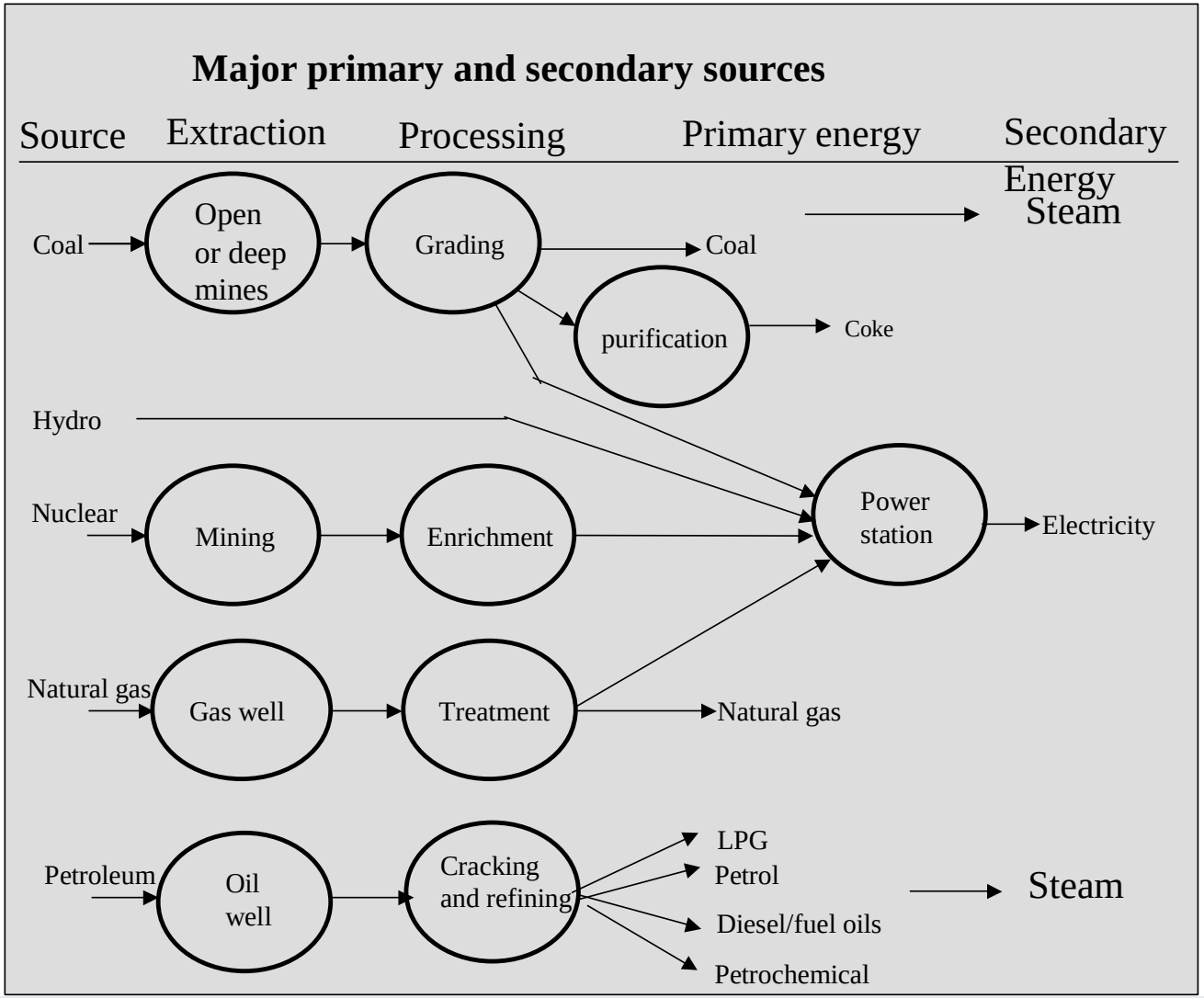
ENERGY EFFICIENCY CONCEPTS & FUNDAMENTALS

Energy Classification

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy

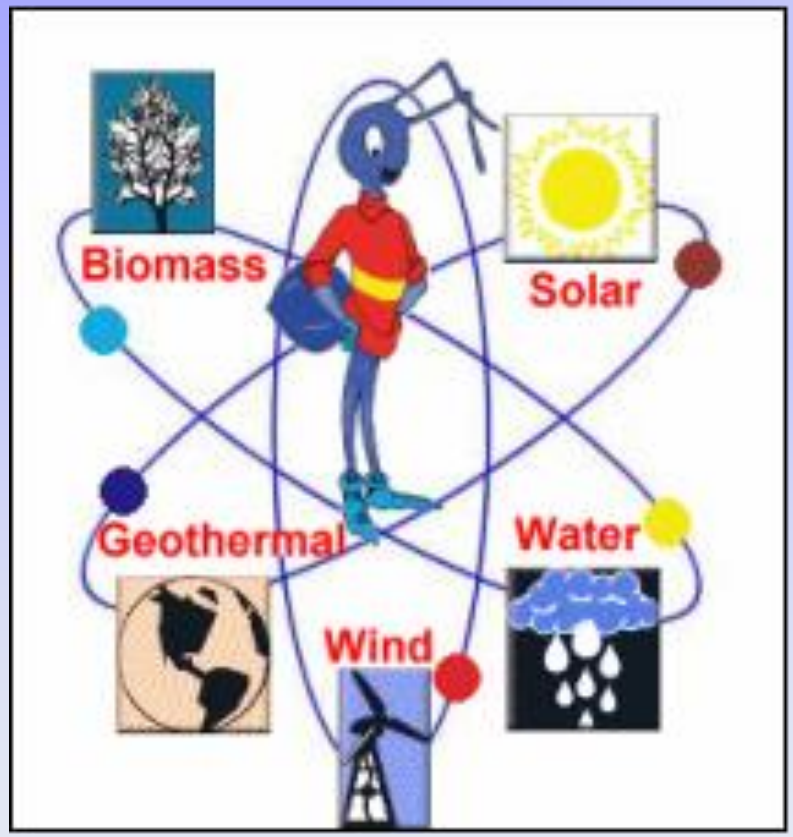
Primary and Secondary Energy

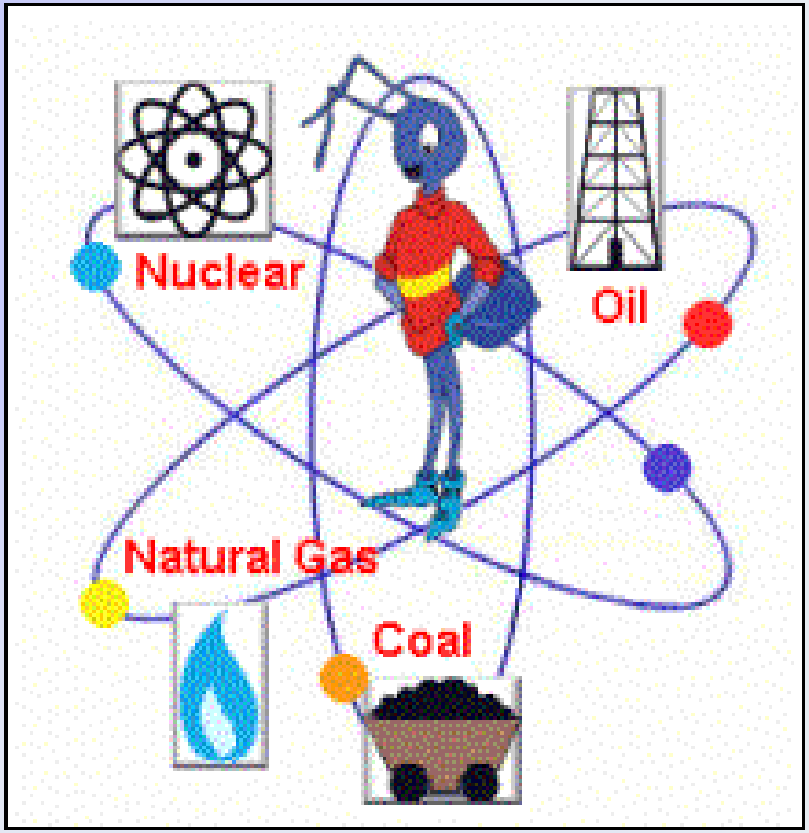


Commercial and Non-commercial Energy

- **Commercial energy** is energy available at price
  - Examples are electricity, coal, lignite, oil, and natural gas
- **Non-commercial energy** is energy not available in market for a price
  - Examples are firewood, cattle dung and agricultural wastes, solar energy, animal power, wind energy

