g), etc.

Given a mass m of a uniform system with a specific property Xˆ, the corresponding extensive amount of X in the system is found using $X = m \hat{X}$. How would you use this expression to calculate the extensive volume of a system? The extensive enthalpy of a system?

Reference States

The specific internal energy and specific enthalpy of a material are always defined relative to a reference state. The reference state can be chosen to refer to any set of conditions, although often it is chosen to be 0 oC and 1 atm. Then, one speaks of Uˆ

or Hˆ of a material relative to the value of Uˆ or Hˆ of that material in the reference state. What is the value of Uˆ or Hˆ for the material in its reference state? Now imagine that a system passes from state 1 to state 2. In general, Uˆ or Hˆ will change when the state of the system changes, with the difference being

$\Delta \hat{U} = \hat{U}_2 - \hat{U}_1$ and $\Delta \hat{H} = \hat{H}_2 - \hat{H}_1$

Does the choice of a reference state affect the value of ΔUˆ or Δ Hˆ ?

Note that, in calculations, we will only be interested in how much the internal energy or enthalpy changed. That is, we will only need to calculate ΔUˆ and Δ Hˆ, but not the absolute values of internal energy or enthalpy.

Heat

When there is a difference in temperature between two points, heat is transferred (flows) from high temperature to the low temperature. By convention the numerical value of heat transferred is positive when it is transferred into the system, thereby increasing the energy contained in the system. That is, if Q is the heat transferred from the surroundings to the system, then $Q > 0$ means that net heat is transferred to the system so as to increase the energy of the system. If $Q < 0$, then net heat is transferred from the system to the surroundings, and the system has lost energy. Note that Q has units of energy (e.g. J, BTU, cal).

Is the heat transferred in going from state 1 to state 2 a state function?

What does "transfer of heat" mean, physically? That is, what are the molecular level processes that give rise to heat transfer?

Work

When a force is applied to a system and causes a displacement, then work has been done on that system. By convention the numerical value of work W is positive when net work is performed by the system on the surroundings. Thus, $W > 0$ means that the system has performed work on the surroundings such that the energy remaining in the system has decreased. If $W < 0$, then surroundings have performed net work on the system so as to increase the system's energy. Work has units of energy (e.g. J, cal, BTU).

Is work a state function?

Provide two examples of a system undergoing work interactions with its surroundings.

Rates vs Amounts

Chemical processes use process streams to transport material from one point to another. Consider a stream with a mass flowrate m& (note that we could equivalently have used molar units). The material in the stream carries its kinetic, potential, and internal energy with it. Therefore, the mass transport is perforce accompanied by energy transport.

The rates of energy transport (units: energy/time, e.g. J/s, BTU/h) that accompany the material flow in a process stream can be calculated as follows:

Heat transport and work can be also expressed as rates, with symbols Q& and W&, respectively. The units of Q& and W& are energy/time. Note that units of energy/time are equivalently called units of power.

FIRST LAW EFFICIENCY

The first law states that energy cannot be created or destroyed, but can be converted from one form to another. As an equation, this is simply:

E system = 0 = E in – E out

Thermal energy can be increased within a system by adding thermal energy (heat) or by performing work in a system. For a closed system its change in energy will be the balance between the heat transferred to (Qin) and the work done on (Win) the system, and the heat transferred from (Q out) and work done by (W out) the system. As an equation, this can be expressed by:

ΔE = (Q in = Q out) - (W out - Win) = Q net in – W net out

or

W net, out = Q in-Q out

A heat engine (think of it like a basic power plant) works as such:

1) Air is compressed (Win);

2) Heat is added (QH or Qin);

3) Air turns turbine (W out);

4) Exhaust gases cool (Q out or QL).

Thermal efficiency is defined as:

Thermal efficiency = (net work output / total input) or η_{th} = W net, out/Qin

We are going to spend most of our time talking about heat engines that operate in a thermodynamic cycle (e.g., a power plant) – most power producing devices do. Closed systems (e.g., a steam power plant) have a working fluid (e.g., water or air), and the heat is transferred to and from this fluid as it cycles through the system. In open systems (e.g., an internal combustion engine), the working fluid (e.g., air) is continuously brought in from outside the system and released as exhaust outside the system.

SECOND LAW EFFICIENCY

The second law states that, due to the increase in entropy, heat cannot be converted to work without Creating some waste heat. There due important efficiency equations with respect to this concept**:**

1. Carnot Efficiency

Carnot efficiency is the theoretical maximum efficiency that a heat engine can achieve operating between hot and cold reservoirs with temperatures T_H and T_L, respectively:

$$\eta_C = (T_H - T_L) / T_H = 1 - (T_L - T_H)$$

The temperatures here should be in Kelvin → K = °C + 273.15 or Rankin = 460 + °F.

Second Law Efficiency

Second Law efficiency is a measure of how much of the theoretical maximum (Carnot) you achieve, or in other words, a comparison of the system's thermal efficiency to the maximum possible efficiency. The Second Law efficiency will always be between the Carnot and First Law efficiencies.

$$\eta_S = \eta_{th} / \eta_C$$

Energy Systems Integration Facility

Reducing investment risk and optimizing systems in a rapidly changing energy world

- Increasing penetration of variable RE in grid
- Increasing ultra high energy efficiency buildings and controllable loads
- New data, information, communications and controls
- Electrification of transportation and alternative fuels
- Integrating energy storage (stationary and mobile) and thermal storage
- Interactions between electricity/thermal/fuels/data pathways
- Increasing system flexibility and intelligence

Energy Systems Integration optimizes the design and performance of electrical, thermal, and fuel pathways at all scales.

Solar and Wind

ESIF System Integration Capabilities

- RE integration
- Power electronics
- Building integration
- Thermal and PV system optimization

Grid Planning and Operations

- Transmission and Distribution Systems
- Smart Grid Technologies

• Micro grids

• Standards

Energy Storage

• CSP Thermal Storage

• Utility scale batteries

• Distributed storage

Buildings

• Sensors and controls

• Design and integration

• Modeling and simulation

• Big Data warehousing and mining

• System integration

Fuel Cells and Hydrogen

•H2/electric interfaces

• RE electrolyzers

• Storage systems

• Standards

• Fuel cell integration

• Fueling systems

A Flight Simulator for Energy System Operators "connecting integration studies to operations".

Operations techniques development for:

• High renewable and energy efficiency penetrations

• New systems configurations and contingency response

• High storage / DR penetrations

• Resource forecast integration .

