Presentation on Energy Scenario

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ELECTRICAL ENERGY CONSERVATION AND AUDITING

OBJECTIVE

1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing.

2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing.

SCOPE

Future is great for the energy conservation lots of advantages over there mainly power saving, increasing life of system and economical advantage.

OUTCOME

CO1. Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing

CO2. Ability to analyze the viability of energy conservation projects

CO3. Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing

Chapter-1 Energy Scenario

Contents

- Commercial and Non-commercial energy,
- primary energy resources,
- commercial energy production,
- final energy consumption,
- energy needs of growing economy,
- long term energy scenario,
- energy pricing, energy sector reforms,
- energy and environment, energy security,
- energy conservation and its importance,
- restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change.
- Energy Conservation Act-2001 and its features.

Introduction

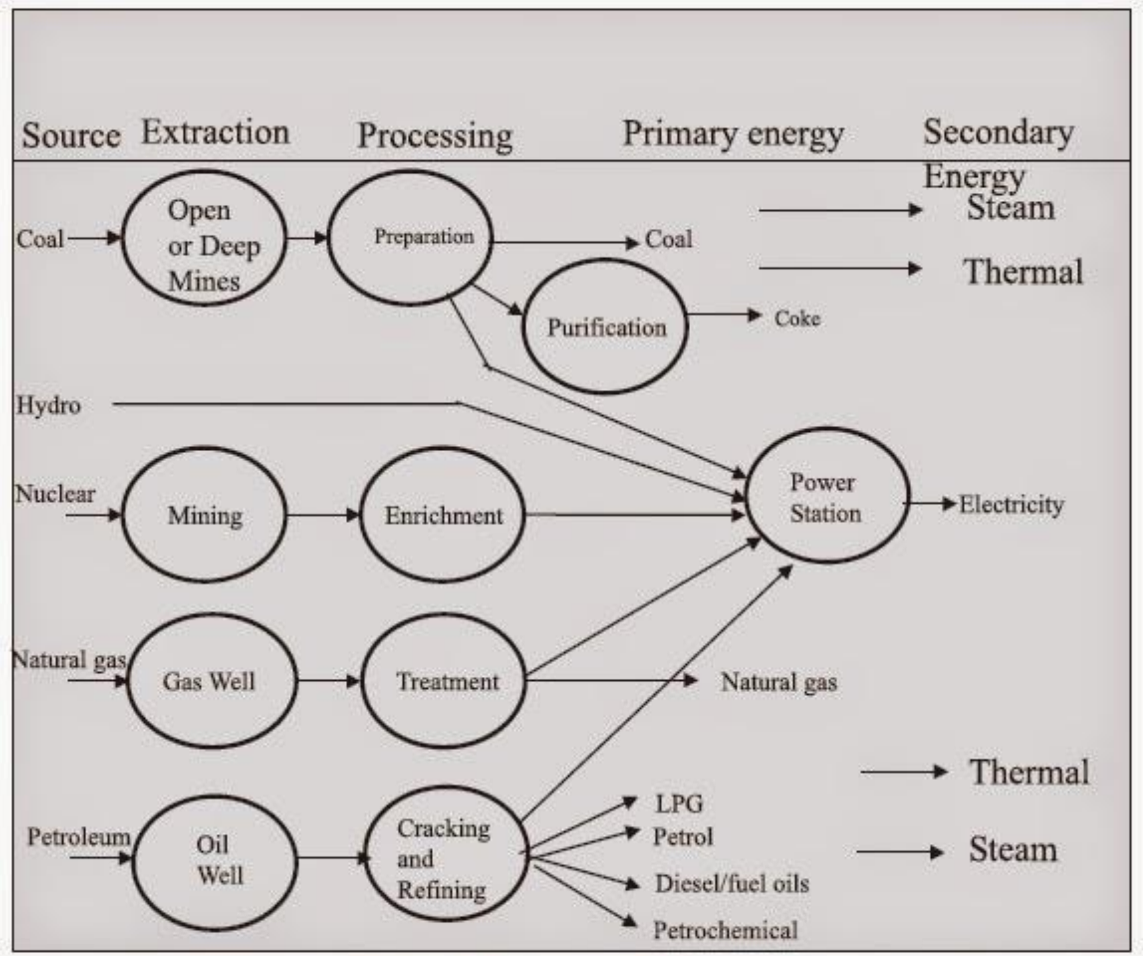
- Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.
- Energy can be classified into several types based on the following criteria:
- Primary and Secondary energy
- Commercial and Noncommercial energy
- Renewable and Non-Renewable energy

Primary and Secondary Energy sources

Primary Energy sources are those that are either found or stored in nature.

Example:coal ,oil,natural gas etc.

Primary energy sources those are converted to other sources like coal is converted to steam and electricity .These are known as Secondary Energy Sources



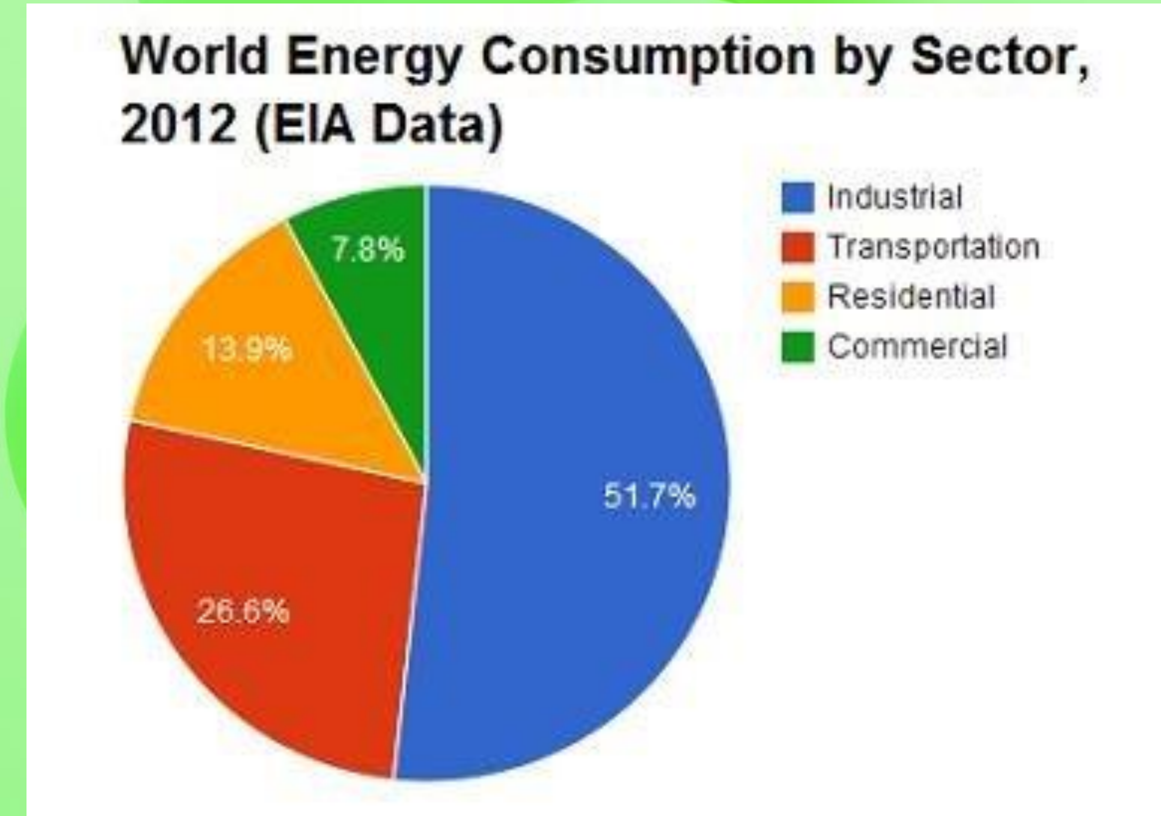
Major Primary and Secondary Sources

- Commercial Energy The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population. Examples: Electricity, lignite, coal, oil, natural gas etc.
- Non-Commercial Energy The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting. Example: Firewood, agro waste in rural areas; solar energy for water heating, electricity generation, for drying grain, fish and fruits; animal power for transport, threshing, lifting water for irrigation, crushing sugarcane; wind energy for lifting water and electricity generation