Renewable & Non-renewable Energy



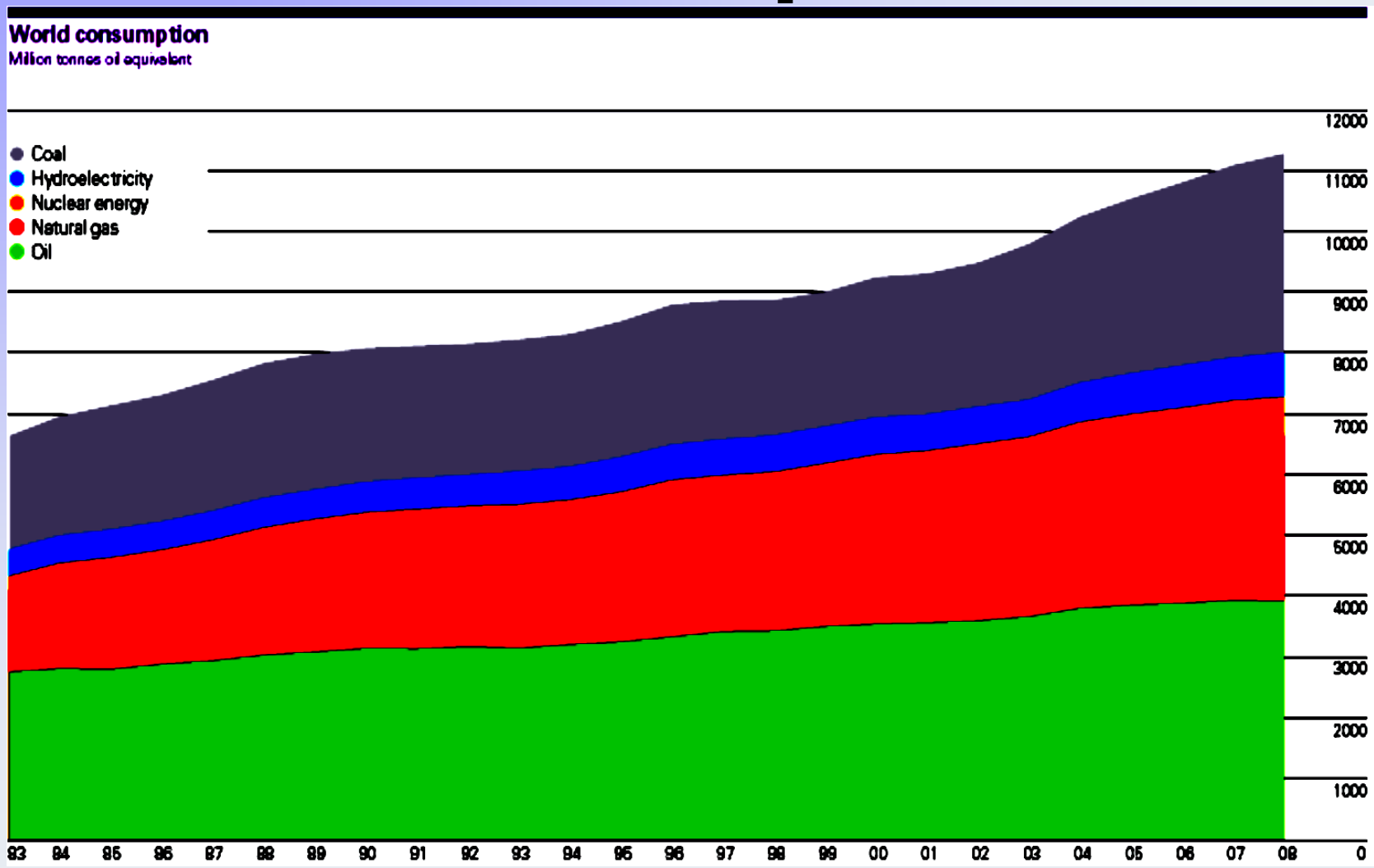


Global Energy Reserves (End 2008)

- Global coal reserves 826,001 million tonnes
- 1258 billion barrels of oil
- 185 trillion cubic metres of gas

- **World oil and gas reserves are estimated to last 43 years and 60 years respectively.**
- **Coal is likely to last a little over 122 years**

