1. Policy - is an principle or protocol to guide decisions and achieve rational outcomes.Framework- 1) Decisions 2) Stakeholders 3)Policies 4)Goals 5)Criteria 6) Analysis

2. Energy Goals -

- Increase Energy Access
- Develop capacities of energy transition
- Enhance energy security
- Manage energy related market power
- Manage energy resource endowments
- Reduce environmental and human health impact
- Accelerate energy related technological changes
- Coordinate and implement international energy related policies

3. India Policy Documents-

1. *Five Year Plans*- First five year Plan (1951–1956), Twelfth Plan (2012–2017). With the Planning Commission dissolved, no more formal plans are made for the economy, but Five-Year Defence Plans continue to be made. The latest would have been 2017–2022. However, there is no Thirteenth Five-Year Plan.
2. *Integrated Energy Policy-* The Integrated Energy Policy, released in August 2006, addresses all aspects of energy, including energy security, access and availability, affordability and pricing, efficiency and the environment.
3. *National Action Plan on Climate Change-* National Action Plan for Climate Change (NAPCC) is a Government of India's programme launched in 2008 to mitigate and adapt to the adverse impact of climate change.
4. *Electricity Regulation Commission Act 1998-* An Act to provide for the establishment of a Central Electricity Regulatory Commission and State Electricity Regulatory Commissions, rationalization of electricity tariff, transparent policies regarding subsidies, promotion of efficient and environmentally benign policies and matters connected therewith or incidental thereto.
5. *Electricity Act 2003-* The act covers major issues involving generation, distribution, transmission and trading in power.
6. *UMPP(Ultra Mega Power Projects)-* are a series of ambitious power stations planned by the Government of India.
7. *Rural Electrification Policy 2006*
8. *INDC 2015-* Countries across the globe committed to create a new international climate agreement by the conclusion of the U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) in Paris in December 2015. In preparation, countries have agreed to publicly outline what post-2020 climate actions they intend to take under a new international agreement, known as their Intended Nationally Determined Contributions (INDCs). The INDCs will largely determine whether the world achieves an ambitious 2015 agreement and is put on a path toward a low-carbon, climate-resilient future.

4. ISO-50001

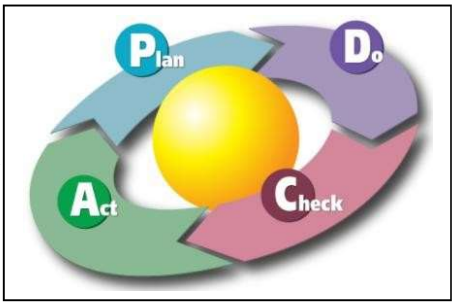
- It is an international standard created by the International Organization for Standardization (ISO). The standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy security, energy use and consumption.
- The standard aims to help organizations continually reduce their energy use, and therefore their energy costs and their greenhouse gas emissions.
- ISO 50001 was originally released by ISO in June 2011 and is suitable for any organization, whatever its size, sector or geographical location. The second edition, ISO 50001:2018 was released in August 2018.
- For organizations committed to addressing their impact, conserving resources and improving the bottom line through efficient energy management.
- ISO 50001 provides a framework of requirements for organizations to:

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions about energy use
- Measure the results
- Review how well the policy works, and
- Continually improve energy management.

5. PDCA (plan–do–check–act or plan–do–check–adjust)

- PDCA (plan–do–check–act or plan–do–check–adjust) is an iterative four-step management method.
- used in business for the control and continual improvement of processes and products.
- It is also known as the Deming circle/cycle/wheel, Shewhart cycle, control circle/cycle, or plan–do–study–act (PDSA).
- The ISO 50001 process follows the same PDCA approach as these other ISO standards and provides a framework to:

  - ✓ Develop a policy for more efficient use of energy
  - ✓ Fix targets and objectives to meet the policy
  - ✓ Use data to better understand and make decisions about en
  - ✓ Measure the results
  - ✓ Review how well the policy works, and
  - ✓ Continually improve energy management.



Plan- Establish objectives and processes required to deliver the desired results.
Do- Carry out the objectives from the previous step.
Check- the data and results gathered from the do phase are evaluated. Data is compared to the expected outcomes to see any similarities and differences.
Act- This act phase is where a process is improved. Records from the "do" and "check" phases help identify issues with the process.