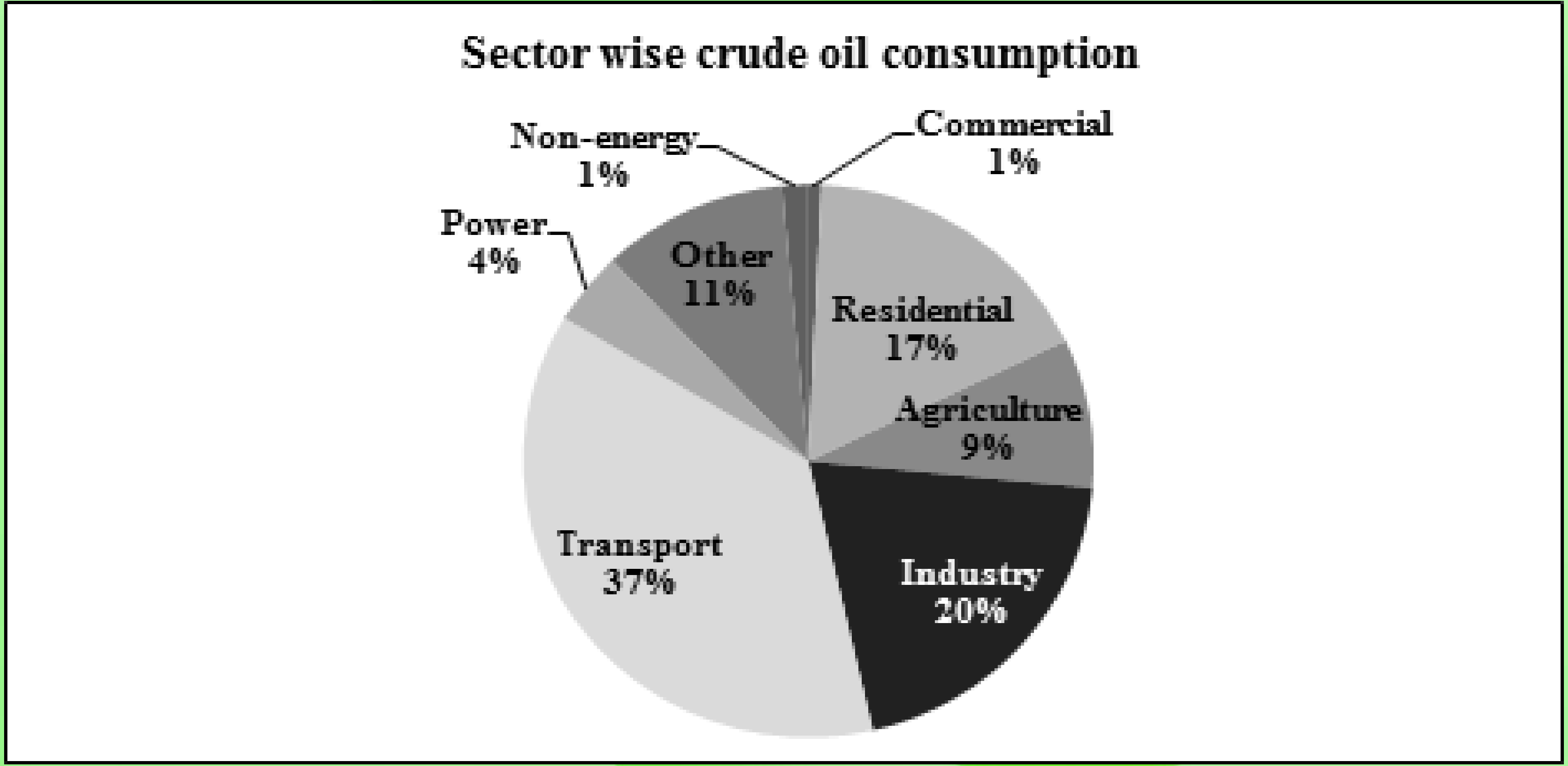
Renewable and Non-Renewable Energy

- Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power.
- The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.
- Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time

Global Energy Consumption



Indian Energy Consumption



Global Primary Energy Reserves

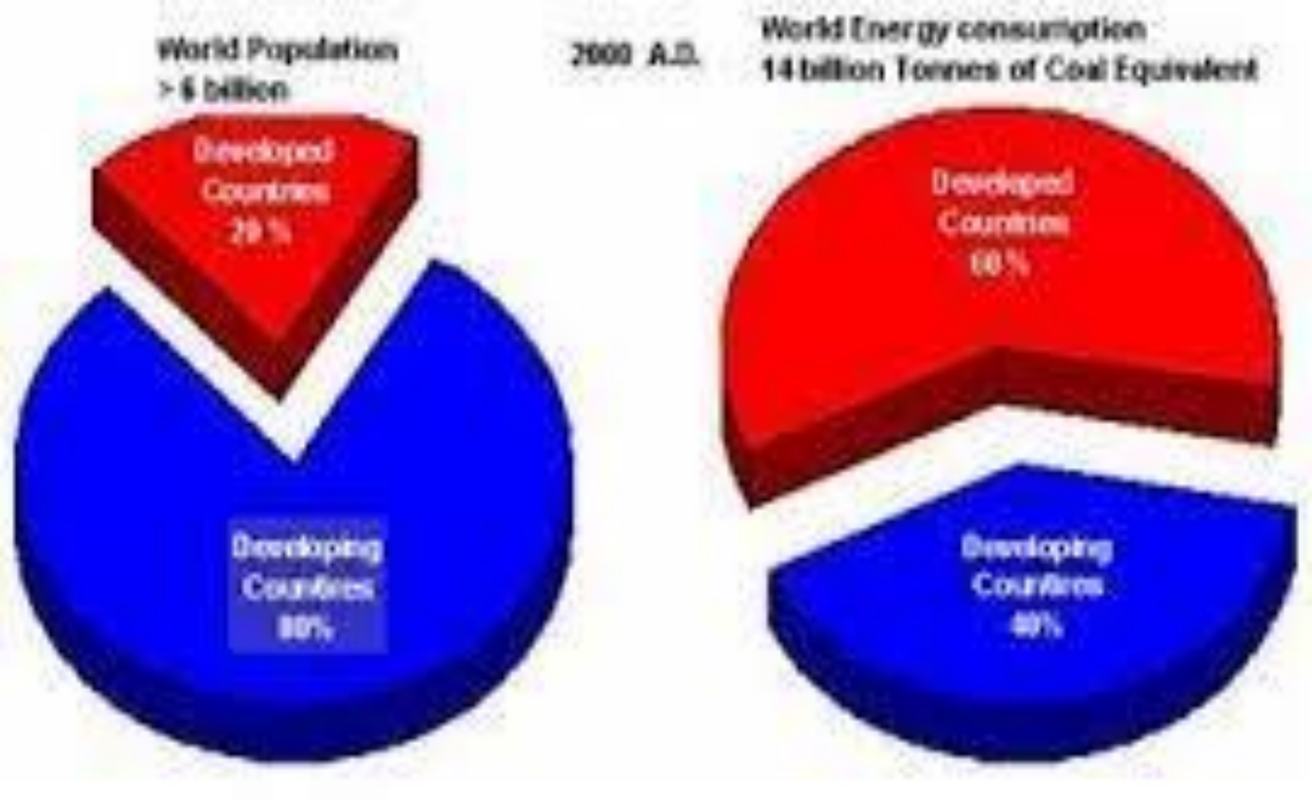
- Coal :The proven global coal reserve was estimated to be 9,84,453 million tonnes by end of 2003. The USA had the largest share of the global reserve (25.4%) followed by Russia (15.9%), China (11.6%). India was 4th in the list with 8.6%.
- Gas:The global proven gas reserve was estimated to be 176 trillion cubic metres by the end of 2003. The Russian Federation had the largest share of the reserve with almost 27%.
- Oil: The global proven oil reserve was estimated to be 1147 billion barrels by the end of 2003. Saudi Arabia had the largest share of the reserve with almost 23%. (One barrel of oil is approximately 160 litres)

Energy Distribution Between Developed and Developing Countries

Although 80 percent of the world's population lies in the developing countries (a fourfold population increase in the past 25 years), their energy consumption amounts to only 40 percent of the world total energy consumption.

The high standards of living in the developed countries are attributable to highenergy consumption levels.

Also, the rapid population growth in the developing countries has kept the per capita energy consumption low compared with that of highly industrialized developed countries.



Indian Energy Scenario

- Coal dominates the energy mix in India, contributing to 55% of the total primary energy production. Over the years, there has been a marked increase in the share of natural gas in primary energy production from 10% in 1994 to 13% in 1999. There has been a decline in the share of oil in primary energy production from 20% to 17% during the same period.

