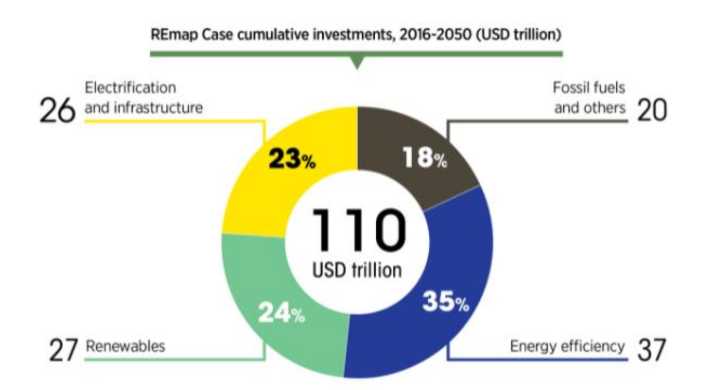
1. **Investment-** Investment is the dedication of an asset to attain an increase in value over a period of time.

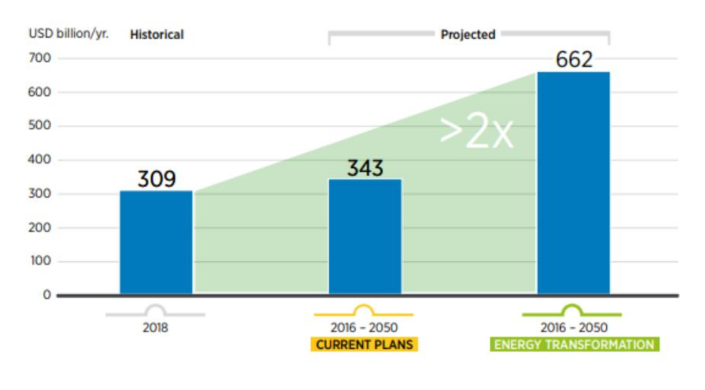
1.1 Investment Needs-

- **Investment needs for the global energy transformation -** The transformation of the global energy system needs to accelerate substantially to meet the objective of the Paris Agreement to limit the rise in average global temperatures to well below 2°C, and ideally to 1.5 °C, by the end of the century, compared to pre-industrial levels. Renewable energy supply, increased electrification of energy services, and energy efficiency can deliver more than 90% of global emission reductions needed in the energy sector.

  To advance the global energy transformation investment in renewable energy needs to be scaled up significantly and urgently. In its latest analysis, Global energy transformation: A roadmap to 2050 (2019 edition), IRENA estimates that to put the world on track with the objectives of the Paris Agreement, cumulative investment in renewable energy needs to reach USD 27 trillion in the 2016-2050 period.

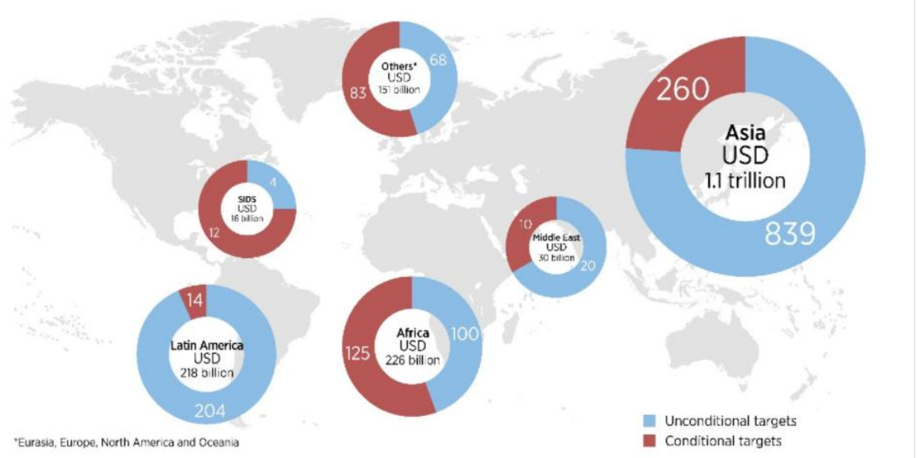
  In the power sector, the global energy transformation would require investment of nearly USD 22.5 trillion in new renewable installed capacity through 2050. This would imply at least a doubling of annual investments compared to the current levels, from almost USD 310 billion to over USD 660 billion.





- **Investment needed to implement the renewable energy targets in Nationally Determined Contributions (NDCs)-** Nationally Determined Contributions (NDCs) constitute a cornerstone of the Paris Agreement on climate change. Most signatories to the Paris climate accords have included renewable energy in their NDCs, recognising that accelerating the energy transition will be key to achieving the climate goals.