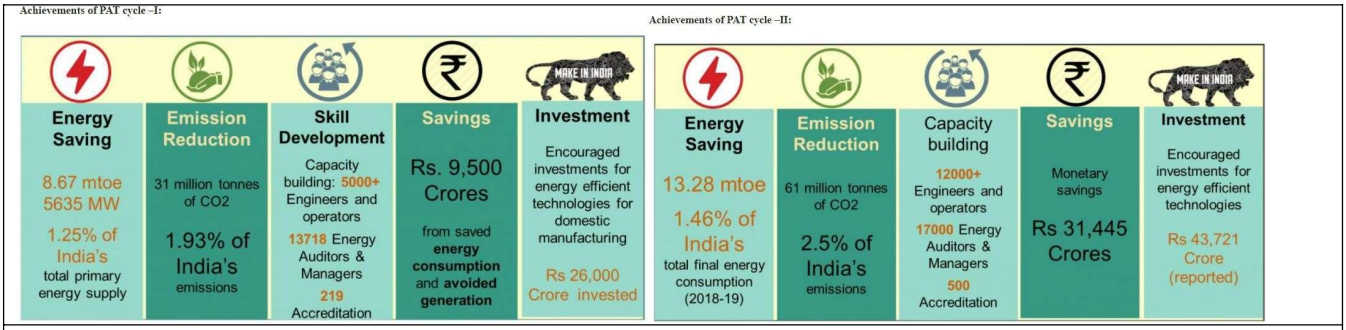
6. PAT scheme

Perform Achieve and Trade (PAT) scheme is a flagship progarmme (**the most important or prioritized concern of the organization)** of Bureau of Energy Efficiency under the National Mission for Enhanced Energy Efficiency (NMEEE). NMEEE is one of the eight national missions under the National Action Plan on Climate Change (NAPCC) launched by the Government of India in the year 2008.

- PAT scheme is a market based compliance mechanism to accelerate improvements in energy efficiency in energy intensive industries.
- The energy savings achieved by notified industries is converted into tradable instruments called Energy Saving Certificates (ESCerts).

PAT Cycles for Implementation of Scheme:

1. PAT Cycle -I (2012-2015)
2. PAT Cycle –II (2016-17 to 2018-19)
3. PAT Cycle –III (2017-18 to 2019-20)
4. PAT Cycle –IV (2018-19 to 2020-21)
5. PAT cycle –V (2019-2020 to 2021-22)
6. PAT cycle –VI (2020-21 to 2022-23)



Achievements of PAT Cycle -1 | Achievement of PAT Cycle -2

7. BEE and State Development Agencies and EESL Programme

7.1 BEE-

- The Government of India set up Bureau of Energy Efficiency (BEE). on 1st March 2002 under the provisions of the Energy Conservation Act, 2001.
- The mission of **the Bureau of Energy Efficiency** is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy.

7.2 Role of BEE-

- BEE co-ordinates with designated consumers, designated agencies and other organizations and recognize, identify and utilize the existing resources and infrastructure, in performing the functions assigned to it under the Energy Conservation Act.
- The Energy Conservation Act provides for regulatory and promotional functions.

7.3 Promotional Functions of BEE-

- Create awareness and disseminate information on energy efficiency and conservation.
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy and its conservation
- Strengthen consultancy services in the field of energy conservation.
- Promote research and development .
- Develop testing and certification procedures and promote testing facilities.
- Formulate and facilitate implementation of pilot projects and demonstration projects
- Promote use of energy efficient processes, equipment, devices and systems
- Take steps to encourage preferential treatment for use of energy efficient equipment or appliances
- Promote innovative financing of energy efficiency projects
- Give financial assistance to institutions for promoting efficient use of energy and its conservation
- Prepare educational curriculum on efficient use of energy and its conservation
- Implement international co-operation programmes relating to efficient use of energy and its conservation

8. State Development Agencies (SDAs)

- In exercise of the powers conferred by section 15(d) of the Energy Conservation (EC) Act 2001, all the State Governments / UT Administrations have designated an agency as State Designated Agency (SDA) to coordinate, regulate and enforce the provisions of this Act within the State, either by assigning additional responsibilities to one of the existing departments of the State Government or by establishing a dedicated Stand-Alone SDA for energy efficiency.
- These agencies differ from State to State with the Renewable Energy Development Agency comprising 44%, Electrical Inspectorate comprising 19%, Distribution Companies comprising 17%, Power Departments comprising 14% and Stand-Alone SDA comprising 6%.