Energy Source	Key location	Remark
Coal	Jharkhand, Odisha, Chhatisgarh, West Bengal, Andhra Pradesh, Madhya Pradesh, Maharastra	Jharkhand, Odisha and Chhatisgarh constitute 69% of total reserve as on 1 April 2010
Oil	Onshore: Assam, Nagaland, Gujarat, Rajasthan Offshore: Andhra Pradesh, Tamil Nadu, Bombay High	94% of onshore production from the four states in 2009-10.
Gas	Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu, Rajasthan, Tripura	89% of gas production from Assam, Nagaland, Gujarat, Andhra Pradesh, Tamil Nadu
Hydro-electricity	All the regions of India	76% identified capacity in North-eastern and Northern region
Electricity (hydro and thermal)	All the regions of India	Thermal power plants are concentrated in coal rich states
Uranium and Thorium	Uranium in Jharkhand and Rajasthan Thorium in coastal Odisha, Kerala, Andhra Pradesh and Tamil Nadu	
Wind Energy	Karnataka, Gujarat, Tamil Nadu, Rajasthan, Maharastra, Kerala, Madhya Pradesh, Andhra Pradesh, Odisha, West Bengal	77% of gross potential in Karnataka, Gujarat, Tamil Nadu, Rajasthan and Maharastra
Biomass Energy	All the regions of India	
Solar Energy	All the regions of India	More prominent in Rajasthan desert because of cheap land availability
Geothermal Energy	Chhatisgarh, Jammu and Kashmir, Madhya Pradesh	
Biogas Energy	All the regions of India	

Supply and Demand Side Factors of Energy Management in India

- The per capita energy consumption in India in 2006 was 510 kgoe agai nst5416 kgoe for high income countries (World Bank, 2009).
- Energyconsumptionin India has been continuously increasing over the years. There is a large gap between actual demand and supply-constrained demand for energy in thecountry. A host of supply side an d demand side factors influence the energy sector.

Supply side Factors

- Reliable and adequate supply of both commercial and noncommercial energy at an affordable price is a complex issue. It is difficult to develop appropriate supplyside strategies in the absence of reliable data, which often is the case for noncommercial energy.
- An analysis of factors affecting noncommercial energy cannot be neglected, since it constitutes a significant part of our energy mix. Although, no reliable recent data is available, against a commerci al energy consumption of 191.6 MTOE in 2000-01 in the country; the noncommercial energy consumption was 80 MTOE in dom estic sector and 23.5 MTOE in unorganised, small and cottage industries. The commercial energy sector in India is highly dependent on fossil fuels. In 200708, about 89% of total primary energy supply is contributed by coal, oil and gas. Although India has large coal reserve, it is faced with poor quality (high ash content and low calorific value), inefficient and expensive mining, environmental restrictions and poor labour relation.

- In India, both installed capacity and generation of electricity, are below the supply constrained demand.

The main reasons for shortfall in thermal power plant capacity addition include “delayed and non-sequential supplyofmaterials by vendors, shortage of skilled manpower for construction and commissioning of projects, contractual disputes between project authorities,contractorsandtheirsubvendors, delay in readiness of balance of plants by the executing agencies, design problems and fuel shortage”

Demand Side Factors

- There are six major factors, which influence the aggregate demand for commercial energy.

These include:

- Process efficiency
- Economic growth
- Position in the technology trajectory of energy using systems
- Population growth
- Energy price
- Substitution for biomass The process efficiency and prices often have negative im pact on the growth of energy demand. Biomass still accounts for about one-third of energy demandin India. Substitution alone is likely to raise overall comme rcial energy demand in the country by perhaps onethird or more in the long term.

- Reserves/Production (R/P) ratio- If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that the remaining reserves would last if production were to continue at that level

Energy Needs of Growing Economy

- Economic growth is desirable for developing countries, and energy is essential for economic growth. However, the relationship between economic growth and increased energy demand is not always a straightforward linear one.
- For example, under present conditions, 6% increase in India's Gross Domestic Product (GDP) would impose an increased demand of 9 % on its energy sector. In this context, the ratio of energy demand to GDP is a useful indicator.
- A high ratio reflects energy dependence and a strong influence of energy on GDP growth. The developed countries, by focusing on energy efficiency and lower energy-intensive routes, maintain their energy to GDP ratios at values of less than 1. The ratios for developing countries are much higher.

- Per Capita Energy Consumption The per capita energy consumption is too low for India as compared to developed countries. It is just 4% of USA and 20% of the world average. The per capita consumption is likely to grow in India with growth in economy thus increasing the energy demand.

Energy Pricing in India

- Price of energy does not reflect true cost to society. The basic assumption underlying efficiency of market place does not hold in our economy, since energy prices are undervalued and energy wastages are not taken seriously.
- Pricing practices in India like many other developing countries are influenced by political, social and economic compulsions at the state and central level. More often than not, this has been the foundation for energy sector policies in India. The Indian energy sector offers many examples of cross subsidies e.g., diesel, LPG and kerosene being subsidised by petrol, petroleum products for industrial usage and industrial, and commercial consumers of electricity subsidising the agricultural and domestic consumers.

- Coal: Grade wise basic price of coal at the pithead excluding statutory levies for run-of-mine (ROM) coal are fixed by Coal India Ltd from time to time. The pithead price of coal in India compares favourably with price of imported coal. In spite of this, industries still import coal due its higher calorific value and low ash content.
- Oil :As part of the energy sector reforms, the government has attempted to bring prices for many of the petroleum products (naphtha, furnace oil, LSHS, LDO and bitumen) in line with international prices. The most important achievement has been the linking of diesel prices to international prices and a reduction in subsidy. However, LPG and kerosene, consumed mainly by domestic sectors, continue to be heavily subsidised. Subsidies and cross-subsidies have resulted in serious distortions in prices, as they do not reflect economic costs in many cases.
- Natural Gas :The government has been the sole authority for fixing the price of natural gas in the country. It has also been taking decisions on the allocation of gas to various competing consumers. The gas prices varies from Rs 5 to Rs.15 per cubic metre

- Electricity

Electricity tariffs in India are structured in a relatively simple manner. While high tension consumers are charged based on both demand (kVA) and energy (kWh), the low-tension (LT) consumer pays only for the energy consumed (kWh) as per tariff system in most of the electricity boards.

The price per kWh varies significantly across States as well as customer segments within a State. Tariffs in India have been modified to consider the time of usage and voltage level of supply. In addition to the base tariffs, some State Electricity Boards have additional recovery from customers in form of fuel surcharges, electricity duties and taxes.

For example, for an industrial consumer the demand charges may vary from Rs. 150 to Rs. 300 per kVA, whereas the energy charges may vary anywhere between Rs. 2 to Rs. 5 per kWh. As for the tariff adjustment mechanism, even when some States have regulatory commissions for tariff review, the decisions to effect changes are still political and there is no automatic adjustment mechanism, which can ensure recovery of costs for the electricity boards.

Energy Sector Reforms

- Since the initiation of economic reforms in India in 1991, there has been a growing acceptance of the need for deepening these reforms in several sectors of the economy, which were essentially in the hands of the government for several decades.
- It is now been realized that if substance has to be provided to macroeconomic policy reform, then it must be based on reforms that concern the functioning of several critical sectors of the economy, among which the infrastructure sectors in general and the energy sector in particular, are paramount.

Electricity Act, 2003

- The government has enacted Electricity Act, 2003 which seeks to bring about a qualitative transformation of the electricity sector. The Act seeks to create liberal framework of development for the power sector by distancing Government from regulation

Salient features of the Electricity Act, 2003 are

- The Central Government to prepare a National Electricity Policy in consultation with State Governments. (Section 3)
- Thrust to complete the rural electrification and provide for management of rural distribution by Panchayats, Cooperative Societies, non-Government organisations, franchisees etc. (Sections 4, 5 & 6)
- Provision for licence free generation and distribution in the rural areas. (Section 14)
- Generation being delicensed and captive generation being freely permitted. Hydro projects would, however, need clearance from the Central Electricity Authority. (Sections 7, 8 & 9)
- Transmission Utility at the Central as well as State level, to be a Government company - with responsibility for planned and coordinated development of transmission network. (Sections 38 & 39) vi) Provision for private licensees in transmission and entry in distribution through an independent network, (Section 14)
- Open access in transmission from the outset. (Sections 38-40)

- Distribution licensees would be free to undertake generation and generating companies would be free to take up distribution businesses. (Sections 7, 12)
- The State Electricity Regulatory Commission is a mandatory requirement. (Section 82)
- Provision for payment of subsidy through budget. (Section 65)

- Trading, a distinct activity is being recognised with the safeguard of the Regulatory Commissions being authorised to fix ceilings on trading margins, if necessary. (Sections 12, 79 & 86)
- Provision for reorganisation or continuance of SEBs. (Sections 131 & 172)
- Metering of all electricity supplied made mandatory. (Section 55)
- An Appellate Tribunal to hear appeals against the decision of the CERC and SERCs. (Section 111)
- Provisions relating to theft of electricity made more stringent. (Section 135-150) xvii) Provisions safeguarding consumer interests.