  In its report, Untapped potential for climate action: Renewable energy in Nationally Determined Contributions, IRENA estimates that around USD 1.7 trillion will be needed between 2015 and 2030 for the implementation of renewable energy targets in NDCs, or on average almost USD 110 billion per year. More than 70% of total investment needed (or USD 1.2 trillion) will have to be mobilised to implement the unconditional targets. A further USD 500 billion will be required in developing countries in the form of international finance to support the conditional targets.



1.2 Investment Criteria

Before you make any investments, Ensure-

- You are getting the best performance from existing plant and equipment
- Your energy charges are set at the lowest possible tariffs
- You are consuming the best energy forms - fuels or electricity - as efficiently as possible
- Good housekeeping practices are being regularly practiced.

When listing investment opportunities, the following criteria need to be considered:

- The energy consumption per unit of production of a plant
- The current state of repair and energy efficiency of the building design, plant and services, including controls
- The quality of the indoor environment - not just room temperatures but indoor air quality and air change rates, drafts, under and overheating including glare, etc.
- The effect of any proposed measure on staff attitudes and behaviour.

1.3 Investment Appraisal-

- It is the **analysis done to consider the profitability of an investment over the life of an asset** alongside considerations of affordability and strategic fit.
- Energy manager has to identify how cost savings arising from energy management could be redeployed within his organization to the maximum effect.
- To do this, he has to work out how benefits of increased energy efficiency can be best sold to top management as-

✓ Reducing operating /production costs
✓ Increasing employee comfort and well-being
✓ Improving cost-effectiveness and/or profits
✓ Protecting under-funded core activities
✓ Enhancing the quality of service or customer care delivered
✓ Protecting the environment

2. Financial Analysis Techniques:

2.1 Simple Payback- a measure of how long it will be before the investment makes money, and how long the financing term needs to be.

- Simple Payback Period (SPP) represents, as a first approximation.
- The time (number of years) required to recover the initial investment (First Cost), considering only the Net Annual Saving.

$$SSP = \frac{First\ \ Cost\ or\ Initial\ \ Investment}{Yearly\ \ Benifits - Yearly\ \ Costs}$$

Example- Simple payback period for a continuous Deodorizer that costs Rs.60 lakhs to purchase and install, Rs.1.5 lakhs per year on an average to operate and maintain and is expected to save Rs. 20 lakhs by reducing steam consumption (as compared to batch deodorizers), may be calculated as follows:

Ans- SSP = 60/(20-1.5)= 3 years 3 Months

Advantages -

- Simple to implement

- Suitable for the projects which generate substantial cash inflows in earlier years (within the payback period), and discriminates against projects, which bring substantial cash inflows in later years (beyond the payback period) but not in earlier years.

Limitation-
- consider the time value of money.
- It ignores cash flows beyond the payback period. This leads to discrimination against projects that generate substantial cash inflows in later years.

Time Value of Money-

- Deposited amount in Bank = 100/-

Interest = 10% p.a.
After 1 year worth = 110/-
Thus, 110/- in one year is the future value equivalent to 100/- present value.

- Similarly, 100/- received one year from now is only worth 90.91/- in today's money.
  90.91+10% Interest = 100/-

- 90.91 represents the present value of Rs.100 cash flow occurring one year in the future.

$$\text{Net Present Value} = \frac{Future\ Value}{(1 + Interest\ Rate)^{Number\ of\ Years\ in\ Future}}$$

2.2 Return on Investment (ROI)- ROI expresses the "annual return" from the project as a percentage of capital cost.

- The annual return takes into account the cash flows over the project life and the discount rate by converting the total present value of ongoing cash flows to an equivalent annual amount over the life of the project, which can then be compared to the capital cost.
- ROI does not require similar project life or capital cost for comparison.

$$\text{ROI} = \frac{Annual\ Net\ Cash\ Flow}{Capital\ Cost} \times 100$$

- ROI must always be higher than cost of money (interest rate).
- the greater the return on investment better is the investment.

Limitation-

- Does not considers time value of Money.
- Does not considers for the variable nature of annual net cash inflows.

2.3 <u>Net Present Value (NPV) -</u> The NPV of a project is equal to the sum of the present values of all the cash flows associated with it.

$$NPV = \frac{CF_0}{(1+k)^0} + \frac{CF_1}{(1+k)^1} + ... \frac{CF_n}{(1+k)^n}$$

NPV = Net Present Value

CF_t is the cash flow occurring at the end of year 't' (t= 0,1,2…n)

n is the project

k is the discount rate

Example

To illustrate the calculation of net present value, consider a project, which has the following cash flow stream:

Investment	Rs. (1,000,000)
Saving in Year	Cash flow
1	200,000
2	200,000
3	300,000
4	300,000
5	350,000

The cost of capital, κ, for the firm is 10 per cent. The net present value of the proposal is:

$$NPV = -\frac{1,000,000}{(1.10)^0} + \frac{200,000}{(1.10)^1} + \frac{200,000}{(1.10)^2}$$

$$+\frac{300,000}{(1.10)^3} + \frac{300,000}{(1.10)^4} + \frac{350,000}{(1.10)^5} = (5,273)$$

The net present value represents the net benefit over and above the compensation for time and risk.