- Some list of SDAs- Maharashtra Energy Development Agency (MEDA, Punjab Energy Development Agency (PEDA), Rajasthan Renewable Energy Corporation Ltd (RRECL), Jharkhand Renewable Energy Development Agency (JREDA), Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA), etc.
- Total 36 SDAs are operating in India.

In order to build and strengthen the institutional, technical and financial capacities and capabilities of the SDAs for undertaking energy efficiency activities at the State level, BEE provides financial assistance to the SDAs under two major components cited as below.

- Providing financial assistance to the State Designated Agencies to coordinate, regulate and enforce efficient use of energy and its conservation.
- Contribution to State Energy Conservation Fund (SECF).

- Key Activities-

1) Providing financial assistance to the State Designated Agencies to coordinate, regulate and enforce efficient use of energy and its conservation.
2) State Partnership for Energy Efficiency Demonstrations (SPEED)
- Implementation of energy efficiency demonstration projects
- Implementation of energy efficiency activities in Government schools

3) Model Energy Efficient Village Campaign
4) Institutionalization of Enforcement Machinery at State level
5) Manpower Support to SDAs
6) State Energy Efficiency Research & Outreach Programme
7) Workshops / Capacity Building of energy professionals
8) Maintenance and updation of Internet Platform and other database created on energy efficiency
9) Analysis and survey of the impact of energy conservation activities by SDAs

9. Energy Efficiency Services Limited (EESL)

- It is a joint venture of state-run power companies, responsible for implementation of Domestic Efficient Lighting Programme (DELP)or the UJALA scheme.
- It has reduced the prices of LED bulbs by 75%.

10. Municipal and Agricultural DSM (DEMAND SIDE MANAGEMENT)Initiatives

- Demand Side Management (DSM) has been traditionally recognized as one of the major intervention to achieve reduction in energy demands while ensuring continuous development.
- In recent past, DSM has gained unprecedented importance and has become an integral part of almost all the central and state missions on promotion of Energy Efficiency.
- DSM interventions have helped utilities not only to reduce the peak electricity demands and but also to defer high investments in generation, transmission and distribution networks.

10.1 Agricultural demand side management

- ✓ This programme promises energy efficiency through agriculture demand side management by reduction in overall power consumption, improving efficiencies of ground water extraction, reducing subsidy burden on state utilities and also investment in power plants through avoided capacity.
- ✓ Over 70 per cent of the rural households depend on agriculture. Agriculture is an important sector of Indian economy as it contributes about **17%** to the total GDP and provides employment to over **60%** of the population.
- ✓ As per the available data, more than 2.1 crore pump sets are installed in agriculture sector, majority of the pump sets are inefficient. Statistics shows that 2.5 to 5 lakh new pump set connections added every year to the sector.

- ✓ The average capacity of agricultural pumps in India is around 5 HP with efficiency levels hovering around 25-30%.
- ✓ BEE in association with various DISCOMs implemented four pilot AgDSM projects in Maharashtra, Karnataka and Andhra Pradesh.
- ✓ An MoU was signed between Indian Council of Agricultural Research (ICAR) and Bureau of Energy Efficiency (BEE), Ministry of Power, to create awareness for energy efficient pumpsets and operational practices so as to adopt energy and resource efficient approaches with aim to create awareness on energy efficiency and conservation in agricultural practices, particularly in using agriculture pumpsets, tractors and other machines and to improve fuel and water resource use efficiency thereby reducing the cost of cultivation so as to increase farmer's income in harmony with strategies of "Per drop more crop" and "Doubling Farmers' income".