Process flow chart

A process flow chart is an instrument that visualises and analyses the various systems and procedures (e.g. delivery of services, decision-making, funds allocation, accounting and monitoring) within an organisation.

The flow chart analysis helps to identify the bottlenecks in the different processes within the organisation. It identifies unnecessary involvement of people, loopholes in decision making or unnecessary delays in the process. It assists to make the organisation more efficient in its operations.

The process flow chart helps to design new processes for the primary process, support processes and supervisory processes, and helps to analyse the bottlenecks in existing procedures. It is very useful to help participants understand the interrelation of the work activities and to realise how the work of one person influences the others.

A process flow chart can be made on an individual basis or in a group (not more than 20 people) on a participatory basis. If made with a few key people it should be adjusted and/or endorsed by all actors in the process. Decision-making is to be prepared for the management concerned to improve the process. It is also a useful tool for presentation purposes to show how processes actually take place (or should look like). Depending on complexity of the process it will take 1-2 hours per process.

Ground work

The choice of which process to analyse should be made in a clear and clever manner: Relevant to the (core) problem owner, and of interest to the other involved stakeholders. A process flow chart can very well be a starting point of an organisation analysis, but may also be chosen if other observations indicate confusion or problems in the way the organisation acts what it does.

Follow up

Depending on the problems identified it can be followed by other analysis tools e.g. using the Integrated Organisation Model to dig deeper into the problem or combining the problems with other related problems in a problem tree analysis or a SWOT.

Requirements and limitations

It is important not to mix up different processes or different levels of abstraction (activities and sub-activities) in one chart. Sometimes it is difficult to define the process to analyse. Certain activities are cyclic and do not have a clear beginning and end. If not used adequately it may turn simple activities into a complicated chart. In a participatory approach there is a danger that participants mix up the present (actual practice), planned (official way of working) and the desired situation. We recommend visualising only one at the time.

Steps in making a process flow chart

0. Formulate the (sub-) question that you want to answer by making a process flow chart.

Aims for which a process flow chart is suitable are:

• To decide how to optimise core processes (operational planning and strategic decision making)
• To prepare strategic choices, identifying strengths and weaknesses (step to strategic decision making)
• To judge organisation suitability and performance (to make funding and programme positioning decisions)

0. Define the field of analysis. Decide whether you depict:

• Current practice (daily practice; the informal reality)
• Current design (how it should happen according to 'the books')
• Redesign (establishing the desired process)
• Clearly distinguish current practice from current design and/or redesign
• Analyse the redesign (and even current design) only after the current practice

1. Choose the process.

• Which process are you going to analyse?

• Unique or standard

• Define the starting point

• Specify the outcome/result of the process

2. Describe the process as indicated below, using the indicated symbolism:

• State the start and end point (outcome/result)

• Divide the process in 5-10 activities of the same level of analysis ("Giving a presentation" is of different level than "Conducting a course").

If you have more than 10 steps:

• Cluster them or

• Make more than one flow chart

• Identify decision moments. Describe these decision moments in yes/no questions. Check that both the "Yes"-side and the "No"- side have a follow-up activity (arrow that leads somewhere), if that is reality.

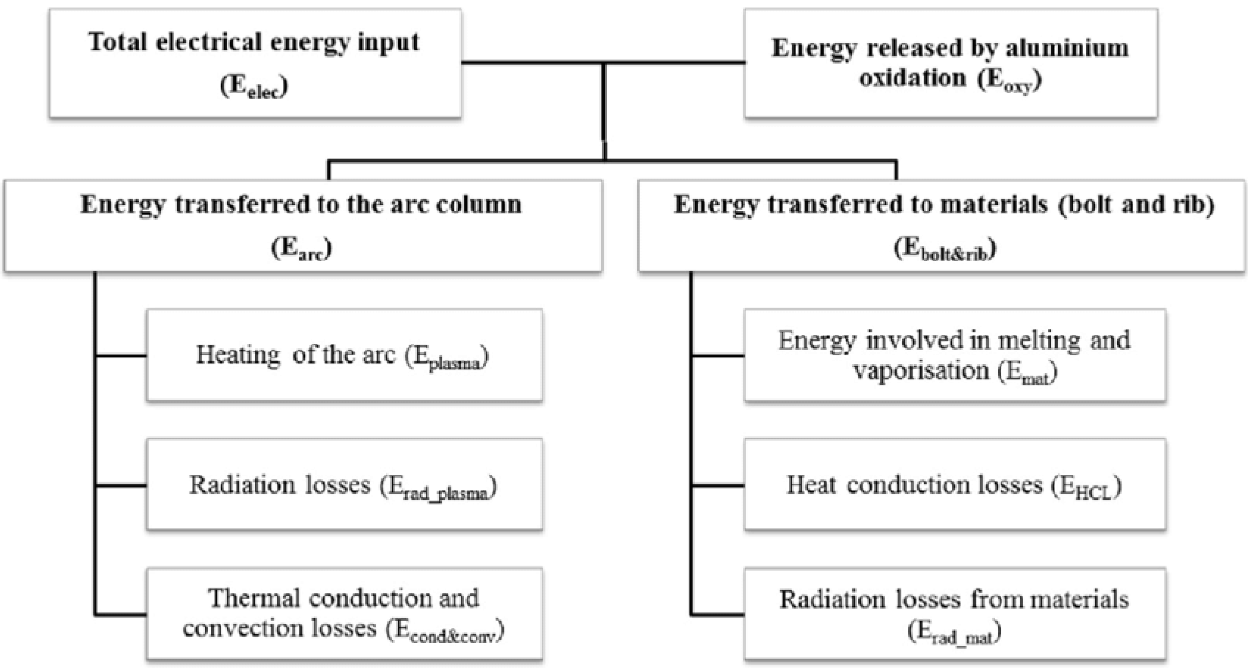
For example: Proposal approved?

• Yes: Proceed + Send confirmation to client

• No: File the proposal + Inform client with reasons

• Identify the responsible person/unit for each activity (this may not be the same as the implementing person). All activities/ decision moments that follow the symbol are the responsibility of the person/unit indicated. Therefore, if the responsible person/unit stays the same, you need not repeat the in-charge.

Materials And Energy Balance Diagram



Energy Use, Loss and Opportunities

The industrial sector uses about one-third of the total energy consumed annually in the United States most of it fossil fuels, at a cost of approximately $100 billion. Given that energy resources are limited, and demand for industrial products continues to rise, meeting industrial energy demand and minimizing its economic impact in the future will be a significant challenge.