Hence the decision rule associated with the net present value criterion is: "Accept the project if the net present value is positive and reject the project if the net present value is negative".

Advantages:-

The net present value criterion has considerable merits.

- Considers the time value of money.
- Considers the cash flow stream in its project life.

2.4 Internal Rate of Return (IRR)

- is the discount rate at which the current system have the same net present cost.
- In other words, this method calculates the rate of return that the investment is expected to yield.
- The expected rate of return is the interest rate for which total discounted benefits become just equal to total discounted costs (i.e net present benefits or net annual benefits are equal to zero, or for which the benefit / cost ratio equals one). <u>It means each year the money which is invested, calculate the net present cost with a common interest rate, NEXT each year whatever money is coming as benefit, calculate the net present cost with the common interest. Add them so that NPV become zero, than the common rate of</u>

interest is called IRR. CASH FLOW WILL BE -VE FOR EXPENDITURE AND +VE FOR SAVING.

CFt value will be negative if it is expenditure and positive if it is savings.

In the net present value calculation we assume that the discount rate (cost of capital) is known and determine the net present value of the project. In the internal rate of return calculation, we set the net present value equal to zero and determine the discount rate (internal rate of return), which satisfies this condition.

To illustrate the calculation of internal rate of return, consider the cash flows of a project:

Year	0	1	2	3	4
Cash flow	(100,000)	30,000	30,000	40,000	45,000

The internal rate of return is the value of " κ " which satisfies the following equation:

$$100{,}000 = \frac{30{,}000}{(1+\kappa)^1} + \frac{30{,}000}{(1+\kappa)^2} + \frac{40{,}000}{(1+\kappa)^3} + \frac{45{,}000}{(1+\kappa)^4}$$

The calculation of "k" involves a process of trial and error. We try different values of "k" till we find that the right-hand side of the above equation is equal to 100,000. Let us, to begin with, try k = 15 per cent. This makes the right-hand side equal to:

$$\frac{30{,}000}{(1.15)} + \frac{30{,}000}{(1.15)^2} + \frac{40{,}000}{(1.15)^3} + \frac{45{,}000}{(1.15)^4} = 100,802$$

This value is slightly higher than our target value, 100,000. So we increase the value of k from 15 per cent to 16 per cent. (In general, a higher k lowers and a smaller k increases the right-hand side value). The right-hand side becomes:

$$\frac{30{,}000}{(1.16)} + \frac{30{,}000}{(1.16)^2} + \frac{40{,}000}{(1.16)^3} + \frac{45{,}000}{(1.16)^4} = 98,641$$

Since this value is now less than 100,000, we conclude that the value of k lies between 15 per cent and 16 per cent. For most of the purposes this indication suffices.

Advantages:

- Considers time value of money.
- Considers cash flow stream in its entirety.
- Sense to businessmen who prefer to think in terms of rate of return and find an absolute quantity, like net present value, somewhat difficult to work with.

Limitations:

- The internal rate of return figure cannot distinguish between lending and borrowing and hence a high internal rate of return need not necessarily be a desirable feature.

3. Cash Flows

Two Kinds -

1) The initial investment as one or more installments, and 2) The savings arising from the investment.

There are usually other cash flows related to a project. These include the following:

- Capital costs are the costs associated with the design, planning, installation and commissioning of the project; these are usually one-time costs unaffected by inflation or discount rate factors, although, as in the example, installments paid over a period of time will have time costs associated with them.
- Annual cash flows, such as annual savings accruing from a project, occur each year over the life of the project; these include taxes, insurance, equipment leases, energy costs, servicing, maintenance, operating labour, and so on. Increases in any of these costs represent negative cash flows, whereas decreases in the cost represent positive cash flows.

Factors that need to be considered in calculating annual cash flows are:-

- Taxes, using the marginal tax rate applied to positive (i.e. increasing taxes) or negative (i.e. decreasing taxes) cash flows.
- Asset depreciation, the depreciation of plant assets over their life; depreciation is a "paper expense allocation" rather than a real cash flow, and therefore is not included directly in the life cycle cost. However, depreciation is "real expense" in terms of tax calculations, and therefore does have an impact on the tax calculation noted above. For example, if a Rs.10,00,000 asset is depreciated at 20% and the marginal tax rate is 40%, the depreciation would be Rs.200,000 and the tax cash flow would be Rs.80,000 and it is this later amount that would show up in the costing calculation.
- Intermittent cash flows occur sporadically rather than annually during the life of the project, relining a boiler once every five years would be an example.