10.2 Municipal demand side management (MuDSM)

- ✓ The growing demand for public utilities due to rising population and improved standards of living of the population has increased the energy demand for the service provided by the urban local bodies. The Municipality sector/urban local bodies (ULBs) consume electricity for various utility services like street lighting, water pumping, sewage treatment, and in various public buildings.
- ✓ Currently around 30% of Indian population lives in urban areas and continuous migration from rural areas is putting additional burden on the urban local bodies.
- ✓ The energy consumption of the municipality sector is characterized by frequent changes and rising peaks in power load curves in the morning hours due to water pumping and evening hours for street lighting.
- ✓ The inefficient use of electricity due to limited diffusion of energy efficiency technology and demand side management (DSM) initiatives, have considerably increased the energy spent of the municipalities.
- ✓ The Municipal Demand Side Management (MuDSM) programme can improve the overall energy efficiency of the Urban Local Bodies (ULBs) which could lead to substantial savings in the electricity consumption, thereby resulting in cost reduction/savings for the ULBs.
- ✓ Identifying the immense energy saving potential in municipal sector, BEE initiated Municipal Demand Side Management (MuDSM) during XI plan.
- ✓ The basic objective of the project is to improve the overall energy efficiency of the ULBs, which could lead to substantial savings in the electricity consumption, thereby resulting in cost reduction/savings for the ULBs. During the XI plan, the situation analysis was carried out in the Municipal sector in 2007 covering 23 States/UTs.
- ✓ Bureau of Energy Efficiency has initiated a programme to cover 175 municipalities in the country by conducting energy audits and preparation of Detailed Project Reports (DPRs) and implementation through ESCO mode.

11. Energy Use and Energy Supply

Energy is essential for a wide range of human activities, both in the United States and around the world, yet its use is the dominant source of emissions of CO_2 and several other important climate forcing agents. In addition to total demand for energy, the type of fuel used and the end-use equipment affect CO_2 emissions. The diversity of ways in which energy is supplied and used provides ample opportunities to reduce energy-related emissions. However, achieving reductions can be very difficult, especially because it involves considerations of human behavior and preferences; economics; multiple time frames for decision making and results; and myriad stakeholders. Questions decision makers are asking, or will be asking, about energy supply and consumption in the context of climate change include the following: What options are currently available for limiting emissions of greenhouse gases (GHGs) and other climate forcing agents in the energy sector, and

- ✓ what are the most promising emerging technologies?
- ✓ What are the major obstacles to widespread adoption of new energy technologies that reduce GHG emissions?

- ✓ What are the best ways to promote or encourage the use of energy-conserving and low-GHG energy options?
- ✓ What impacts will climate change have on energy production, distribution, and consumption systems, and how should possible impacts be accounted for when designing and developing new systems and infrastructure?
- ✓ What are the possible unintended consequences of new energy sources for human and environmental well-being?

- Energy Consumption
- Reduction in Energy Demand
- Energy Efficiency Improvement
- Energy sources which reduces emissions and Green House Gases
- Fuel Switching
- Solar Energy
- Wind Energy
- Bio Energy
- Geothermal Energy
- Hydro power
- Nuclear Power
- Carbon Dioxide Removal Approaches
- Carbon Capture and Storage
- Direct Air Capture
- Energy Carrier Transmission and Storage
- Science to Supply Technology Deployment
- Likely Impact of Climate change on Energy System Operation
- Science to Support Adapting to climate change
- Research Needs

(https://www.nap.edu/read/12782/chapter/18#375)

12. Standards & Labeling Programme

- ➢ It is one of the major thrust areas of BEE.
- ➢ A key objective of this scheme is to provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the relevant marketed product.
- ➢ The scheme targets display of energy performance labels on high energy end use equipment & appliances and lays down minimum energy performance standards.

Star Labelled Appliances:-

Presently, S&L program covers star rating for **26 appliances/equipment.** List of the appliances covered under the ambit of Star Labeling is as given below:

Mandatory Appliances

- ✓ Room Air Conditioners
- ✓ Frost Free Refrigerators
- ✓ Tubular Florescent Lamp
- ✓ Distribution Transformer
- ✓ Room Air Conditioner
- ✓ Direct Cool Refrigerator
- ✓ Color TV
- ✓ Electric Geysers
- ✓ Variable Capacity Inverter Air conditioners
- ✓ LED Lamps

Voluntary Appliances

- ✓ Induction Motors
- ✓ Pump Sets
- ✓ Ceiling Fans
- ✓ LPG -Stoves
- ✓ Washing Machine
- ✓ Computer (Notebooks/Laptops)
- ✓ Ballast (Electronic/ Magnetic)

- ✓ Office equipment's (Printer, Copier, Scanner, MFD's)
- ✓ Diesel Engine Driven Mono-set Pumps
- ✓ Solid State Inverter
- ✓ DG Sets
- ✓ Chillers
- ✓ Microwave Oven
- ✓ Solar Water Heater
- ✓ Light Commercial Air Conditioner
- ✓ Deep freezers