The U.S. manufacturing sector depends heavily on fuels and power for the conversion of raw materials into usable products,

and also uses energy as a source of raw materials (feedstock energy). How efficiently energy is used, its cost, and its availability consequently have a substantial impact on the competitiveness and economic health of U.S. manufacturers.

More efficient use of fuels and power lowers production costs, conserves limited energy resources, and increases productivity.

Efficient use of energy also has positive impacts on the environment – reductions in fuel use translate directly into decreased emissions of pollutants such as sulfur oxides, nitrogen oxides, particulates, and greenhouse gases (e.g., carbon dioxide).

Improved efficiency can also reduce the use of feedstock energy through greater yields, which translates to more product manufactured for the same amount of energy. Reducing the use of energy feedstock impacts directly our dependence on imported oil, and alleviates pressure on increasingly scarce and expensive natural gas supplies.

Energy efficiency can be defined as the effectiveness with which energy resources are converted into usable work. Thermal efficiency is commonly used to measure the efficiency of energy conversion systems such as process heaters, steam systems, engines, and power generators. Thermal efficiency is essentially the measure of the efficiency and completeness of fuel combustion, or in more technical terms, the ratio of the net work supplied to the heat supplied by the combusted fuel. In a gas-fired heater, for example, thermal efficiency is equal to the total heat absorbed divided by the total heat supplied; in an automotive engine, thermal efficiency is the work done by the gases in the cylinder divided by the heat energy of the fuel supplied.

Energy efficiency varies dramatically across industries and manufacturing processes, and even between plants manufacturing the same products. Efficiency can be limited by mechanical, chemical, or other physical parameters, or by the age and design of equipment. In some cases, operating and maintenance practices contribute to lower than optimum efficiency. Regardless of the reason, less than optimum energy efficiency implies that not all of the energy input is being converted to useful work – some is released as lost energy. In the manufacturing sector, these energy losses amount to several quadrillion Btus (quadrillion British Thermal Units, or quads) and billions of dollars in lost revenues every year.

Given this resource and cost perspective, it is clear that increasing the efficiency of energy use could result in substantial benefits to both industry and the nation. Unfortunately, the sheer complexity of the thousands of processes used in the manufacturing sector makes this a daunting task. A first step in understanding and assessing the opportunities for improving energy efficiency is to identify where and how industry is using energy – how much is used for various systems, how much is lost, how much goes directly to processes, and so forth.

Energy losses occur all along the energy supply and distribution system . Energy is lost in power generation and steam systems, both off-site at the utility and on-site within the plant boundary, due to equipment inefficiency and mechanical and

thermal limitations. Energy is lost in distribution and transmission systems carrying energy both to the plant and within the plant boundary.

Losses also occur in energy conversion systems (e.g., heat exchangers, process heaters, pumps, motors) where efficiencies are thermally or mechanically limited by materials of construction and equipment design. In some cases, heat-generating processes are not located optimally near heat sinks, and it may be economically impractical to recover that excess energy. Energy is sometimes lost simply because it cannot be stored. Energy is also lost from processes when waste heat is not recovered and when waste by-products with fuel value are not utilized.

Losses were determined by applying equipment loss factors to the energy used in selected functional categories: steam systems, fired systems (heating and cooling), refrigeration, and others. The loss factors used in this study were obtained from literature sources and through discussions with equipment experts (see Reference section).Boiler losses represent energy lost due to oiler inefficiency.

In practice, boiler efficiency can be as low as 55-60%, or as high as 90%. The age of the boiler, maintenance practices, and fuel type are contributing factors to boiler efficiency. As shown in Table 1-2, an average loss factor of 20% was used. Power generation losses vary depending on whether cogeneration is employed (systems producing both steam and electricity). It is assumed that the greater losses are in steam pipes (20%), with small losses incurred in other fuel transmission lines (3%) and electricity transmission lines (3%). Losses in steam pipes and traps have been reported to be as high as from 20 to 40%. A conservative value of 20% was used for steam distribution losses in this study.

Distribution losses represent steam heat lost in traps, valves, and steam pipes, and transmission losses in onsite fuel and electricity lines. In practice, these losses are strongly site-specific and depend largely on plant size and configuration. The loss factors shown may underestimate these losses, which have been reported to be as high as 10-40%. For simplicity, distribution losses are spread among the largest end-use categories.

Motor losses represent losses in motor windings as well as mechanical losses in the motor-driven systems (e.g., compressor) that occur during the conversion of energy to useful work. Effective rewind practices can reduce these losses. The energy footprints represent an average picture of energy use and losses across an industry. They provide the means to begin assessing the relative losses due to inefficiencies in addition to sources of energy-intensity. They also provide a baseline from which to calculate the opportunities for improving energy efficiency.

Loss Reduction and Recovery Opportunities Analysis

Using the rankings of the top energy systems users provided by the energy use and loss study as a starting point , additional analyses were conducted to narrow down process-specific opportunities. The following criteria were used to guide the selection of industries for further analysis:

1) Energy use and losses were large,

2) Waste heat represented a significant source of energy losses, and

3) The potential for cross-industry impacts was high.

For example, the thermal processes used in chemicals, petroleum refining, forest products and food processing share many
characteristics, and waste heat is a substantial potential energy source in each of these industries. Thus, based on their energy use profile, the industries ultimately selected for further study included petroleum refining, chemicals, forest products, iron and steel, food and beverage, and cement.

Average equipment efficiencies were estimated and energy losses were then calculated for each process to ascertain quantifiable energy reduction opportunities for each major process. Average equipment efficiencies were determined based on open literature, communication with industry experts, and equipment suppliers and energy system consultants. In some cases, assumptions of equipment efficiency were made based on widely known best practices.

The second phase of the study differs from the first in that energy loss calculations encompass those losses occurring at the end of the process (e.g., exit gases, flue gases, hot water).

The first phase of the study concentrated entirely on losses occurring *prior to use in the process operation* (e.g., central energy generation losses, losses in distribution and conversion to work). However, because energy systems are often integrated closely into the process, energy conversion losses are difficult isolate. Thus, there may be some overlap with end-of-process losses. The second phase of the analysis focused on the major process level, with the primary objective of pinpointing the major loss targets in each industry and later tying those losses to specific processes and energy systems equipment. By doing so, conclusions can then be reached regarding high profile targets and possible technology options for reducing energy system losses.