4. Sensitivity and Risk Analysis

Many of the cash flows in the project are based on assumptions that have an element of uncertainty. The present day cash flows, such as capital cost, energy cost savings, maintenance costs, etc can usually be estimated fairly accurately. Even though these costs can be predicted with some certainty, it should always be remembered that they are only estimates. Cash flows in future years normally contain inflation components which are often "guess-timates" at best. The project life itself is an estimate that can vary significantly.

Sensitivity analysis is an assessment of risk. Because of the uncertainty in assigning values to the analysis, it is recommended that a sensitivity analysis be carried out - particularly on projects where the feasibility is marginal. How sensitive is the project's feasibility to changes in the input parameters? What if one or more of the factors in the analysis is not as favourable as predicted? How much would it have to vary before the project becomes unviable? What is the probability of this happening?

Suppose, for example, that a feasible project is based on an energy cost saving that escalates at 10% per year, but a sensitivity analysis shows the break-even is at 9% (i.e. the project becomes unviable if the inflation of energy cost falls below 9%). There is a high degree of risk associated with this project - much greater than if the break-even value was at 2%.

Many of the computer spreadsheet programs have built-in "what if" functions that make sensitivity analysis easy. If carried out manually, the sensitivity analysis can become laborious - reworking the analysis many times with various changes in the parameters.

Sensitivity analysis is undertaken to identify those parameters that are both uncertain and for which the project decision, taken through the NPV or IRR, is sensitive. Switching values showing the change in a variable required for the project decision to change from acceptance to rejection are presented for key variables and can be compared with post evaluation results for similar projects. For large projects and those close to the cut-off rate, a quantitative risk analysis incorporating different ranges for key variables and the likelihood of their occurring simultaneously is recommended. Sensitivity and risk analysis should lead to improved project design, with actions mitigating against major sources of uncertainty being outlined

Micro factors

- Operating expenses (various expenses items)
- Capital structure
- Costs of debt, equity
- Changing of the forms of finance e.g. leasing
- Changing the project duration

Macro factors

Macro economic variables are the variable that affects the operation of the industry of which the firm operates. They cannot be changed by the firm's management.
Macro economic variables, which affect projects, include among others:

- Changes in interest rates
- Changes in the tax rates
- Changes in the accounting standards e.g. methods of calculating depreciation
- Changes in depreciation rates
- Extension of various government subsidized projects e.g. rural electrification
- General employment trends e.g. if the government changes the salary scales
- Imposition of regulations on environmental and safety issues in the industry
- Energy Price change
- Technology changes

The sensitivity analysis will bring changes in various items in the analysis of financial statements or the projects, which in turn might lead to different conclusions regarding the implementation of projects.

5. Financing Options

Financing options for in-house energy management

- ✓ From Central Budget
- ✓ From a specific departmental or section budget such as engineering
- ✓ By obtaining a bank loan
- ✓ By raising money from stock market
- ✓ By awarding the project to Energy Service Company (ESCO)
- ✓ By retaining a proportion of the savings achieved.

6. Energy Performance Contracting and Role of Energy service companies (ESCOS)

ESCOS- are usually companies that provide a complete energy project service, from assessment to design to construction or installation, along with engineering and project management services, and financing.
Contract- involves the capitalization of all of the services and goods purchased, and repayment out of the energy savings that result from the project.
Performance Contracting- an end-user (such as an industry, institution, or utility), seeking to improve its energy efficiency, contracts with ESCO for energy efficiency services and financing.

What is Performance Contracting?

The core of performance contracting is an agreement involving a comprehensive package of services provided by an ESCO, including:

- An energy efficiency opportunity analysis
- Project development
- Engineering
- Financing
- Construction/Implementation
- Training
- Monitoring and verification

Monitoring and verification, is key to the successful involvement of an ESCO in performance contracting where energy cost savings are being guaranteed.

ESCOs are not "bankers" in the narrow sense. Their strength is in putting together a package of services that can provide guaranteed and measurable energy savings that serve as the basis for guaranteed cost savings. But, the energy savings must be measurable. The Figure 6.1 shows ESCO Role.