Energy and Environment

- The usage of energy resources in industry leads to environmental damages by polluting the atmosphere. Few of examples of air pollution are sulphur dioxide (SO2), nitrous oxide (NOX) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, etc. In chemical and fertilizers industries, toxic gases are released. Cement plants and power plants spew out particulate matter. Typical inputs, outputs, and emissions for a typical industrial process

Air Pollution

- A variety of air pollutants have known or suspected harmful effects on human health and the environment. These air pollutants are basically the products of combustion from fossil fuel use. Air pollutants from these sources may not only create problems near to these sources but also can cause problems far away. Air pollutants can travel long distances, chemically react in the atmosphere to produce secondary pollutants such as acid rain or ozone

- The principle pollutants produced by industrial, domestic and traffic sources are sulphur dioxide, nitrogen oxides, particulate matter, carbon monoxide, ozone, hydrocarbons, benzene, 1,3-butadiene, toxic organic micropollutants, lead and heavy metals.

Brief introduction to the principal pollutants are as follows:

- Sulphur dioxide is a corrosive acid gas, which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses. SO2 in ambient air is also associated with asthma and chronic bronchitis. The principal source of this gas is power stations and industries burning fossil fuels containing sulphur.

- Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides - nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x - is road traffic. NO and NO_2 concentrations are greatest in urban areas where traffic is heaviest.
- Other important sources are power stations and industrial processes. Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised to NO_2 by reaction with ozone. Elevated levels of NO_x occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse. Nitrogen dioxide has a variety of environmental and health impacts. It irritates the respiratory system and may worsen asthma and increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. Nitrogen oxides combine with water vapour to form nitric acid. This nitric acid is in turn removed from the atmosphere by direct deposition to the ground, or transfer to aqueous droplets (e.g. cloud or rainwater), thereby contributing to acid deposition.
- Acidification from SO_2 and NO_x Acidification of water bodies and soils, and the consequent impact on agriculture, forestry and fisheries are the result of the re-deposition of acidifying compounds resulting principally from the oxidation of primary SO_2 and NO_2 emissions from fossil fuel combustion. Deposition may be by either wet or dry processes, and acid deposition studies often need to examine both of these acidification routes.

- A major source of fine primary particles are combustion processes, in particular diesel com bustion, where transport of hot exhaust vapour into a cooler exhaust pipe can lead to spontaneous nucleation of "carbon" particles before emission. Secondary particles are typically formed when low volatility products are generated in the atmosphere, for example the oxidation of sulphur dioxide to sulphuric acid. The atmospheric lifetime of particulate matter is strongly related to particle size, but may be as long as 10 days for particles of about 1mm in diameter. Concern about the potential health impacts of PM10 has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring of the smaller particle fraction PM2.5 capable of penetrating deepest into the lungs, or to even smaller size fractions or total particle numbers.
- Carbon monoxide (CO) is a toxic gas, which is emitted into the atmosphere as a result of combustion processes, and from oxidation of hydrocarbons and other organic compounds. In urban areas, CO is produced almost entirely (90%) from road traffic emissions. CO at levels found in ambient air may reduce the oxygen-carrying capacity of the blood. It survives in the atmosphere for a period of approximately 1 month and finally gets oxidised to carbon dioxide (CO2).

- Ground-level ozone (O_3), unlike other primary pollutants mentioned above, is not emitted directly into the atmosphere, but is a secondary pollutant produced by reaction between nitrogen dioxide (NO_2), hydrocarbons and sunlight. Ozone can irritate the eyes and air passages causing breathing difficulties and may increase susceptibility to infection. It is a highly reactive chemical, capable of attacking surfaces, fabrics and rubber materials. Ozone is also toxic to some crops, vegetation and trees. Whereas nitrogen dioxide (NO_2) participates in the formation of ozone, nitrogen oxide (NO) destroys ozone to form oxygen (O_2) and nitrogen dioxide (NO_2).
- For this reason, ozone levels are not as high in urban areas (where high levels of NO are emitted from vehicles) as in rural areas. As the nitrogen oxides and hydrocarbons are transported out of urban areas, the ozone-destroying NO is oxidised to NO_2, which participates in ozone formation.
- Hydrocarbons There are two main groups of hydrocarbons of concern: volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). VOCs are released in vehicle exhaust gases either as unburned fuels or as combustion products, and are also emitted by the evaporation of solvents and motor fuels.
- Benzene and 1,3-butadiene are of particular concern, as they are known carcinogens. Other VOCs are important because of the role they play in the photochemical formation of ozone in the atmosphere.

- Benzene is an aromatic VOC, which is a minor constituent of petrol (about 2% by volume). The main sources of benzene in the atmosphere are the distribution and combustion of petrol. Of these, combustion by petrol vehicles is the single biggest source (70% of total emissions) whilst the refining, distribution and evaporation of petrol from vehicles accounts for approximately a further 10% of total emissions. Benzene is emitted in vehicle exhaust not only as unburnt fuel but also as a product of the decomposition of other aromatic compounds. Benzene is a known human carcinogen

- 1,3-butadiene, like benzene, is a VOC emitted into the atmosphere principally from fuel combustion of petrol and diesel vehicles. Unlike benzene, however, it is not a constituent of the fuel but is produced by the combustion of olefins. 1,3-butadiene is also an important chemical in certain industrial processes, particularly the manufacture of synthetic rubber. It is handled in bulk at a small number of industrial locations. Other than in the vicinity of such locations, the dominant source of 1,3-butadiene in the atmosphere are the motor vehicles. 1,3 Butadiene is also a known, potent, human carcinogen.
- TOMPs (Toxic Organic Micropollutants) are produced by the incomplete combustion of fuels. They comprise a complex range of chemicals some of which, although they are emitted in very small quantities, are highly toxic or and carcinogenic. Compounds in this category include: · PAHs (PolyAromatic Hydrocarbons) · PCBs (PolyChlorinated Biphenyls) · Dioxins · Furans Heavy Metals.

- Heavy Metals and Lead Particulate metals in air result from activities such as fossil fuel combustion (including vehicles), metal processing industries and waste incineration. There are currently no emission standards for metals other than lead. Lead is a cumulative poison to the central nervous system, particularly detrimental to the mental development of children. Lead is the most widely used non-ferrous metal and has a large number of industrial applications. Its single largest industrial use worldwide is in the manufacture of batteries and it is also used in paints, glazes, alloys, radiation shielding, tank lining and piping. As tetraethyl lead, it has been used for many years as an additive in petrol; with the increasing use of unleaded petrol, however, emissions and concentrations in air have reduced steadily in recent years.
- Climatic Change Human activities, particularly the combustion of fossil fuels, have made the blanket of greenhouse gases (water vapour, carbon dioxide, methane, ozone etc.) around the earth thicker. The resulting increase in global temperature is altering the complex web of systems that allow life to thrive on earth such as rainfall, wind patterns, ocean currents and distribution of plant and animal species.

- Greenhouse Effect and the Carbon Cycle Life on earth is made possible by energy from the sun, which arrives mainly in the form of vis- the balance 70 percent reaches the earth's surface, which reflects it in form of infrared radiation. The escape of slow moving infrared radiation is delayed by the green house gases. A thicker blanket of greenhouse gases traps more infrared radiation and increase the earth's temperature (Refer Figure 1.11). Greenhouse gases makeup only 1 percent of the atmosphere, but they act as a blanket around the earth, or like a glass roof of a greenhouse and keep the earth 30 degrees warmer than it would be otherwise - without greenhouse gases, earth would be too cold to live. Human activities that are responsible for making the greenhouse layer thicker are emissions of carbon dioxide from the combustion of coal, oil and natural gas; by additional methane and nitrous oxide from farming activities and changes in land use; and by several man made gases that have a long life in the atmosphere. The increase in greenhouse gases is happening at an alarming rate. If greenhouse gases emissions continue to grow at current rates, it is almost certain that the atmospheric levels of carbon dioxide will increase twice or thrice from pre-industrial levels during the 21st century.