After assessing the potential opportunities, estimates were made concerning the percent of energy that could be likely reduced or recovered and the various technology options that might be suitable candidates. These estimates were based on communications with equipment and industry experts, open literature citations documenting potential efficiency improvements, and best engineering practices.

Definition of Terms

Combined heat and power (CHP)– energy system used for onsite cogeneration of steam and electricity.

Conventional power – gas or steam turbines generating onsite power, with heat recovery.

Electricity demand – the net use of electricity at the plant site, equaling purchased electricity and electricity generated onsite minus electricity exported offsite.

Electrochemical or Electrolytic Cells – Energy used in systems that convert raw inputs to products through an electrochemical reaction

Energy conversion systems – systems that convert energy into usable work for delivery to processes, such as heat exchangers, fired heaters, condensers, heat pumps, machine-drive, and onsite transportation.

Energy distribution systems – pipes and transmission lines for delivering fuels, steam, and electricity to processes and equipment.

Energy export – excess energy (mostly electricity) generated onsite that is exported offsite to the local grid or another facility.

Energy source flexibility – feasibility of alternative energy systems, such as using direct heat rather than steam or electricity, or systems fired with renewable fuels.

Facilities – energy used to provide heat, cooling, and lighting for building envelopes at the plant site.

Feedstock energy – energy used as a raw material in the production of non-fuel products, such as chemicals, materials, tar, asphalt, wax, steel, and others. The most commonly used energy feedstock's are petroleum/petroleum derivatives and natural gas.

Fired Systems– direct- and indirect-fired process heaters such as furnaces, dryers, re-boilers, and evaporators.

Fuel and electricity use – direct use of fuels and electricity at the plant site, taken directly from the Manufacturing Energy Consumption Survey [MECS 1998] for the manufacturing sector, and estimated for mining based on a recent study [Mining 2002]. Electricity includes purchased electricity only, not electricity generated onsite (see electricity demand, below). Fuels used to generate on-site electricity as well as byproduct fuels are included in the fuels category. Offsite electricity losses are not included.

Motor systems– motor-driven systems, such as compressors, fans, pumps, materials handling and processing equipment, and refrigeration. Materials handling equipment includes conveyors and assembly processes that are typically motorized. Materials processing includes grinders, crushers, mixers, and other similar equipment of this nature. Motor energy is converted to external work (rotating, lifting, spinning, moving), and is sometimes called shaft work.

Offsite losses– the energy losses incurred during the generation and transmission of electricity at offsite utilities, plus the energy losses incurred during the transport of fuels to the plant boundary. The efficiency of utility power generation and transmission is assumed to be 10,500 Btu/kWh, which is equal to an overall efficiency of about 32.5%. This does not represent the state-of-the-art, but an average value for the national grid. Fuel transport energy losses are assumed to be approximately3%.

Onsite losses– losses incurred in energy distribution and conversion systems, and in the central energy plant where steam and electricity are generated. Boiler generation losses represent energy lost due to boiler inefficiency. Onsite power generation losses are those associated with generation or cogeneration of electricity. Distribution losses represent steam heat lost in traps, valves, and steam pipes, and transmission losses in onsite fuel and electricity lines. Energy conversion losses occur in heat exchangers, preheat systems, motor driven systems, or other equipment where the transfer of energy from steam, direct heat or cooling, or electricity takes place, prior to delivery of energy to the process. In many cases energy conversion equipment is integrated directly with the process unit, making it difficult to estimate pre-process losses.

Onsite Transport – Energy used to fuel equipment (trucks, forklifts, etc.) that carry materials between locations at the plant site.

Primary energy use – the total processing energy consumption associated with an industrial sector. It is the sum of energy purchases (fuel and electricity), byproduct energy produced onsite, and the offsite losses associated with energy purchased from utilities and fuel suppliers (see offsite losses, below). Primary energy does not include feedstock energy, i.e., energy used as a raw material.

Process cooling – energy used for cryogenic and other cooling systems. This category may have some overlap with motor-driven refrigeration.

Process energy – energy used in industry-specific processes, such as chemical reactors, steel furnaces, glass melters, casting, welding or forging of parts, concentrators, distillation columns, and so forth.

Process heating – an aggregate of the energy used for process heating, including the use of steam, fired heaters, and all other heating devices.

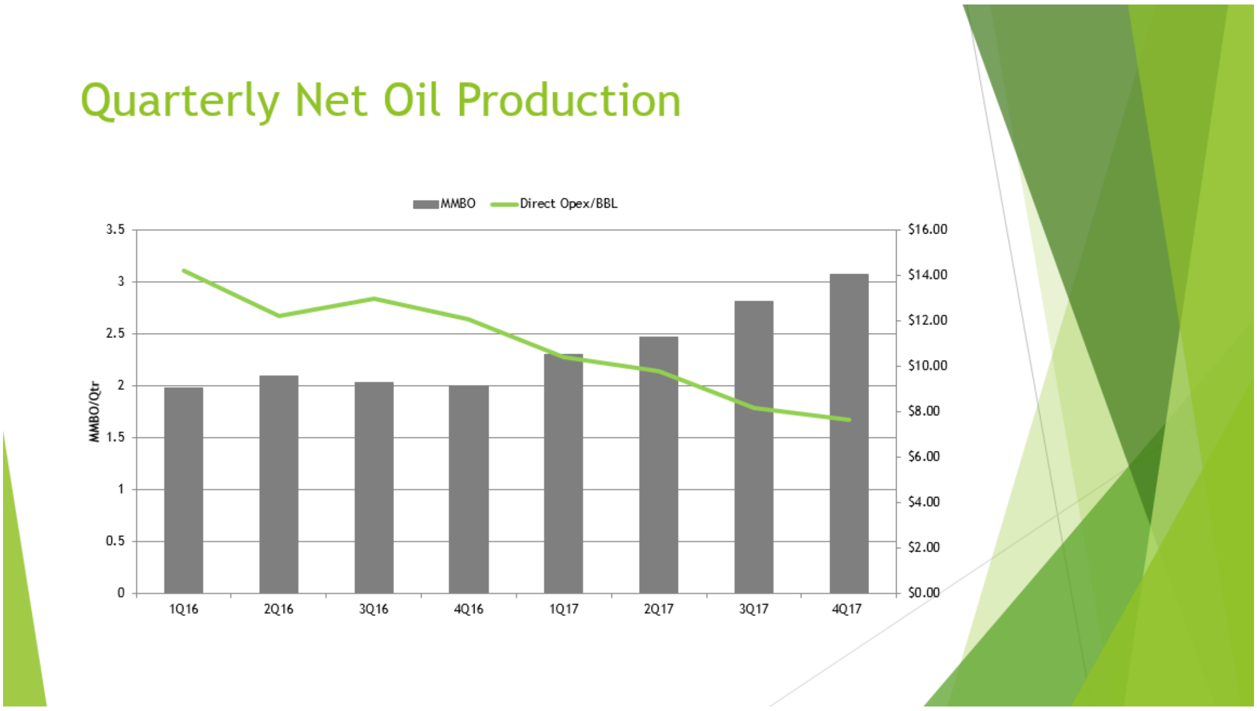
Steam systems– the complete steam system, including boilers, steam distribution lines, steam traps, and final delivery of steam to the process (e.g., heat exchangers).