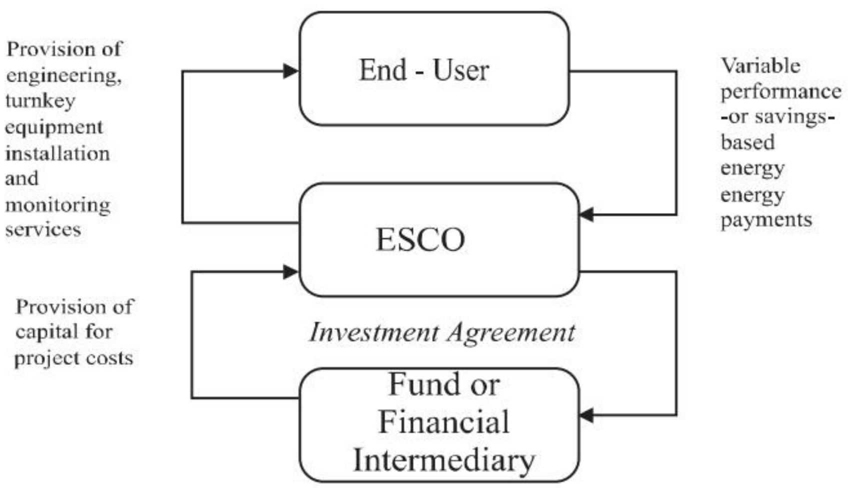


Figure 6.1 ESCO Role

7. <u>Energy Monitoring and Targeting</u>

- It is primarily a management technique that uses energy information as a basis to eliminate waste, reduce and control current level of energy use and improve the existing operating procedures.
- It builds on the principle "you can't manage what you don't measure".
- It essentially combines the principles of energy use and statistics.
- **<u>Monitoring</u>** is essentially aimed at establishing the existing pattern of energy consumption.
- **<u>Targeting</u>** is the identification of energy consumption level which is desirable as a management goal to work towards energy conservation.
- Monitoring and Targeting is a management technique in which all plant and building utilities such as fuel, steam, refrigeration, compressed air, water, effluent, and electricity are man aged as controllable resources in the same way that raw materials, finished product inventory, building occupancy, personnel and capital are managed. It involves a systematic, disciplined division of the facility into Energy Cost Centers. The utilities used in each centre are closely monitored, and the energy used is compared with production volume or any other suitable measure of operation. Once this information is available on a regular basis, targets can be set, variances can be spotted and interpreted, and remedial actions can be taken and implemented.

7.1 Elements of Monitoring and Targeting-

- **Recording** -Measuring and recording energy consumption.
- **Analysing** -Correlating energy consumption to a measured output, such as production quantity.
- **Comparing -**Comparing energy consumption to an appropriate standard or benchmark
- **Setting Targets -**Setting targets to reduce or control energy consumption
- **Monitoring -**Comparing energy consumption to the set target on a regular basis
- **Reporting -**Reporting the results including any variances from the targets which have been set
- **Controlling -**Implementing management measures to correct any variances, which may have occurred.

Particularly M&T system will involve the following:

- **Checking-** the accuracy of energy invoices
- **Allocating-** energy costs to specific departments (Energy Accounting Centres)
- **Determining-** energy performance/efficiency
- **Recording-** energy use, so that projects intended to improve energy efficiency can be checked
- **Highlighting-** performance problems in equipment or systems

7.2 Data and Information Analysis

Electricity bills and other fuel bills should be collected periodically and analysed as below. A typical format for monitoring plant level information is given below in the Table 8.1.

TABLE 8.1 ANNUAL ENERGY COST SHEET									
	Thermal Energy Bill				Electricity Bill				Total Energy Bill
Month	Fuel 1	Fuel 2	Fuel 3	Total Rs. Lakh	Day kWh	Night kWh	Maximum Demand	Total Rs. Lakh	Rs.Lakh
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
Sub-Total									
%									

After obtaining the respective annual energy cost, a pie chart (see Figure 8.1) can be drawn as shown below:

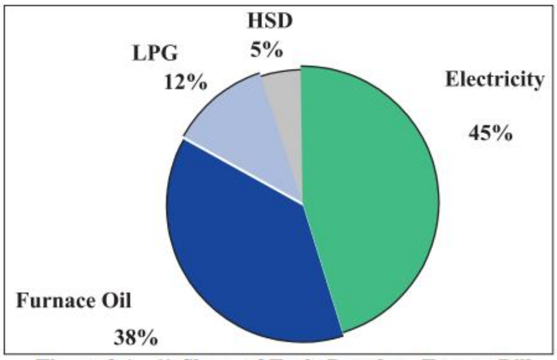


Figure 8.1 % Share of Fuels Based on Energy Bill

➢ Pie Chart on Energy Consumption

TABLE 8.2 FUEL CONVERSION DATA

Energy source	Supply unit	Conversion Factor to Kcal
Electricity	kWh	860
HSD	kg	10,500
Furnace Oil	kg	10,200
LPG	kg	12,000

After conversion to a common unit, a pie chart can be drawn showing the percentage distribution of energy consumption as shown in Figure 8.2.

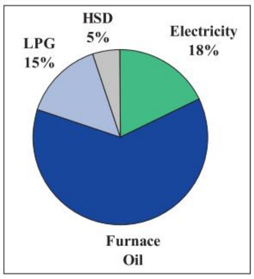


Figure 8.2 %Share of Fuels Based on Consumption in kCals

7.3 Relating Energy Consumption and Production

- Graphing the Data
- Use of Bar Chart

7.4 Cumulative Sum (CUSUM)

- Represents the difference between the base line (expected or standard consumption) and the actual consumption points over the base line period of time.
- This useful technique not only provides a trend line, it also calculates savings/losses to date and shows when the performance changes.