Global Primary Energy Consumption



Primary Energy Consumption-
Some Developing and Developed Countries

Primary Energy consumption at the end of 2008						
Country	Million tones of oil equivalent(Mtoe)					
	OIL	**COAL**	**Natural Gas**	**Nuclear**	**Hydro**	**Total**
USA	884.5	565	600.7	192	56.7	2298.9
Canada	102	33	90	21.1	83.6	329.7
France	92.2	11.9	39.8	99.6	14.3	257.8
Russian Federation	130.4	101.3	378.2	36.9	37.8	684.6
UK	78.7	35.4	84.5	11.9	1.1	211.6
China	375.7	1406.3	2.3	15.5	132.4	1932.2
India	135	231.4	37.2	3.5	26.2	433.3
Pakistan	19.3	6.7	33.8	0	6.3	66.1
Indonesia	57.4	30.2	34.2	0	2.7	124.4
Iran	83.3	1.3	105.8	0	1.7	192.1
Japan	221.8	128.7	84.4	57	15.7	507.6
Malaysia	21.8	5	27.6	0	1.5	55.9
Singapore	49.9	66.1	8.3	34.2	0.9	159.4
Total World	3927.9	3303.7	2726.1	619.7	717.5	11294.9

Energy Intensity

Definition:

Energy intensity is energy consumption per unit of GDP. Energy intensity indicates the development stage of the country.

Energy Intensive Industries

Energy demand in the Iron and Steel, Chemical and petrochemical, chlor-alkali, non-metallic and other minerals,cement, food, paper and textile industries together currently represent over half of total industrial energy demand. They are hence categorised as energy intensive industries.

Energy Pricing

- Pricing influenced by economic, social and political compulsions
- Cross-subsidies: Diesel, LPG and Kerosene subsidized by Petrol
- Agricultural and domestic users subsidized by Industrial and commercial users

Energy Security

- High energy demand growth rate projected.
- Many developing nations has to depend on import of oil and coal to meet domestic energy requirement .
- Developing nations are vulnerable to external price shocks and supply fluctuations
- Need to reduce dependence on import and diversify supplies