Waste heat source reduction – reducing the amount of heat required through the use of innovative energy systems, heat integration, heating system redesign, or other means.

Waste heat recovery – recovering or recycling of high; medium; and low-temperature waste energy through means such as energy recycling, energy cascading, absorption heat pumps, optimized condensate recovery, or other technology.

Controls, automation, and robotics– advanced controls, automation, and robotics to improve energy system efficiency.

ENERGY BALANCE SHEET



MIS

Management Information Systems (MIS), referred to as Information Management and Systems, is the discipline covering the application of people, technologies, and procedures collectively called information systems, to solving business problems.

"***'MIS' is a planned system of collecting, storing and disseminating data in the form of information needed to carry out the functions of management***." Academically, the term is commonly used to refer to the group of information management methods tied to the automation or support of human decision making, e.g. Decision Support Systems, Expert Systems, and Executive Information Systems. Management : Management is art of getting things done through and with the people in formally organized groups. The basic functions performed by a manager in an organization are: Planning, controlling, staffing, organizing, and directing.

Information: Information is considered as valuable component of an organization. Information is data that is processed and is presented in a form which assists decision maker.

System: A system is defined as a set of elements which are joined together to achieve a common objective. The elements are interrelated and interdependent. Thus every system is said to be composed of subsystems. A system has one or multiple inputs, these inputs are processed through a transformation process to convert these input(s) to output.

Objectives of MIS :

1. Data Capturing : MIS capture data from various internal and external sources of organization. Data capturing may be manual or through computer terminals**.**

2. Processing of Data : The captured data is processed to convert into required information. Processing of data is done by such activities as calculating, sorting, classifying, and summarizing.

3. Storage of Information : MIS stores the processed or unprocessed data for future use. If any information is not immediately required, it is saved as an organization record, for later use.

4. Retrieval of Information : MIS retrieves information from its stores as and when required by various users.

5. Dissemination of Information : Information, which is a finished product of **MIS,** is

1. disseminated to the users in the organization. It is periodic or online through computer terminal.

Characteristics of MIS :

1. **Systems Approach :** The information system follows a systems approach. Systems approach
2. means taking a comprehensive view or a complete look at the interlocking sub-systems that operate
3. within an organization.
4. **Management Oriented :** Management oriented characteristic of MIS implies that the management actively directs the system development efforts. For planning of MIS, top-down approach should be followed. Top down approach suggests that the system development starts from the determination of management's needs and overall business objective. To ensure that the implementation of system's polices meet the specification of the system, continued review and participation of the manager is necessary.
5. **Need Based :** MIS design should be as per the information needs of managers at different levels.
6. **Exception Based :** MIS should be developed on the exception based also, which means that in an abnormal situation, there should be immediate reporting about the exceptional situation to the decision –makers at the required level.
7. **Future Oriented :** MIS should not merely provide past of historical information; rather it should provide information, on the basis of future projections on the actions to be initiated.
8. **Integrated :** Integration is significant because of its ability to produce more meaningful information. Integration means taking a comprehensive view or looking at the complete picture of the interlocking subsystems that operate within the company.
9. **Common Data Flow :** Common data flow includes avoiding duplication, combining similar functions and simplifying operations wherever possible. The development of common data flow is an economically sound and logical concept, but it must be viewed from a practical angle.
10. **Long Term Planning :** MIS is developed over relatively long periods. A heavy element of planning should be involved.
11. **Sub System Concept :** The MIS should be viewed as a single entity, but it must be broken down into digestible sub-systems which are more meaningful.
12. **Central database :** In the MIS there should be common data base for whole system.

Energy modeling

Energy system modeling is the process of building computer models of energy systems in order to analyze them. Such models often employ scenario analysis to investigate different assumptions about the technical and economic conditions at play. Outputs may include the system feasibility, greenhouse gas emissions, cumulative financial costs, natural resource use, and energy efficiency of the system under investigation.

A wide range of techniques are employed, ranging from broadly economic to broadly engineering. Mathematical optimization is often used to determine the least-cost in some sense. Models can be international, regional, national, municipal, or stand-alone in scope. Governments maintain national energy models for energy policy development.

Energy models are usually intended to contribute variously to system operations, engineering design, or energy policy development. This page concentrates on policy models. Individual building energy simulations are explicitly excluded, although they too are sometimes called energy models. IPCC-style integrated models, which also contain a representation of the world energy system and are used to examine global transformation pathways through to 2050 or 2100 are not considered here in detail.

Energy modeling has increased in importance as the need for climate change mitigation has grown in importance. The energy supply sector is the largest contributor to global greenhouse gas emissions.

A wide variety of model types are in use. This section attempts to categorize the key types and their usage. The divisions provided are not hard and fast and mixed-paradigm models exist. In addition, the results from more general models can be used to inform the specification of more detailed models, and vice versa, thereby creating a hierarchy of models. Models may, in general, need to capture "complex dynamics such as:

- energy system operation
- technology stock turnover
- technology innovation
- firm and household behavior
- energy and non-energy capital investment and labor market adjustment dynamics leading to economic restructuring
- infrastructure deployment and urban planning

Models may be limited in scope to the electricity sector or they may attempt to cover an energy system in its entirety (see below).

Most energy models are used for scenario analysis. A scenario is a coherent set of assumptions about a possible system. New scenarios are tested against a baseline scenario – normally business-as-usual (BAU) – and the differences in outcome noted.