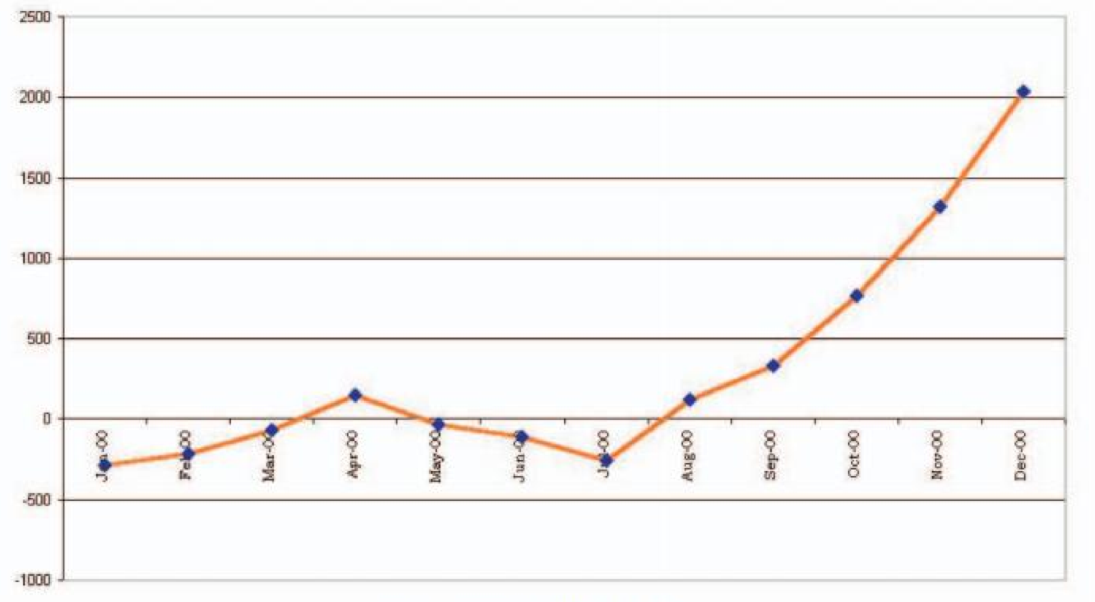


Figure 8.8 CUSUM Chart

7.4.1 Case Study (using CUSUM Technique)

Question - Energy consumption and production data were collected for a plant over a period of 18 months. During month 9, a heat recovery system was installed. Using the plant monthly data, estimate the savings made with the heat recovery system. The plant data is given in Table.

TABLE 8.3 MONTH WISE PRODUCTION WITH ENERGY CONSUMPTION		
Month	E_{act} - Monthly Energy Use (toe * / month)	P - Monthly Production (tonnes / month)
1	340	380
2	340	440
3	380	460
4	380	520
5	300	320
6	400	520
7	280	240
8	424	620
9	420	600
10	400	560
11	360	440
12	320	360
13	340	420
14	372	480
15	380	540
16	280	280
17	280	260
18	380	500

*** toe = tonnes of oil equivalent.**

Solution -

Steps for CUSUM Analysis:

- Plot the Energy - Production graph for the first 9 months
- Draw the best fit straight line
- Derive the equation of the line

After the completion of above steps the equation derived is $E = 0.4\,P + 180$

- Calculate the expected energy consumption based on the equation.
- Calculate the difference between actual and calculated energy use
- Compute CUSUM

TABLE 8.4 CUSUM

Month	E_{act}	P	E_{calc} (0.4 P + 180)	$E_{act} - E_{calc}$	CUSUM (Cumulative Sum)
1	340	380	332	+8	+8
2	340	440	356	-16	-8
3	380	460	364	+16	+8
4	380	520	388	-8	0
5	300	320	308	-8	-8
6	400	520	388	+2	-6
7	280	240	276	+4	-2
8	424	620	428	-4	-6
9	420	600	420	0	-6
10	400	560	404	4	-10
11	360	440	356	+4	-6
12	320	360	324	-4	-10
13	340	420	348	-8	-18
14	372	480	372	0	-18
15	380	540	396	-16	-34
16	280	280	292	-12	-46
17	280	260	284	-4	-50
18	380	500	380	0	-50

E_{act}- Actual Energy consumption E_{calc} - Calculated energy consumption

- Plot CUSUM graph
- Estimate the savings accumulated from use of the heat recovery system.