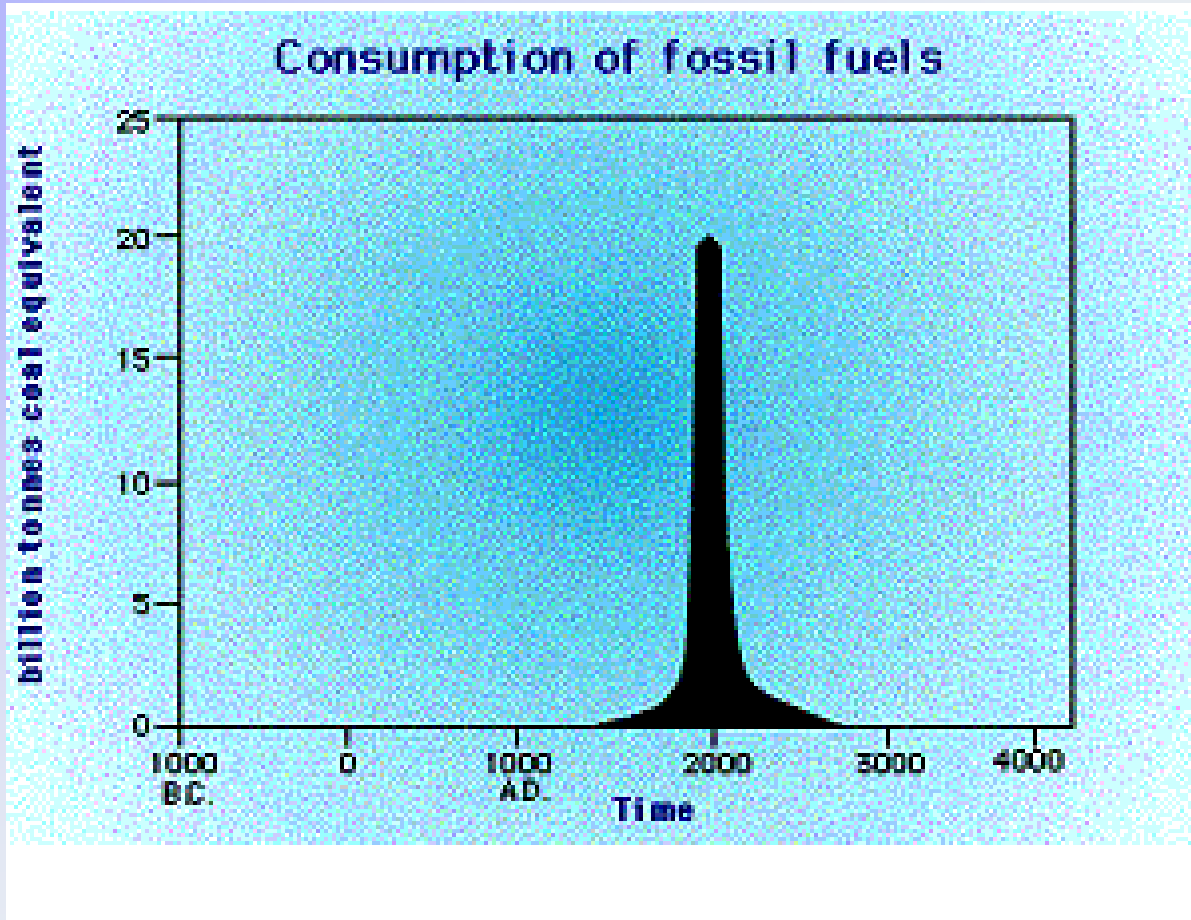
Energy Security

- Building stock piles
- 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

60% of world resources consumed so far

85% of raw energy comes from non-renewable sources and hence not available for future generation



Energy Conservations Vs Energy Efficiency

Energy Efficient Equipment uses less energy for same output and reduces CO_2 emissions

Incandescent Lamp
60 W

CO_2 Emission – 65 g/hr

Compact fluorescent Lamp
15 W

CO_2 Emission – 16 g/hr

Figure 1.14

Energy Strategy for the Future

Energy Strategies-Immediate

- Rationalizing tariff structure of various energy sources
- Efficiency in production, reduction in distribution losses
- Promoting R&D and use of energy efficient technologies and practices
- Promoting energy efficiency standards

Energy Strategies-Medium

- Demand side management
- Optimum fuel mix
- Increased dependence on economic mode of transportation system for goods and passenger movement.
- Recycling and waste minimisation
- Shift to inexhaustible sources of energy such as solar, wind and biomass energy

Energy Strategies-Long

- Optimum utilization of domestic fuel sources
- Improved energy infrastructure
- Enhancing energy efficiency
- Legislation towards energy efficiency improvement.

Energy Management

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

"The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems"

Objective of Energy Management

- To achieve and maintain optimum energy procurement and utilization, throughout the organization
- To minimize energy costs / waste without affecting production & quality
- To minimize environmental effects.

Energy Audit

Energy Audit is defined as

"the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption "

Need for Energy Audit

- Three top operating expenses are energy (both electrical and thermal), labor and materials.
- Energy would emerge as a top ranker for cost reduction
- primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs
- Energy Audit provides a " bench-mark" (Reference point) for managing energy in the organization

Types of Energy Audit

- Preliminary energy audit
- Detailed energy audit

- Type of energy audit chosen depends on
  - **Function and type of industry**
  - **Depth to which final audit is needed**
  - **Potential and magnitude of cost reduction desired**

Preliminary Energy Audit Methodology

Preliminary energy audit uses existing, or easily obtained data

Establish energy consumption in the organization

- Estimate the scope for saving
- Identify the most likely areas for attention
- Identify immediate (no-/low-cost) improvements
- Set a 'reference point'
- Identify areas for more detailed study/measurement

Detailed Energy Audit

- Evaluates all energy using system, equipment and include detailed energy savings and costs

- Carried out in 3 phases
  - **Pre-audit Phase**
  - **Audit Phase**
  - **Post-Audit**

Ten Steps Methodology for Detailed Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation

Step 3	Phase II –Audit Phase • Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.

Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc. - Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures ▪ Conceive, develop, and refine ideas ▪ Review the previous ideas suggested by unit personal ▪ Review the previous ideas suggested by energy audit if any ▪ Use brainstorming and value analysis techniques ▪ Contact vendors for new/efficient technology
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	Documentation, Report Presentation to the top Management.