The time horizon of the model is an important consideration. Single-year models – set in either the present or the future (say 2050) – assume a non-evolving capital structure and focus instead on the operational dynamics of the system. Single-year models normally embed considerable temporal (typically hourly resolution) and technical detail (such as individual generation plant and transmissions lines). Long-range models – cast over one or more decades (from the present until say 2050) – attempt to encapsulate the structural evolution of the system and are used to investigate capacity expansion and energy system transition issues.

Models often use mathematical optimization to solve for redundancy in the specification of the system. Some of the techniques used derive from operations research. Most rely on linear (including mixed-integer programming), although some use nonlinear programming. Solvers may use classical or genetic optimisation, such as CMA-ES. Models may be recursive-dynamic, solving sequentially for each time interval, and thus evolving through time. Or they may be framed as a single forward-looking inter temporal problem, and thereby assume perfect foresight. Single-year engineering-based models usually attempt to minimize the short-run financial cost, while single-year market-based models use optimization to determine market clearing. Long-range models, usually spanning decades, attempt to minimize both the short and long-run costs as a single inter temporal problem.

The demand-side (or end-user domain) has historically received relatively scant attention, often modeled by just a simple demand curve. End-user energy demand curves, in the short-run at least, are normally found to be highly inelastic.

UNIT - V

ENERGY AUDIT INSTRUMENTS

INSTRUMENTATION FOR ENERGY AUDIT

With the rising costs of energy and concerns about global warming, it is imperative that countries adopt the most efficient energy conservation measures and technologies. Energy conservation must evolve as a way of life in developing countries in the Asia-Pacific region given the limited availability of resources. If we are to share commercial energy equitably across all sections of society, it is necessary to conserve energy and use it efficiently. Industries can become globally competitive when their products are energy efficient and their production processes consume the least amount of energy.

For this purpose, energy audits and conservation studies must be conducted at regular intervals in all industries. One of the main bottlenecks in conducting these studies is the lack of technical information on various types of equipment and how energy performance should be measured. Energy audit is an official survey or study of the energy consumption and its objectives are to recommend steps for improving energy efficiencies, reducing the energy costs and wastage, improving quality etc.

The requirement for an energy audit such as identification and quantification of energy necessitates various measurements; these measurements require the use of instruments. The parameters generally monitored during the energy audit may include basic electrical parameters in AC and DC systems and parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow etc. Measuring electrical parameters does not seem to be much of a problem except for total harmonic distortions and transients, or the occasional blowing of fuse because screw drivers and bus bars are a bad mix. However, other more common measuring tasks such as flows of gases and liquids, as well as stack gas composition are more challenging and riddled with problems, even if one uses expensive and sophisticated equipment.

Whilst much data and characteristics on equipment/systems can be obtained from the energy audit personnel, the information may not be adequate to provide a full picture of their operation. To obtain accurate operating conditions and operating performance of equipment/systems, the auditor should have the necessary measuring instruments to take readings of corresponding parameters such as temperature, pressure, flow, lighting lux level, running current, etc.

The requirement for an energy audit such as identification and quantification of energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive.

The parameters generally monitored during energy audit may include the following:

Basic Electrical Parameters in AC and DC systems – Voltage (V), Current(I)

Power factor, Active power (kW), apparent power (demand) (kVA), Reactive power (kVA), Energy consumption (kWh), Frequency (Hz),etc.

Parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow, revolutions per minute (RPM), air velocity, noise and vibration, dust concentration, Total Dissolved Solids (TDS), pH, moisture content, relative humidity, flue gas analysis – CO_2, O_2, CO, SO_x, NO_x, combustion efficiency etc.

The operating instructions for all instruments must be understood and staff should familiarize themselves with the instruments and their operation prior to actual audit use.

ELECTRICAL MEASURING INSTRUMENTS

These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals. Some commonly used.

TYPICAL ELECTRICAL INSTRUMENTS

Voltmeter

An inexpensive voltmeter is useful for determining operating voltages on electrical equipment, and especially useful when the nameplate has worn off of a piece of equipment or is otherwise unreadable or missing. The most versatile instrument is a combined volt-ohm ammeter with a clamp-on feature for measuring currents in conductors that are easily accessible. This type of multimeter is convenient and relatively inexpensive.

Wattmeter/Power Factor Meter

A portable hand-held wattmeter and power factor meter is very handy for determining the power consumption and power factor of individual motors and other inductive devices. This meter typically has a clamp-on feature which allows an easy connection to the current-carrying conductor, and has probes for voltage connections.

Clamp On Ammeter

These are very useful instruments for measuring current in a wire without having to make any live electrical connections. The clamp is opened up and put around one insulated conductor, and the meter reads the current in that conductor. New clamp on ammeters can be purchased rather inexpensively that read true RMS values. This is important because of the level of harmonics in many of our facilities. An idea of the level of harmonics in a load can be estimated from using an old non-RMS ammeter, and then a true RMS ammeter to measure the current. If there is more than a five to ten percent difference between the two readings, there is a significant harmonic content to that load.

Lux meters

A lux meter is a device for measuring brightness. It specifically measures the intensity with which the brightness appears to the human eye. This is different than measurements of the actual light energy produced by or reflected from an object or light source.

The lux is a unit of measurement of brightness, or more accurately, luminance. It ultimately derives from the candela, the standard unit of measurement for the power of light. A candela is a fixed amount, roughly equivalent to the brightness of one candle.

While the candela is a unit of energy, it has an equivalent unit known as the lumen, which measures the same light in terms of its perception by the human eye. One lumen is equivalent to the light produced in one direction from a light source rated at one candela. The lux takes into account the surface area over which this light is spread, which affects how bright it appears. One lux equals one lumen of light spread across a surface one square meter.

A lux meter works by using a photo cell to capture light. The meter then converts this light to an electrical current. Measuring this current allows the device to calculate the lux value of the light it captured.

4. TEMPARATURE MEASURING INSTRUMENTS

Several temperature measuring devices are generally needed to measure temperatures in offices and other worker areas, and to measure the temperature of operating equipment. Knowing process temperatures allows the auditor to determine process equipment efficiencies, and also to identify waste heat sources for potential heat recovery programs. Inexpensive electronic thermometers with interchangeable probes are now available to measure temperatures in both these areas. Some common types include an immersion probe, a surface temperature probe, and a radiation shielded probe for measuring true air temperature.

Some typical temperature measuring instruments used for energy audit are:

Contact Thermometer

These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature, a leaf type probe is used with the same instrument.