From the Figure 8.10, it can be seen that the CUSUM graph oscillates around the zero line for several months and then drops sharply after month 11. This suggests that the heat recovery system took almost two months to commission and reach proper operating conditions, after which steady savings have been achieved. Based on the graph 8.10 (see Table 8.4), savings of 44 toe (50-6) have been accumulated in the last 7 months. This represents savings of almost 2% of energy consumption.

$$\frac{44}{2352^{\#}} \cdot 100 = 1.8\%$$

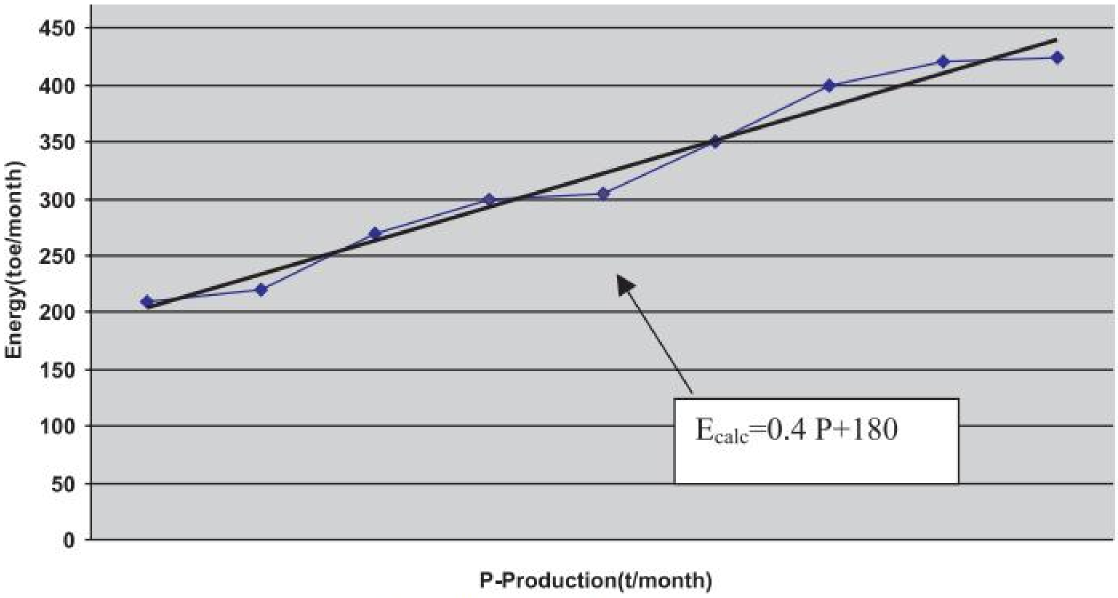


Figure 8.9 Energy Production Graph

#E_{act} for the last 7 months (from month 12 to month 18 in Table 8.4)