- Carbon dioxide is responsible for 60 percent of the "enhanced greenhouse effect". Humans are burning coal, oil and natural gas at a rate that is much faster than the rate at which these fossil fuels were created. This is releasing the carbon stored in the fuels into the atmosphere and upsetting the carbon cycle (a precise balanced system by which carbon is exchanged between the air, the oceans and land vegetation taking place over millions of years). Currently, carbon dioxide levels in the atmospheric are rising by over 10 percent every 20 years.
- Current Evidence of Climatic Change

Cyclones, storm, hurricanes are occurring more frequently and floods and draughts are more intense than before. This increase in extreme weather events cannot be explained away as random events. This trend toward more powerful storms and hotter, longer dry periods is predicted by computer models. Warmer temperatures mean greater evaporation, and a warmer atmosphere is able to hold more moisture and hence there is more water aloft that can fall as precipitation. Similarly, dry regions are prone to lose still more moisture if the weather is hotter and hence this leads to more severe droughts and desertification.

- Future Effects Even the minimum predicted shifts in climate for the 21st century are likely to be significant and disruptive. Predictions of future climatic changes are wide-ranging. The global temperature may climb from 1.4 to 5.8 degrees C; the sea level may rise from 9 to 88 cm. Thus, increases in sea level this century are expected to range from significant to catastrophic. This uncertainty reflects the complexity, interrelatedness, and sensitivity of the natural systems that make up the climate.

- Severe Storms and Flooding The minimum warming forecast for the next 100 years is more than twice the 0.6 degree C increase that has occurred since 1900 and that earlier increase is already having marked consequences. Extreme weather events, as predicted by computer models, are striking more often and can be expected to intensify and become still more frequent. A future of more severe storms and floods along the world's increasingly crowded coastlines is likely. Food Shortages Although regional and local effects may differ widely, a general reduction is expected in potential crop yields in most tropical and sub-tropical regions. Mid-continental areas such as the United States' "grain belt" and vast areas of Asia are likely to become dry. Sub-Saharan Africa where dryland agriculture relies solely on rain, the yields would decrease dramatically even with minimum increase in temperature. Such changes could cause disruptions in food supply in a world is already afflicted with food shortages and famines. Dwindling Freshwater supply Salt-water intrusion from rising sea levels will reduce the quality and quantity of freshwater supplies. This is a major concern, since billions of people on earth already lack access to freshwater. Higher ocean levels already are contaminating underground water sources in many parts of the world.

- Loss of Biodiversity Most of the world's endangered species (some 25 per cent of mammals and 12 per cent of birds) may become extinct over the next few decades as warmer conditions alter the forests, wetlands, and rangelands they depend on, and human development blocks them from migrating elsewhere. Increased Diseases Higher temperatures are expected to expand the range of some dangerous "vector-borne" diseases, such as malaria, which already kills 1 million people annually, most of them children. A World Under Stress Ongoing environmentally damaging activities such as overgrazing, deforestation, and denuded agricultural soils means that nature will be more vulnerable than previously to changes in climate. Similarly, the world's vast human population, much of it poor, is vulnerable to climate stress. Millions live in dangerous places such as floodplains or in slums around the big cities of the developing world. Often there is nowhere else for population to move. In the distant past, man and his ancestors migrated in response to changes in habitat. There will be much less room for migration in future. Global warming almost certainly will be unfair. The industrialized countries of North America and Western Europe, and other countries such as Japan, are responsible for the vast amount of past and current greenhouse-gas emissions. These emissions are incurred for the high standards of living enjoyed by the people in those countries. Yet those to suffer most from climate change will be in the developing world. They have fewer resources for coping with storms, with floods, with droughts, with disease outbreaks, and with disruptions to food and water supplies. They are eager for economic development themselves, but may find that this already difficult process has become more difficult because of climate change. The poorer nations of the world have done almost nothing to cause global warming yet is most exposed to its effects

- Acid Rain Acid rain is caused by release of SOX and NOX from combustion of fossil fuels, which then mixwith water vapour in atmosphere to form sulphuric and nitric acids respectively
- The effects of acid rain are as follows: • Acidification of lakes, streams, and soils • Direct and indirect effects (release of metals, For example: Aluminum which washes away plant nutrients) • Killing of wildlife (trees, crops, aquatic plants, and animals) • Decay of building materials and paints, statues, and sculptures • Health problems (respiratory, burning- skin and eyes)

- Energy Security The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth. India will continue to experience an energy supply shortfall throughout the forecast period. This gap has widened since 1985, when the country became a net importer of coal. India has been unable to raise its oil production substantially in the 1990s. Rising oil demand of close to 10 percent per year has led to sizable oil import bills. In addition, the government subsidised refined oil product prices, thus compounding the overall monetary loss to the government.

- Increasing dependence on oil imports means reliance on imports from the Middle East, a region susceptible to disturbances and consequent disruptions of oil supplies. This calls for diversification of sources of oil imports. The need to deal with oil price fluctuations also necessitates measures to be taken to reduce the oil dependence of the economy, possibly through fiscal measures to reduce demand, and by developing alternatives to oil, such as natural gas and renewable energy. Some of the strategies that can be used to meet future challenges to their energy security are • Building stockpiles • Diversification of energy supply sources • Increased capacity of fuel switching • Demand restraint, • Development of renewable energy sources. • Energy efficiency • Sustainable development

- Energy Conservation and its Importance

Coal and other fossil fuels, which have taken three million years to form, are likely to deplete soon. In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures. Today, 85% of primary energy comes from nonrenewable, and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations

What is Energy Conservation?

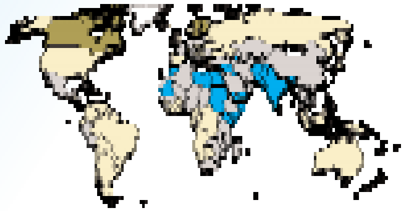
- Energy Conservation and Energy Efficiency are separate, but related concepts. Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms. Energy Conservation can, therefore, be the result of several processes or developments, such as productivity increase or technological progress. On the other hand Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Promotion of energy efficiency will contribute to energy conservation and is therefore an integral part of energy conservation promotional policies.

Energy Efficiency Benefits

Industry

- Reduced energy bills
- Increased Competitiveness
- Increased productivity
- Improved quality
- Increased profits !

Nation



- Reduced energy imports
- Avoided costs can be used for poverty reduction
- Conservation of limited resources
- Improved energy security

Globe

- Reduced GHG and other emissions
- Maintains a sustainable environment

Energy Strategy for the Future

- The energy strategy for the future could be classified into immediate, medium-term and longterm strategy. The various components of these strategies are listed below: Immediate-term strategy: • Rationalizing the tariff structure of various energy products. • Optimum utilization of existing assets • Efficiency in production systems and reduction in distribution losses, including those in traditional energy sources. • Promoting R&D, transfer and use of technologies and practices for environmentally sound energy systems, including new and renewable energy sources.

- Medium-term strategy: • Demand management through greater conservation of energy, optimum fuel mix, structural changes in the economy, an appropriate model mix in the transport sector, i.e. greater dependence on rail than on road for the movement of goods and passengers and a shift away from private modes to public modes for passenger transport; changes in design of different products to reduce the material intensity of those products, recycling, etc. • There is need to shift to less energy-intensive modes of transport. This would include measures to improve the transport infrastructure viz. roads, better design of vehicles, use of compressed natural gas (CNG) and synthetic fuel, etc. Similarly, better urban planning would also reduce the demand for energy use in the transport sector. • There is need to move away from non-renewable to renewable energy sources viz. solar, wind, biomass energy, etc.

- Long-term strategy: Efficient generation of energy resources • Efficient production of coal, oil and natural gas • Reduction of natural gas flaring Improving energy infrastructure • Building new refineries • Creation of urban gas transmission and distribution network • Maximizing efficiency of rail transport of coal production. • Building new coal and gas fired power stations. Enhancing energy efficiency • Improving energy efficiency in accordance with national, socio-economic, and environmental priorities • Promoting of energy efficiency and emission standards • Labeling programmes for products and adoption of energy efficient technologies in large industries Deregulation and privatization of energy sector • Reducing cross subsidies on oil products and electricity tariffs • Decontrolling coal prices and making natural gas prices competitive • Privatization of oil, coal and power sectors for improved efficiency. Investment legislation to attract foreign investments. • Streamlining approval process for attracting private sector participation in power generation, transmission and distribution