Infrared thermometer

An infrared thermometer is a thermometer which infers temperature from a portion of the thermal radiation sometimes called blackbody radiation emitted by the object being measured. They are sometimes called laser thermometers if a laser is used to help aim the thermometer, or non-contact thermometers to describe the device's ability to measure temperature from a distance. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined. Infrared thermometers can be used to serve a wide variety of temperature monitoring functions. A few examples provided to this article include:

- Detecting clouds for remote telescope operation
- Checking mechanical equipment or electrical circuit breaker boxes or outlets for hot spots
- Checking heater or oven temperature, for calibration and control purposes
- Detecting hot spots / performing diagnostics in electrical circuit board manufacturing
- Checking for hot spots in fire fighting situations

- Monitoring materials in process of heating and cooling, for research and development or manufacturing quality control situations.

  There are many varieties of infrared temperature sensing devices available today, including configurations designed for flexible and portable handheld use, as well many designed for mounting in a fixed position to serve a dedicated purpose for long periods.

5. PRESSURE AND FLOW MEASURING INSTRUMENTS

Measuring air flow from heating, air conditioning or ventilating ducts, or from other sources of air flow is one of the energy auditor's tasks. Airflow measurement devices can be used to identify problems with air flows, such as whether the combustion air flow into a gas heater is correct. Some of the typical instruments measuring air and water pressure, flow rates etc include:

Pitot Tube and manometer

Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.

Anemometers

Two types of anemometers are available for measuring airflow: vane and hot-wire. The volume of air moving through an orifice can be determined by estimating the free area of the opening (e.g., supply air register, exhaust hood face, etc.) and multiplying by the air speed. This result is approximate due to the difficulty in determining the average air speed and the free vent area. Regular calibrations are necessary to assure the accuracy of the instrument. The anemometer can also be used to optimize the face velocity of exhaust hoods by adjusting the door opening until the anemometer indicates the desired airspeed.

Water flow meter

This non-contact flow measuring device using Doppler effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

Flow meters are used in fluid systems (liquid and gas) to indicate the rate of flow of the fluid. They can also control the rate of flow if they are equipped with a flow control valve.

6. MISCELLANEOUS INSTRUMENTS

Combustion Analyzer

Combustion analyzers are portable devices capable of estimating the combustion efficiency of furnaces, boilers, or other fossil fuel burning machines. Two types are available: digital analyzers and manual combustion analysis kits. Digital combustion analysis equipment performs the measurements and reads out in percent combustion efficiency. These instruments are fairly complex and expensive.

The manual combustion analysis kits typically require multiple measurements including exhaust stack: temperature, oxygen content, and carbon dioxide content. The efficiency of the combustion process can be calculated after determining these parameters. The manual process is lengthy and is frequently subject to human error.

Fyrite Gas Analyzers

They are fast, accurate and easy to use instruments for measuring and analyzing carbon dioxide or oxygen. Fyrite absorbing fluid is selective in the chemical absorption of carbon dioxide or oxygen, respectively. Therefore, the Fyrite's accuracy, which is well within the range required for industrial and professional applications, does not depend upon complicated sequential test procedures. In addition, Fyrite readings are unaffected by the presence of most background gases in the sample.

Tachometers

In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading. A simple tachometer is a contact type instrument which can be used where direct access is possible. More sophisticated and safer ones are non contact instruments such as stroboscopes.

Mechanical stroboscopic instruments are instruments with mechanical shutters (choppers) in the form of disks or hollow cylinders with slits through which the object is observed. By measuring the disk's speed of rotation at which the object viewed through the shutter appears stationary, the frequency of the periodic motion of the object can be determined. Such instruments are called stroboscopic tachometers. The principal advantage of the stroboscopic tachometer is that it permits the angular speeds of rotation of objects to be measured without contact between the instrument and the object. Consequently, speeds can be measured for objects that are visible but not easily accessible. This advantage also permits measurement of the speeds of low-power objects without the speed being affected by the use of the instrument.

Leak Detectors

Compressed air is one of the most costly utilities in a facility today. A simple program of leak inspection and repair can go a long way towards reducing excessive energy costs.

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities. Ultrasonic Leak Detector is a hand held, high quality compressed air leak detection system that has all the features necessary for flexible use in finding costly air leaks. Ultrasonic Leak Detector is a complete kit, the high quality flexible sensor is mounted on the end of a flexible steel pipe so the ultrasonic sound sensor can access hard to reach areas. The unit converts the ultrasonic noise of a leak into a sound humans can here (hissing sound) with some beeping sound or LED display.

Fuel Efficiency Monitor

This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

Metering and Monitoring System

Energy

Drivers

> Monitor energy consumption by different areas, different systems enables the owner to identify opportunities to save energy.

> Observe energy flow in, energy flow out and where its been used.

Level of detail

> Identify billing discrepancies

> Allocate costs/tenant billing

> Reduce peak demand, power factor penalties

> Find opportunities, verify savings

> Green standards compliance

> Reduce rates with energy suppliers

Power Monitoring

Drivers

> Maximising the efficiency and reliability of the electrical infrastructure

> Measuring the quality and quantity of power flowing through a given part of the electrical system.

Level of detail

> Increase facility uptime

> Verify reliable power equipment operation

> Improve response to power related issues

> Ensure PQ/energy contract compliance

> Network protection and control

Selection of meters

> The cost of the meter determines its limitations.

> Metering devices are constrained by hardware, firmware and software functionality.

> Complex meters provide greater accuracy, and more information

Where to measure and why?

> The most important location to measure power quality is at the main switchboard(s)

> Although every building is different, their loads can be divided into three common categories.

> Incoming power meters are designed to monitor connections points with external utility sources or local powers sources (renewable, generators)

> Critical loads power meters for critical loads or specialty equipment.

> Feeders metering to monitor power distribution that serve non-critical loads

Types of meters and their core features

Power meters (Incoming)

Energy data (active, reactive, apparent)

Electrical parameters (V, I, PF, F)

Power Quality (THD, Individual Harmonics up to 511th)

512 Samples per cycle or greater

Waveform capture, Detection of sags and swells and transients

On board logging and alarming with device time stamp

Gateway functionality

0.2% accurate

Disturbance Direction Detection

PQ standards comparison

IEC61000-4-30 Class A

Power meters (Feeder)

Energy data (active, reactive, apparent)

Electrical parameters (V, I, PF, F)

Basic Power Quality (THD, Individual harmonics up to 31st)

On board logging and alarming with device time stamp

64 Samples per cycle

0.5% accurate

Power meters (Critical Loads)

Energy data (active, reactive, apparent)

Electrical parameters (V, I, PF, F)

Power Quality (THD, Individual Harmonics up to 127st)

256 Samples per cycle or greater

Waveform capture, Detection of sags and swells and transients

On board logging and alarming with device time stamp

Gateway functionality

0.2% accurate

Disturbance Direction Detection

Disturbance Direction Detection

> Disturbance direction detection helps determine the location of a power system disturbance.