Step10	<u>Phase III –Post Audit phase</u> • Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance ▪ Action plan, Schedule for implementation ▪ Follow-up and periodic review

Identification of Energy Conservation Opportunities

- Energy generation
- Energy distribution:
- Energy usage by processes:
- Fuel substitution:

Technical and Economic feasibility

Technology availability, space, skilled manpower, reliability, service,Impact of measure on safety, quality, production or process. Maintenance requirements and spares availability

Sample Worksheet for Economic Feasibility

Name of Energy Efficiency Measure

i. Investment

a. Equipments
b. Civil works
c. Instrumentation
d. Auxiliaries

2. Annual operating costs

- Cost of capital
- Maintenance
- Manpower
- Energy
- Depreciation

3. Annual savings

- Thermal Energy
- Electrical Energy
- Raw material
- Waste disposal

Net Savings /Year (Rs./year)
= (Annual savings-annual operating costs)

Payback period in months
= (Investment/net savings/year) x 12

Energy Audit Reporting Format

Report on

DETAILED ENERGY AUDIT

TABLE OF CONTENTS

Energy Audit Reporting Format

4.0 Detailed Process flow diagram and Energy& Material balance

4.1 Flow chart showing flow rate, temperature, pressures of all input-output streams

4.2 Water balance for entire industry

5.0 Energy efficiency in utility and process systems

5.1 Specific Energy consumption

5.2 Boiler efficiency assessment

5.3 Thermic Fluid Heater performance assessment

5.4 Furnace efficiency Analysis

5.5 Cooling water system performance assessment

5.6 DG set performance assessment

5.7 Refrigeration system performance

5.8 Compressed air system performance

5.9 Electric motor load analysis

5.10 Lighting system

6.0 Energy Conservation Options & Recommendations

6.1 List of options in terms of No cost/ Low Cost, Medium cost and high investment Cost, Annual Energy & Cost savings, and payback

6.2 Implementation plan for energy saving measures/Projects

ANNEXURE

A1. List of Energy Audit Worksheets

A2. List of instruments

A3. List of Vendors and Other Technical details

NATIONAL PRODUCTIVITY COUNCIL OF INDIA

Understanding energy costs

Typical summary of energy bill by a company

Table-3.4				
Type of energy	Original units	Unit cost	Monthly bill INR	Equivalent cost US$
Electricity	5,00,000 kWh	Rs. 5.00/KWh	25,00,000	50,000
Fuel oil	200 Kl	RS. 20,000/KL	40,00,000	80,000
coal	1000 tons	RS.2,000/ ton	20,00,000	40,000
Total			85,00,000	1,70,000

Conversion to common unit of energy

Electricity	(1 kWh)	= 860 kcal/kWh (0.0036 GJ)
Heavy fuel oil	(calorific value, GCV)	=10.000 kcal/litre (0.0411 GJ/litre)
Coal	(calorific value, GCV)	=4000 kcal/kg (28 GJ/ton)

Benchmarking parameters for Energy Performance

- **Gross production related**

e.g. kWh/MT clinker or cement produced (cement plant)
e.g. kWh/MT, kCal/kg, paper produced (Paper plant)
e.g. kCal/kWh Power produced (Heat rate of a power plant)
e.g. Million kilocals/MT Urea or Ammonia (Fertilizer plant)

- **Equipment / utility related**

e.g. kWh/ton of refrigeration (on Air conditioning plant)
e.g. % thermal efficiency of a boiler plant
e.g. kWh/NM^3 of compressed air generated
e.g. kWh /litre in a diesel power generation plant.

Energy Audit Instruments

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

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

Combustion analyzer:
This instrument has in-built chemical cells which measure various gases such as CO_2, CO, NO_X, SO_X etc

Fuel Efficiency Monitor:
This measures Oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

Fyrite:

A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. Percentage Oxygen or CO_2 can be read from the scale.

Energy Audit Instruments

	**Contact thermometer:** These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature a leaf type probe is used with the same instrument.
	**Infrared Pyrometer:** This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. Can be useful for measuring hot jobs in furnaces, surface temperatures etc.
	**Pitot Tube and manometer:** Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.
	**Ultrasonic flow meter:** This a non contact flow measuring device using Doppler effect principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

Energy Audit Instruments

Tachometer

Stroboscope

Speed Measurements:

In any audit exercise speed measurements are critical as thay may change with frequency, belt slip and loading.

A simple tachometer is a contact type instrument which can be used where direct access is possible.

More sophisticated and safer ones are non contact instruments such as stroboscopes.

Leak Detectors:

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible with human abilities.

Lux meters:

Illumination levels are measured with a lux meter. It consists of a photo cell which senses the light output, converts to electrical impulses which are calibrated as lux.

Thank You
for your kind attention

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