The Energy Conservation Act, 2001 and its Features

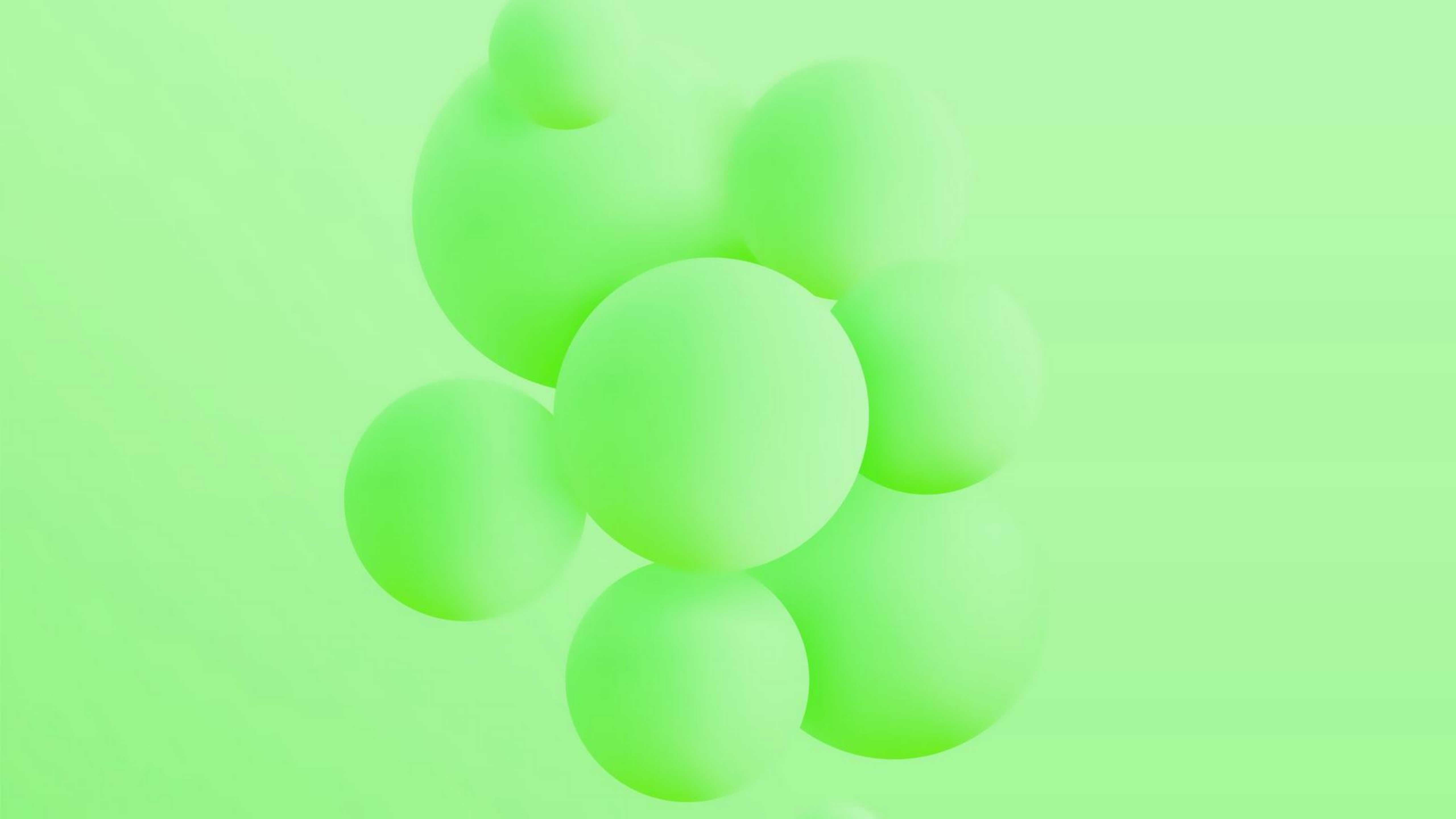
- Policy Framework - Energy Conservation Act - 2001 With the background of high energy saving potential and its benefits, bridging the gap between demand and supply, reducing environmental emissions through energy saving, and to effectively overcome the barrier, the Government of India has enacted the Energy Conservation Act - 2001. The Act provides the much-needed legal framework and institutional arrangement for embarking on an energy efficiency drive. Under the provisions of the Act, Bureau of Energy Efficiency has been established with effect from 1st March 2002 by merging erstwhile Energy Management Centre of Ministry of Power. The Bureau would be responsible for implementation of policy programmes and coordination of implementation of energy conservation activities.

Important Features

- Standards and Labeling Standards and Labeling (S & L) has been identified as a key activity for energy efficiency improvement. The S & L program, when in place would ensure that only energy efficient equipment and appliance would be made available to the consumers.

- The main provision of EC act on Standards and Labeling are: • Evolve minimum energy consumption and performance standards for notified equipment and appliances. • Prohibit manufacture, sale and import of such equipment, which does not conform to the standards. • Introduce a mandatory labeling scheme for notified equipment appliances to enable consumers to make informed choices • Disseminate information on the benefits to consumers Designated Consumers The main provisions of the EC Act on designated consumers are: • The government would notify energy intensive industries and other establishments as designated consumers; • Schedule to the Act provides list of designated consumers which covered basically energy intensive industries, Railways, Port Trust, Transport Sector, Power Stations, Transmission & Distribution Companies and Commercial buildings or establishments; • The designated consumer to get an energy audit conducted by an accredited energy auditor; • Energy managers with prescribed qualification are required to be appointed or designated by the designated consumers; • Designated consumers would comply with norms and standards of energy consumption as prescribed by the central government.

- Certification of Energy Managers and Accreditation of Energy Auditing Firms The main activities in this regard as envisaged in the Act are: A cadre of professionally qualified energy managers and auditors with expertise in policy analysis, project management, financing and implementation of energy efficiency projects would be developed through Certification and Accreditation programme. BEE to design training modules, and conduct a National level examination for certification of energy managers and energy auditors.
- Energy Conservation Building Codes: The main provisions of the EC Act on Energy Conservation Building Codes are: • The BEE would prepare guidelines for Energy Conservation Building Codes (ECBC); • These would be notified to suit local climate conditions or other compelling factors by the respective states for commercial buildings erected after the rules relating to energy conservation building codes have been notified. In addition, these buildings should have a connected load of 500 kW or contract demand of 600 kVA and above and are intended to be used for commercial purposes; • Energy audit of specific designated commercial building consumers would also be prescribed.



Central Energy Conservation Fund:

- The fund would be set up at the centre to develop the delivery mechanism for large-scale adoption of energy efficiency services such as performance contracting and promotion of energy service companies. The fund is expected to give a thrust to R & D and demonstration in order to boost market penetration of efficient equipment and appliances. It would support the creation of facilities for testing and development and to promote consumer awareness.

Bureau of Energy Efficiency (BEE):

• The mission of Bureau of Energy Efficiency is to institutionalize energy efficiency services, enable delivery mechanisms in the country and provide leadership to energy efficiency in all sectors of economy. The primary objective would be to reduce energy intensity in the Indian Economy. • The general superintendence, directions and management of the affairs of the Bureau is vested in the Governing Council with 26 members. The Council is headed by Union Minister of Power and consists of members represented by Secretaries of various line Ministries, the CEOs of technical agencies under the Ministries, members representing equipment and appliance manufacturers, industry, architects, consumers and five power regions representing the states. The Director General of the Bureau shall be the ex-officio member-secretary of the Council. • The BEE will be initially supported by the Central Government by way of grants through budget, it will, however, in a period of 5-7 years become self-sufficient. It would be authorized to collect appropriate fee in discharge of its functions assigned to it. The BEE will also use the Central Energy Conservation Fund and other funds raised from various sources for innovative financing of energy efficiency projects in order to promote energy efficient investment.

- Role of Bureau of Energy Efficiency

The role of BEE would be to prepare standards and labels of appliances and equipment, develop a list of designated consumers, specify certification and accreditation procedure, prepare building codes, maintain Central EC fund and undertake promotional activities in co-ordination with center and state level agencies. The role would include development of Energy service companies (ESCOs), transforming the market for energy efficiency and create awareness through measures including clearing house.

- Role of Central and State Governments:

The following role of Central and State Government is envisaged in the Act • Central - to notify rules and regulations under various provisions of the Act, provide initial financial assistance to BEE and EC fund, Coordinate with various State Governments for notification, enforcement, penalties and adjudication. • State - to amend energy conservation building codes to suit the regional and local climatic condition, to designate state level agency to coordinate, regulate and enforce provisions of the Act and constitute a State Energy Conservation Fund for promotion of energy efficiency.

- Enforcement through Self-Regulation:
- E.C. Act would require inspection of only two items.

The following procedure of self-regulation is proposed to be adopted for verifying areas that require inspection of only two items that require inspection.

• The certification of energy consumption norms and standards of production process by the Accredited Energy Auditors is a way to enforce effective energy efficiency in Designated Consumers. • For energy performance and standards, manufacturer's declared values would be checked in Accredited Laboratories by drawing sample from market. Any manufacturer or consumer or consumer association can challenge the values of the other manufacturer and bring to the notice of BEE. BEE can recognize for challenge testing in disputed cases as a measure for self-regulation. Penalties and Adjudication:

• Penalty for each offence under the Act would be in monetary terms i.e. Rs.10,000 for each offence and Rs.1,000 for each day for continued non Compliance.