> Meter analyses the disturbance information to determine the direction of the disturbance relative to the meter.

> Analysis includes a confidence level indicating the level of certainty that the disturbance is in the determined direction.

> Disturbance direction detection is enabled on meter by default.

> The results of the disturbance direction detection algorithm appear in the meter's event log.

Incoming metering – application

Application

Energy usage monitoring

Monitor total energy usage of the building

Load monitoring

Monitor power demand to avoid penalties and help to select the best utility contract

Reliable data

On board logging allows the meter to store data even if comms is lost

Basic Power Quality monitoring

Monitor total power factor to avoid penalties

Monitor THD (Total Harmonic Distortion) to make sure electrical equipment is working within specification and
enable preventive maintenance to extend life

Advanced Power Quality event monitoring

Monitor power quality events (sags, swells, power outages, transients) and use the information to determine the
source of the event. User can use this info to ask utility for compensation in case of equipment damage

Utility bill verification

Revenue grade accuracy allows one to verify utility bills and detect billing issue.

Alarm configuration

Capturing time stamped events in a non-volatile memory

Additional Inputs

Bring other measurements such as water, gas consumed or temperature or pressure

Standards

EN50160 reporting to check incoming power supply quality

IEC61000-4-30 Class A compliant to measure harmonics to comply with G5/4-1

Incoming meter recommended features

> **High accurate** (0.2 class) equal or greater than utility meter

> **High sampling rate** (512 or higher samples per cycle) for accuracy, individual harmonics and to capture high resolution waveforms of high speed PQ events (20μS)

> **Short-term disturbances** Transients, interruption, sag and swell

> **Long-term disturbances** under voltage, over voltage, harmonics, unbalance, voltage fluctuations, power frequency variations, power factor, flicker

> **Disturbance direction detection** helps determine the location of a power system disturbance

> **On board logging with device time stamp** for reliable and accurate capture of historical trend data and Power Quality waveforms in non-volatile memory in case of loss of communications to device

> **On board alarming with device time stamp** for reliable and accurate capture of events including short-term and long-term Power Quality disturbances for diagnostics and root cause analysis purposes

> **Inputs** to bring in additional energy measurements (WAGES) from other devices or to monitor status of breakers and other equipment

> Outputs to share energy pulses with external sources or alarm status

> **High speed time stamping** to determine sequence of events

Critical loads – application

Application

Reliable data

On board logging allows the meter to store data even if comms is lost

Basic Power Quality monitoring

Monitor total power factor to avoid penalties

Monitor THD (Total Harmonic Distortion) to make sure electrical equipment is working within specification and enable preventive maintenance to extend life

Advanced Power Quality event monitoring

Monitor power quality events (sags, swells, transients) and use the information to determine the source of the event.

Alarm configuration

Capturing time stamped events in a non-volatile memory

Additional Inputs

Bring other measurements such as water, gas consumed or temperature or pressure

Critical load meter recommended features

> High accurate (0.2 class meter).

> **High sampling rate** (256 or higher samples per cycle) for accuracy, individual harmonics and to capture high resolution waveforms of high speed PQ events.

> **Short-term disturbances** Transients, sag and swell.

> **Long-term disturbances** under voltage, over voltage, harmonics, unbalance, voltage fluctuations, power frequency variations, power factor.

> **Disturbance direction detection** helps determine the location of a power system disturbance.

> **On board logging with device time stamp** for reliable and accurate capture of historical trend data and Power Quality waveforms in non-volatile memory in case of loss of communications to device.

> **On board alarming with device time stamp** for reliable and accurate capture of events including short-term and long-term Power Quality disturbances for diagnostics and root cause analysis purposes.

> **Inputs** to bring in additional energy measurements (WAGES) from other devices or to monitor status of breakers and other equipment.

> **Outputs** to share energy pulses with external sources or alarm status Confidential Property of Schneider Electric 29Feeder meter – application.

Feeder meter – Application

Energy usage monitoring

Monitor energy usage by group of area or group of loads.

Help to plan and audit energy saving activities.

Load monitoring

Monitor power demand to better manager electrical infrastructure (circuit breakers, transformers, etc.)

Help to plan and audit energy saving activities.

Avoid downtime and perform preventive maintenance to critical loads.

Reliable data

On board logging allows the meter to store data even if comms is lost.

Basic Power Quality monitoring

Monitor total power factor to identify source of anomalies and enable preventive maintenance.

Monitor THD (Total Harmonic Distortion) to make sure electrical equipment is working within specification and enable preventive maintenance to extend life.

Feeder meter recommended features

> **Good accuracy** (0.5 class meter).

> **Long-term disturbances** (under voltage, over voltage, harmonics, unbalance, power factor).

> **Onboard logging with device timestamp** for reliable and accurate capture of historical trend data in non-volatile memory in case of loss of communications to device.

> **Onboard alarming with device timestamp** for reliable and accurate capture of events including most long-term Power Quality disturbances for increasing power quality awareness and diagnostic purposes.

> **Inputs** to bring in additional energy measurements (WAGES) from other devices or to monitor status of breakers and other equipment.

> **Outputs** to share alarms status or energy pulses with external sources.

Software

> To unlock the potential behind a good power quality monitoring system is an extensive link between hardware and software.

> Hardware meters collect stores data and capture events

> Power Monitoring Software allows the user to carry out visualisation and root cause analysis.

> Features of power quality software.

> Tracking of real time power conditions.

> Analysis and isolate the source of power quality issues.

> Verify compliance with power quality standards.

> Visualisation of power quality alarms and events.

Common Power Management Applications

> Most applications involving energy or power meters are not possible without software. Software plays a

key role in common power management applications by providing the following.

> Data acquisition from multiple sources for a system wide data set.

>Long-term storage of historical metering data in a database.

> Business logic for virtual metering, aggregation and hierarchy definition.

> Ability to share power management data with other systems.

> Rich set of visualization and reporting tools.

> Many systems (BMS, EMS, SCADA) may offer energy monitoring functions do not have power monitoring capabilities.