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(H_2O) 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.