• The initial phase of 5 years would be promotional and creating infrastructure for implementation of Act. No penalties would be effective during this phase. • The power to adjudicate has been vested with state Electricity Regulatory Commission which shall appoint any one of its member to be an adjudicating officer for holding an enquiry in connection with the penalty imposed.

Unit-2

- Basics of Energy and its form

Syllabus

- Basics of Energy and its various forms: Electricity basics - DC & AC currents, Electricity tariff, Load management and Maximum demand control, Power factor. Thermal basics -Fuels, Thermal energy contents of fuel, Temperature & Pressure, Heat capacity, Sensible and Latent heat, Evaporation, Condensation, Steam, Moist air and Humidity & Heat transfer, Units and conversion.

Energy

- Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy.

Various Forms of Energy

- Potential Energy

Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

Chemical Energy :Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

Nuclear Energy :Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

Stored Mechanical :Energy Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Gravitational Energy Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin the turbines, it becomes motion energy.

- Kinetic Energy

Kinetic energy is energy in motion- the motion of waves, electrons, atoms, molecules and substances.

It exists in various forms.

Radiant Energy :Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

Thermal Energy :Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Motion :The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

Sound :Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

Electrical Energy :Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy

Energy Conversion

- Energy is defined as "the ability to do work." In this sense, examples of work include moving something, lifting something, warming something, or lighting something. The following is an example of the transformation of different types of energy into heat and power.

Grades of Energy

- High-Grade Energy Electrical and chemical energy are high-grade energy, because the energy is concentrated in a small space. Even a small amount of electrical and chemical energy can do a great amount of work. The molecules or particles that store these forms of energy are highly ordered and compact and thus considered as high grade energy. High-grade energy like electricity is better used for high grade applications like melting of metals rather than simply heating of water.
- Low-Grade Energy Heat is low-grade energy. Heat can still be used to do work (example of a heater boiling water), but it rapidly dissipates. The molecules, in which this kind of energy is stored (air and water molecules), are more randomly distributed than the molecules of carbon in a coal. This disordered state of the molecules and the dissipated energy are classified as low-grade energy.

Electricity basics - DC & AC currents

- Electric current is divided into two types:

Directional Current (DC) and Alternating Current (AC).

Directional (Direct) Current: A non-varying, unidirectional electric current (Example: Current produced by batteries)

Characteristics:

• Direction of the flow of positive and negative charges does not change with time

• Direction of current (direction of flow for positive charges) is constant with time

• Potential difference (voltage) between two points of the circuit does not change polarity with time

Alternating Current: A current which reverses in regularly recurring intervals of time and which has alternately positive and negative values, and occurring a specified number of times per second.

(Example: Household electricity produced by generators, Electricity supplied by utilities.) Characteristics: · Direction of the current reverses periodically with time · Voltage (tension) between two points of the circuit changes polarity with time. · In 50 cycle AC, current reverses direction 100 times a second (two times during onecycle)

- Ampere (A) Current is the rate of flow of charge. The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires, which are 1 metre apart in a vacuum.
- Voltage (V) The volt is the International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance.

- Resistance= Voltage/Current
- The unit of resistance is ohm (Ω) Ohm' Law
- Ohm's law states that the current through a conductor is directly proportional to the potential difference across it, provided the temperature and other external conditions remain constant.
- Frequency The supply frequency tells us the cycles at which alternating current changes. The unit of frequency is hertz (Hz :cycles per second).

- Kilovolt Ampere (kVA) It is the product of kilovolts and amperes. This measures the electrical load on a circuit or system. It is also called the apparent power. 1000 V
- For a single phase electrical circuit ,

Apparent power(kVA)=voltage*amperes/1000

For a three phase electrical circuit ,Apparent power(kVA)=√3*voltage*amperes/1000

- kVAr (Reactive Power) kVAr is the reactive power. Reactive power is the portion of apparent power that does no work. This type of power must be supplied to all types of magnetic equipment, such as motors, transformers etc. Larger the magnetizing requirement, larger the kVAr.
- Kilowatt (kW) (Active Power) kW is the active power or the work-producing part of apparent power.

For single phase ,power=voltage*ampere*pf/1000

For three phase ,power=voltage*ampere*pf*1.732/1000

- Power Factor Power Factor (PF) is the ratio between the active power (kW) and apparent power (kVA).

Power factor=active power/apparent power

- Kilowatt-hour (kWh) Kilowatt-hour is the energy consumed by 1000 Watts in one hour. If 1kW (1000 watts) of a electrical equipment is operated for 1 hour, it would consume 1 kWh of energy (1 unit of electricity). For a company, it is the amount of electrical units in kWh recorded in the plant over a month for billing purpose. The company is charged / billed based on kWh consumption

Electricity Tariff

- Calculation of electric bill for a company

Electrical utility or power supplying companies charge industrial customers not only based on the amount of energy used (kWh) but also on the peak demand (kVA) for each month. Contract Demand Contract demand is the amount of electric power that a customer demands from utility in a specified interval. Unit used is kVA or kW. It is the amount of electric power that the consumer agreed upon with the utility. This would mean that utility has to plan for the specified capacity. Maximum demand Maximum demand is the highest average kVA recorded during any one-demand interval within the month. The demand interval is normally 30 minutes, but may vary from utility to utility from 15 minutes to 60 minutes. The demand is measured using a tri-vector meter / digital energy meter.

- Prediction of Load

While considering the methods of load prediction, some of the terms used in connection with power supply must be appreciated.

Connected Load - is the nameplate rating (in kW or kVA) of the apparatus installed on a consumer's premises.

Demand Factor - is the ratio of maximum demand to the connected load.

Load Factor - The ratio of average load to maximum load.

PF Measurement

A power analyzer can measure PF directly, or alternately kWh, kVAh or kVArh readings are recorded from the billing meter installed at the incoming point of supply. The relation kWh / kVAh gives the power factor.

Time of Day (TOD)

Tariff Many electrical utilities like to have flat demand curve to achieve high plant efficiency. They encourage user to draw more power during off-peak hours (say during night time) and less power during peak hours. As per their plan, they offer TOD Tariff, which may be incentives or disincentives. Energy meter will record peak and nonpeak consumption separately by timer control. TOD tariff gives opportunity for the user to reduce their billing, as off peak hour tariff charged are quite low in comparison to peak hour tariff.

Thermal Energy Basics

- Temperature and Pressure

Temperature and pressure are measures of the physical state of a substance. They are closely related to the energy contained in the substance. As a result, measurements of temperature and pressure provide a means of determining energy content.

Temperature It is the degree of hotness or coldness measured on a definite scale. Heat is a form of energy; temperature is a measure of its thermal effects. In other words, temperature is a means of determining sensible heat content of the substance In the Celsius scale the freezing point of water is 0°C and the boiling point of water is 100°C at atmospheric pressure. To change temperature given in Fahrenheit (°F) to Celsius (°C) Start with (°F); subtract 32; multiply by 5; divide by 9; the answer is (°C) To change temperature given in Celsius (°C) to Fahrenheit (°F) Start with (°C); multiply by 9; divide by 5; add on 32; the answer is (°F)

- Pressure :It is the force per unit area applied to outside of a body. When we heat a gas in a confined space, we create more force; a pressure increase.

For example, heating the air inside a balloon will cause the balloon to stretch as the pressure increases.

Pressure, therefore, is also indicative of stored energy. Steam at high pressures contains much more energy than at low pressures.

- Heat :Heat is a form of energy, a distinct and measurable property of all matter. The quantity of heat depends on the quantity and type of substance involved.
- Unit of Heat Calorie is the unit for measuring the quantity of heat. It is the quantity of heat, which can raise the temperature of 1 g of water by 1°C. Calorie is too small a unit for many purposes. Therefore, a bigger unit Kilocalorie (1 Kilocalorie

- Specific Heat: If the same amount of heat energy is supplied to equal quantities of water and milk, their temperature goes up by different amounts. This property is called the specific heat of a substance and is defined as the quantity of heat required to raise the temperature of 1kg of a substance through 1°C. The specific heat of water is very high as compared to other common substances; it takes a lot of heat to raise the temperature of water. Also, when water is cooled, it gives out a large quantity of heat.