Voluntary Appliances

13. Excellence Enhancement Centre (EEC)

- It has been setup in India under Indo-German Energy Forum established by Republic of India and Federal Republic of Germany in 2006 to promote energy efficiency and energy security.
- The Centre aimed to create greater awareness of energy efficiency in the Indian power sector by encouraging the exchange of ideas and experience, providing examples of best practice and facilitating technology transfer.
- The long-term goal was to establish more efficient power and heating plants and to introduce modern plant operation and management methods in the Indian power sector.
- The EEC is structured in accordance with the European model of an industrial association.
- **EEC Membership** is open to power sector companies, manufacturers and research and development organisations.
- Regular professional exchanges, sector events and technical publications and guidelines help to ensure the EEC retains its practical orientation.

Member Benifits:-

- ✓ Free Expert Technical Advices (conditions apply) to recepient members.
- ✓ Generating Business Opportunities for Experts/Donor Member organizaions.
- ✓ Access to discounted purchase of EEC's Technical Studies
- ✓ Preference in the Study/Expert committees of EEC.

Aims and Objectives

- **To become a truly representative voluntary association** of the entire Power Sector including Generation (Coal, Hydro, Nuclear, Renewables), Transmission, Distribution, Manufacturing, EPC Consultants, Testing, R&D, Academic and Regulatory institutions.
- **To promote Peer to Peer cooperation** between Indian Power Sector Stakeholders.
- **To provide a platform for the top Experts in Power Sector** and power plant operators for knowledge exchange and resolving related problems.
- **To share best practices** in all areas of power sector and provide broad based expertise.
- **To identify challenges**, develop common solutions and initiate joint action plans for power sector.
- **To create a "Technical Discussion Forum"** for Indian Power Sector on EEC Website.
- **To promote policy initiatives of MOP, GOI** by taking up suggested studies and giving feedback from stakeholders of Indian Power Sector.
- **To facilitate bilateral cooperation** in the Indian Power Sector.
- **To engage pro-actively with foreign organizations** such as VGB Germany, for Technical knowhow, Expertise, Consultancy, Studies and Reviews.
- **To raise awareness** for the need of excellence in Power Sector.

Activities of EEC

- **Making EEC more broad based** by catering to the entire Power Sector including Generation (Coal, Hydro, Nuclear, Renewables) , Transmission, Distribution, Manufacturing, EPC Consultants, Testing, R&D, Academic and Regulatory institutions.
- **Promoting Peer to Peer** cooperation by facilitating Expert Technical Advice from leading organizations such as CEA / BEE / NTPC/ PGCIL/ STEAG/ BHEL/ Tata Power etc. to stakeholders of Indian Power Sector who may seek such expertise. While the recipient member organizations will get the service largely free as a benefit of EEC membership, the donor organizations will be compensated by EEC for their services thereby generating business opportunities for the leading Indian Power Sector organizations.
- **Organizing an EEC Conference on annual basis** with Key note address by Ministers & Policy Makers, Economists, Visionaries and Technical Experts from Indian and international Power Sector, followed by presentation and discussion Sessions on key issues and challenges facing the Indian Power Sector.
- **Conducting 4-5 workshops every year** on relevant topics of interest to EEC Members / Power Utilities.
- **Conducting 4-5 training programs every year** on operational & maintenance issues of Indian Power Sector.
- **Facilitating Knowledge Exchange** through "Technical Discussion Forum" on EEC Website.
- **Facilitating Technical Advice / Consultancy services** from VGB Germany or other Foreign Organizations to Indian Power Sector member organizations for whichEEC will bear part of the costs as a benefi t of EEC membership - subject to conditions.
- **Facilitating Knowledge Exchange** between German/European power Sector and Indian Power Sector.
- **Taking up Technical studies** for the Indian Power Sector with the association of VGB Germany or other foreign organizations.
- **Creating an Archive of Best Practices**, Reference Guidelines, Technical and Operational Studies, Case Studies and Solutions which shall be available for purchase in hard & soft copies. Already EEC has Best Practices for Coal Based Power Plants in Germany and 22 Guidelines in its Library which are available to Member organizations for reference and consultation.