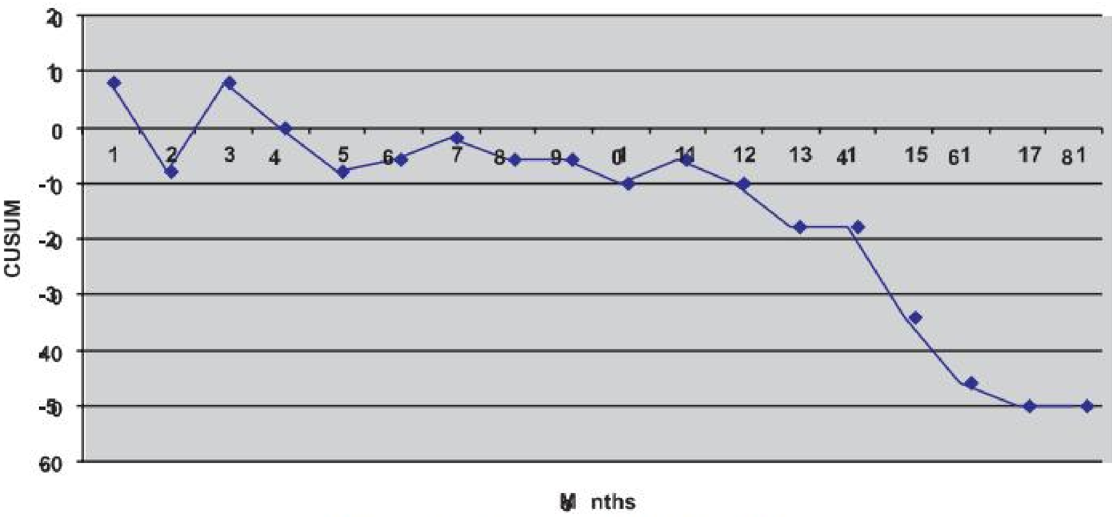
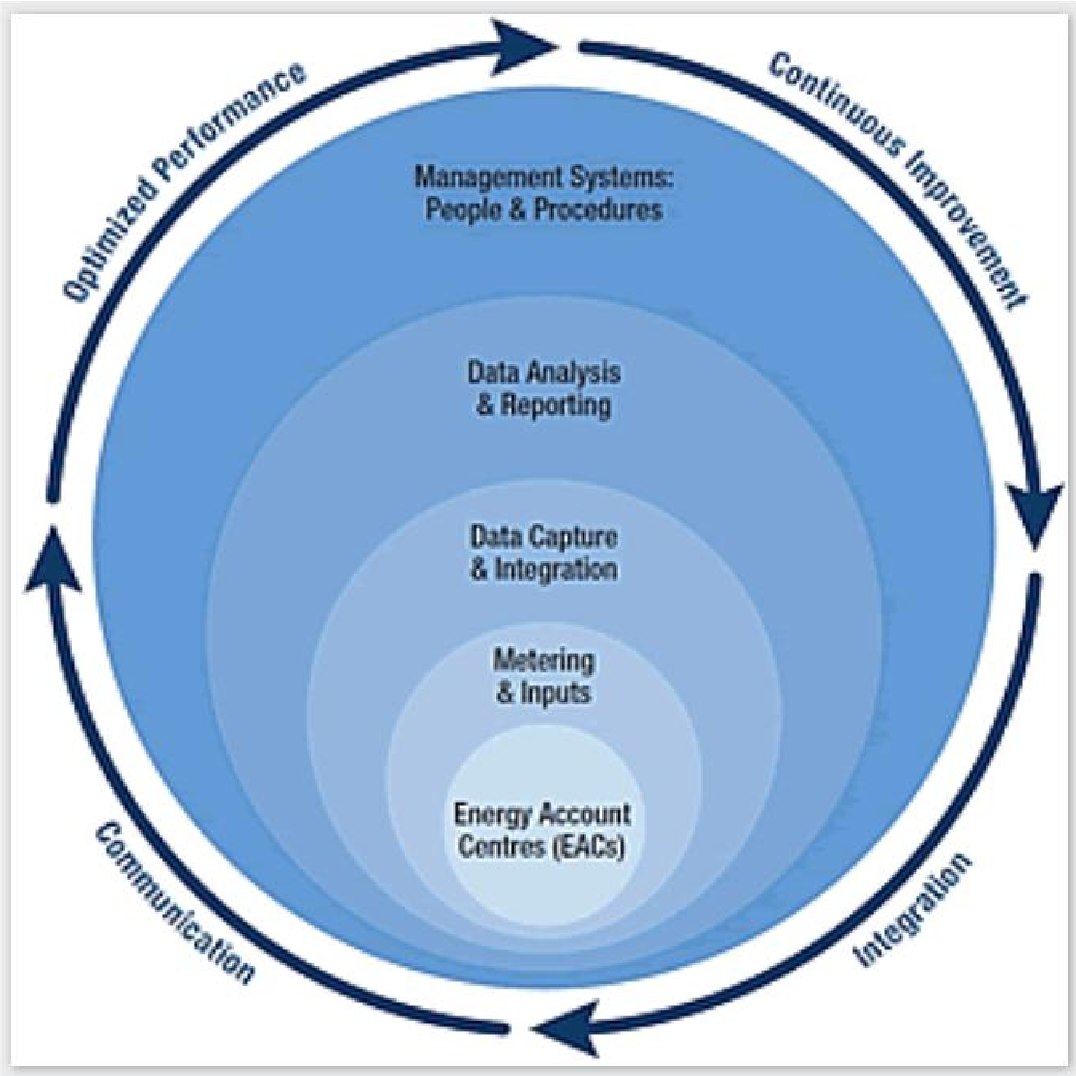


Figure 8.10 Example CUSUM Graph

7.5 Energy Management Information System (EMIS)

EMIS is a performance management system that enables individuals and organizations to plan, make decisions and take effective actions to manage energy use and costs.



How to implement EMIS in any organization-

<u>Phase 1: EMIS Audit:</u> An EMIS audit is an in-depth, eight-step process that will help your organization find out how much energy it is using, identify gaps and make recommendations. Critically, it will help you determine whether there is a financial case for implementing EMIS.

<u>Phase 2: Implementation Plan</u>: This phase shows you accurate costs for implementing EMIS and details the scope of the project and the resources your organization needs to manage it. It also gives you a schedule to implement and manage an EMIS.

<u>Phase 3: Implementation:</u> The implementation phase allows your organization to make continuous energy efficiency improvements. Once all aspects of your plan are implemented, your EMIS will

- Gather information on energy consumption
- Gather information on the useful outputs that result from the consumption of energy
- Gather information on any other factors that may affect energy consumption

- Contain analysis routines that allow you to compare between energy consumption and utility drivers
- Build and display energy performance reports