- Sensible heat It is that heat which when added or subtracted results in a change of temperature.
- Quantity of Heat

The quantity of heat, Q, supplied to a substance to increase its temperature by t°C depends on – mass of the substance (m) – increase in temperature (Δt) – specific heat of the substance (Cp)

The quantity of heat is given by: Q = mass x specific heat x increase in temperature $Q = m \times Cp \times \Delta t$

- Phase Change :The change of state from the solid state to a liquid state is called fusion. The fixed temperature at which a solid changes into a liquid is called its melting point. The change of a state from a liquid state to a gas is called vaporization.
- Latent heat of fusion :The latent heat of fusion of a substance is the quantity of heat required to convert 1kg solid to liquid state without change of temperature. It is represented by the symbol L. Its unit is Joule per kilogram (J/Kg) Thus, L (ice) = 336000 J/kg,
- Latent Heat of Vaporization :The latent heat of vaporization of a substance is the quantity of heat required to change 1kg of the substance from liquid to vapour state without change of temperature. It is also denoted by the symbol L and its unit is also J/kg. The latent heat of vaporization of water is 22,60,000 J/kg. When 1 kg of steam at 100°C condenses to form water at 100°C, it gives out 2260 kJ (540 kCals) of heat. Steam gives out more heat than an equal amount of boiling water because of its latent heat.

- Latent heat :It is the change in heat content of a substance, when its physical state is changed without a change in temperature.
- Super Heat :The heating of vapour, particularly saturated steam to a temperature much higher than the boiling point at the existing pressure. This is done in power plants to improve efficiency and to avoid condensation in the turbine.
- Humidity :The moisture content of air is referred to as humidity and may be expressed in two ways: specific humidity and relative humidity.
- Specific Humidity: It is the actual weight of water vapour mixed in a kg of dry air.
- Humidity Factor :Humidity factor = kg of water per kg of dry air (kg/kg)

- Relative Humidity (RH) It is the measure of degree of saturation of the air at any dry-bulb (DB) temperature. Relative humidity given as a percentage is the actual water content of the air divided by the moisture content of fully saturated air at the existing temperature.
- Dew Point It is the temperature at which condensation of water vapour from the air begins as the temperature of the air-water vapour mixture falls.
- Dry bulb Temperature It is an indication of the sensible heat content of air-water vapour mixtures.
- Wet bulb Temperature It is a measure of total heat content or enthalpy. It is the temperature approached by the dry bulb and the dew point as saturation occurs.
- Dew Point Temperature It is a measure of the latent heat content of air-water vapour mixtures and since latent heat is a function of moisture content, the dew point temperature is determined by the moisture content.

- Fuel Density

Density is the ratio of the mass of the fuel to the volume of the fuel at a stated temperature. Specific gravity of fuel

The density of fuel, relative to water, is called specific gravity. The specific gravity of water is defined as 1. As it is a ratio there are no units. Higher the specific gravity, higher will be the heating values. Viscosity The viscosity of a fluid is a measure of its internal resistance to flow. All liquid fuels decrease in viscosity with increasing temperature

Calorific Value Energy content in an organic matter (Calorific Value) can be measured by burning it and measuring the heat released. This is done by placing a sample of known mass in a bomb calorimeter, a device that is completely sealed and insulated to prevent heat loss. A thermometer is placed inside (but it can be read from the outside) and the increase in temperature after the sample is burnt completely is measured. From this data, energy content in the organic matter can be found out. The heating value of fuel is the measure of the heat released during the complete combustion of unit weight of fuel. It is expressed as Gross Calorific Value (GCV) or Net Calorific Value (NCV). The difference between GCV and NCV is the heat of vaporization of the moisture and atomic hydrogen (conversion to water vapour) in the fuel. Typical GCV and NCV for heavy fuel oil are 10,500 kcal/kg and 9,800 kcal/kg.

Heat Transfer

- Heat will always be transferred from higher temperature to lower temperature independent of the mode.
- The energy transferred is measured in Joules (kcal or Btu). The rate of energy transfer, more commonly called heat transfer, is measured in Joules/second (kcal/hr or Btu/hr).
- Heat is transferred by three primary modes:

o Conduction (Energy transfer in a solid)

o Convection (Energy transfer in a fluid)

o Radiation (Does not need a material to travel through

Conduction

- The conduction of heat takes place, when two bodies are in contact with one another. If one body is at a higher temperature than the other, the motion of the molecules in the hotter body will vibrate the molecules at the point of contact in the cooler body and consequently result in increase in temperature.
- The amount of heat transferred by conduction depends upon the temperature difference, the properties of the material involved, the thickness of the material, the surface contact area, and the duration of the transfer. Good conductors of heat are typically substances that are dense as they have molecules close together. This allows the molecular agitation process to permeate the substance easily.
- metals are good conductors of heat, while gaseous substance, having low densities or widely spaced molecules, are poor conductors of heat. Poor conductors of heat are usually called insulators.
- Typical units of measure for conductive heat transfer are: Per unit area (for a given thickness) Metric (SI) : Watt per square meter (W/m2) Overall Metric (SI) : Watt (W) or kilowatts (kW

Convection

- The transfer of heat by convection involves the movement of a fluid such as a gas or liquid from the hot to the cold portion.
- There are two types of convection: natural and forced. In case of natural convection, the fluid in contact with or adjacent to a high temperature body is heated by conduction. As it is heated, it expands, becomes less dense and consequently rises. This begins a fluid motion process in which a circulating current of fluid moves past the heated body, continuously transferring heat away from it.
- In the case of forced convection, the movement of the fluid is forced by a fan, pump or other external means. A centralized hot air heating system is a good example of forced convection. Convection depends on the thermal properties of the fluid as well as surface conditions at the body and other factors that affect the ability of the fluid to flow

Thermal Radiation

- Thermal radiation is a process in which energy is transferred by electromagnetic waves similar to light waves. These waves may be both visible (light) and invisible. A very common example of thermal radiation is a heating element on a heater. When the heater element is first switched on, the radiation is invisible, but you can feel the warmth it radiates. As the element heats, it will glow orange and some of the radiation is now visible. The hotter the element, the brighter it glows and the more radiant energy it emits.
- The key processes in the interaction of a substance with thermal radiation are: Absorption the process by which radiation enters a body and becomes heat Transmission the process by which radiation passes through a body Reflection the process by which radiation is neither absorbed or transmitted through the body; rather it bounces off.

- The condition of a body's surface will determine the amount of thermal radiation that is absorbed, reflected or re-emitted. Surfaces that are black and rough, such as black iron, will absorb and re-emit almost all the energy that strikes them. Polished and smooth surfaces will not absorb, but reflect, a large part of the incoming radiant energy.
- Typical units of measure for rate of radiant heat transfer Metric (SI) Watt per square meter (W/m2)

Evaporation

- The change by which any substance is converted from a liquid state and carried off as vapour.
- Example: People are cooled by evaporation of perspiration from the skin and refrigeration is accomplished by evaporating the liquid refrigerant. Evaporation is a cooling process

- Condensation

The change by which any substance is converted from a gaseous state to liquid state.

Example: Condensation on the other hand is a heating process. As molecules of vapour condense and become liquid, their latent heat of vapourisation evidences itself again as sensible heat, indicated by a rise in temperature. This heating effect of condensation is what causes the considerable rise in atmospheric temperature often noted as fog forms and as rain or snow begins to fall

Steam

- Steam has been a popular mode of conveying energy, since the industrial revolution.

The following characteristics of steam make it so popular and useful to the industry:

- High specific heat and latent heat
- High heat transfer coefficient
- Easy to control and distribute
- Cheap and inert

- Steam is used for generating power and also used in process industries, such as, sugar, paper, fertilizer, refineries, petrochemicals, chemical, food, synthetic fibre and textiles. In the process industries, the high pressure steam produced in the boiler, is first expanded in a steam turbine for generating power. The extraction or bleed from the turbine, which are generally at low pressure, are used for the process. This method of producing power, by using the steam generated for process in the boiler, is called "Cogeneration."

First law of Thermodynamics

It states that energy may be converted from one form to another, but it is never lost from the system.

Second Law of Thermodynamics

• In any conversion of energy from one form to another, some amount of energy will be dissipated as heat.

• Thus no energy conversion is 100 % efficient. • This principle is used in energy equipment efficiency calculations

Law of Conservation of Matter

• In any physical or chemical change, matter is neither created nor destroyed, but it may be changed from one form to another.

For example, if a sample of coal were burnt in an enclosed chamber, carbon in coal would end up as CO_2 in the air inside the chamber; In fact, for every carbon atom there would be one carbon dioxide molecule in the combustion products (each of which has one carbon atom). So the carbon atoms would be conserved, and so would every other atom. Thus, no matter would be lost during this conversion of the coal into heat.

This principle is used in energy and material balance calculations