14. Input Output Analysis

- ✓ In economics, an input–output model is a quantitative economic model that represents the interdependencies between different sectors of a national economy or different regional economies.
- ✓ Wassily Leontief (Soviet American Economics) is credited with developing this type of analysis and earned the Nobel Prize in Economics for his development of this model.
- ✓ Related to these models are economic multipliers measuring total (direct plus indirect) changes in sales, income and employment.
- ✓ In general, input-output models depict the monetary flow of goods and services throughout the economy. All sectors in the economy purchase goods from one another and use these goods in the production of a final product.
- ✓ Mathematically, this type of interaction may be expressed as:

where

$$x_{11} + x_{12} + \ldots\ldots + x_{1n} + y_1 = X_1$$
$$x_{21} + x_{22} + \ldots\ldots + x_{2n} + y_2 = X_2$$
$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$
$$x_{n1} + x_{n2} + \ldots\ldots + x_{nn} + y_n = X_n$$

x_{ij} = sales from sector i to sector j, $i, j = 1, 2, \ldots\ldots, n$

y_i = final demand for products of sector i, $i = 1, 2, \ldots\ldots, n$

X_i = total output of sector i, $i = 1, 2, \ldots\ldots, n$

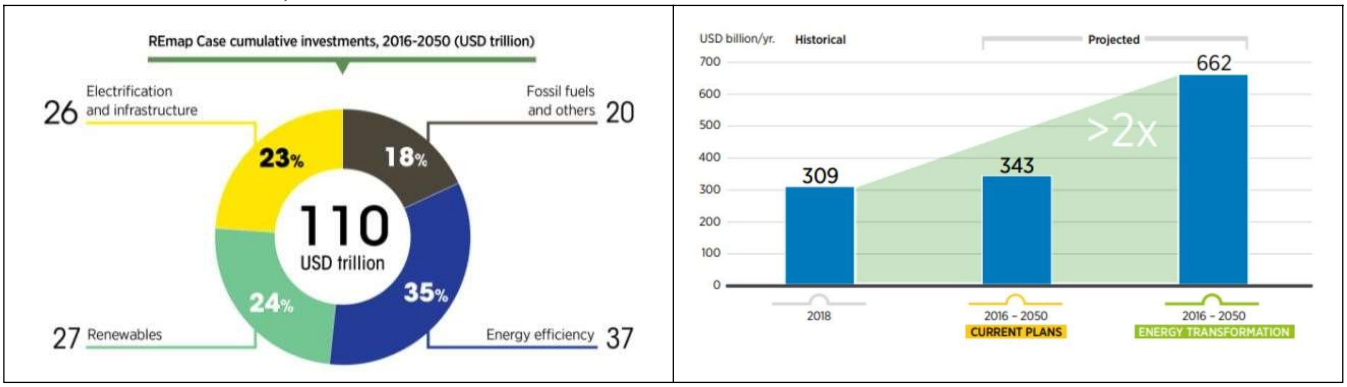
1. Investment- Investment is the dedication of an asset to attain an increase in value over a period of time.

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

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

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). 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

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.

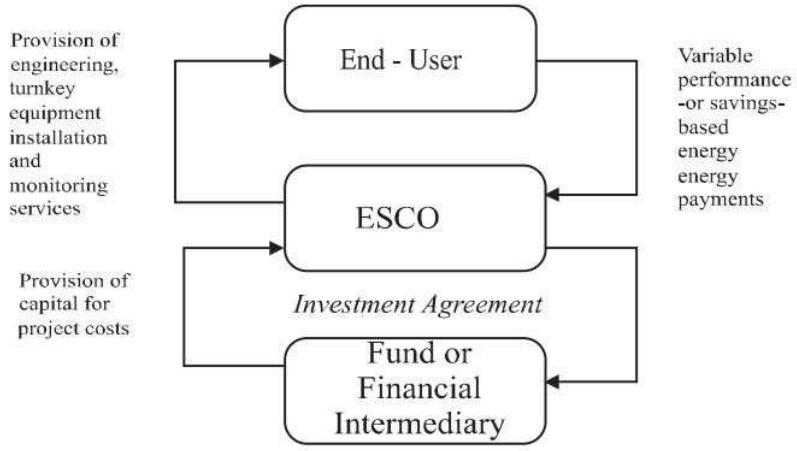


Figure 6.1 ESCO Role

7. Energy Monitoring and Targeting

- 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.
- **Monitoring** is essentially aimed at establishing the existing pattern of energy consumption.
- **Targeting** 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.

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.

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.

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

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

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-

Phase 1: EMIS Audit: 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.

Phase 2: Implementation Plan: 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.

Phase 3: Implementation: 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 report