ENERGY AUDIT
UNIT-3(EECA)

Audit Process Management

- ***Evaluation*** **of a person, organization, system, process, enterprise, project or product**

- **Most commonly refers to audits in accounting, quality management, water management and energy management**

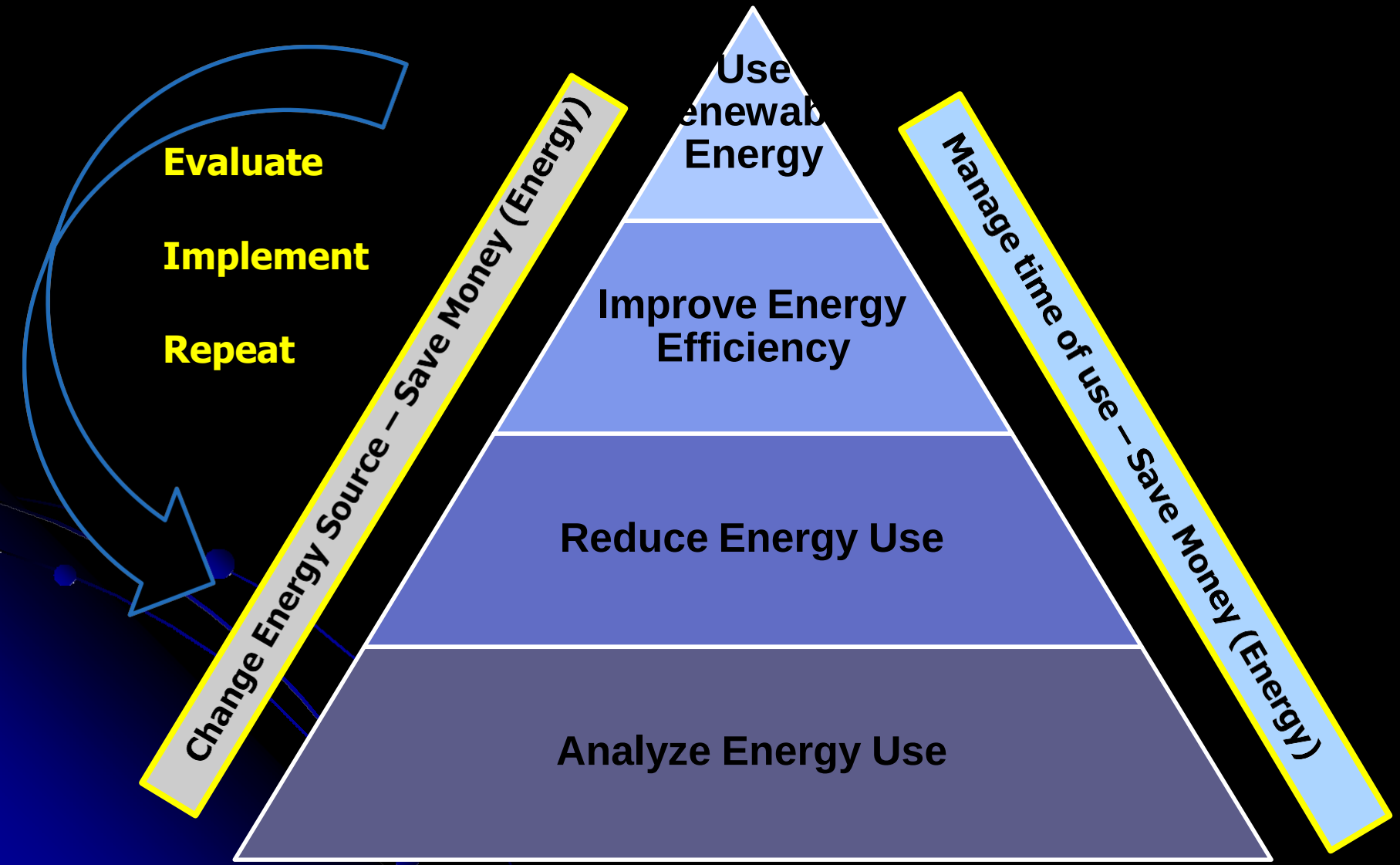


Fig.1. Energy Priority Pyramid

CONTENTS

- Energy Conservation & Management
- What is Energy Audit
- Aims of Energy Audit
- Energy Conservation Opportunities
- Types Of Energy Audit
- Preparing for Audit
- Steps in Energy Audit
- Barriers in Energy Audit
- Energy Action Plan
- Conclusion

ENERGY CONSERVATION & MANAGEMENT

- Energy and development are two sides of a coin
- Rapid industrial growth resulted in serious gap between supply and demand of energy
- Faulty planning & mismanagement cause loss of energy
- It gave birth to the concept of energy conservation and management
- Energy Audit-Tool for energy conservation

WHAT IS ENERGY AUDIT ?

- Study to determine how & where the energy is being used & wasted, also to identify the possibilities of energy saving i.e. Energy Conservation Opportunities (ECOs)
- EA is the general term for a systematic procedure that aims at obtaining an adequate knowledge of the energy consumption profile of a building or an industrial plant
- Also aims at identifying and scaling the cost-effective energy saving opportunities for the unit
- Also called as Energy Survey or Energy Analysis
- The word 'ECO' is the key-word in any EA process

DEFINITION OF ENERGY AUDIT

As per the Energy Conservation Act, 2001, ***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".

Objectives & Need

Provides a systematic approach for decision-making in the area of energy management

Helps to understand about ways energy and fuel are used in facility, and helps identify the areas where waste can occur and where scope for improvement exists

Helps quantify opportunities to become more energy efficient

Helps conform with regional and country specific energy efficiency mandates

Fig.3 Goals of energy audit

ENERGY AUDIT'S SCOPE & REQUIREMENTS

- EAs are crucial in the implementation of energy saving measures and in the assurance of the targets of Energy Management
- In an energy audit:
  - the main goal is to achieve energy savings,
  - the point of view is energy consumption and saving possibilities,
  - there may be other aspects to consider (technical condition, environment) but the main interest is on energy savings,
  - produces reporting on energy saving measures
  - the audit work may cover all energy using aspects of a site or certain limited parts (systems, equipment) of several sites (="horizontal audit")

WHERE ENERGY AUDIT CAN BE APPLIED

- Home (Domestic)
- Building
- Institution (Offices, colleges, schools etc.)
- Factory
- Industries (Having great potential)
- SAIL saved 1200 crores in 1993-94 by Energy Audit

WHO CONDUCT THE ENERGY AUDIT ?

NEED FOR ENERGY AUDIT

- Top 3 operating expenses are energy (electrical and thermal), labour & materials
- Cost of energy would invariably emerge as a top
- EA helps in identifying energy waste and give positive orientation to the energy cost reduction
- In general, EA is the translation of conservation ideas into realities
- EA provides a “bench mark” (reference point) for managing energy

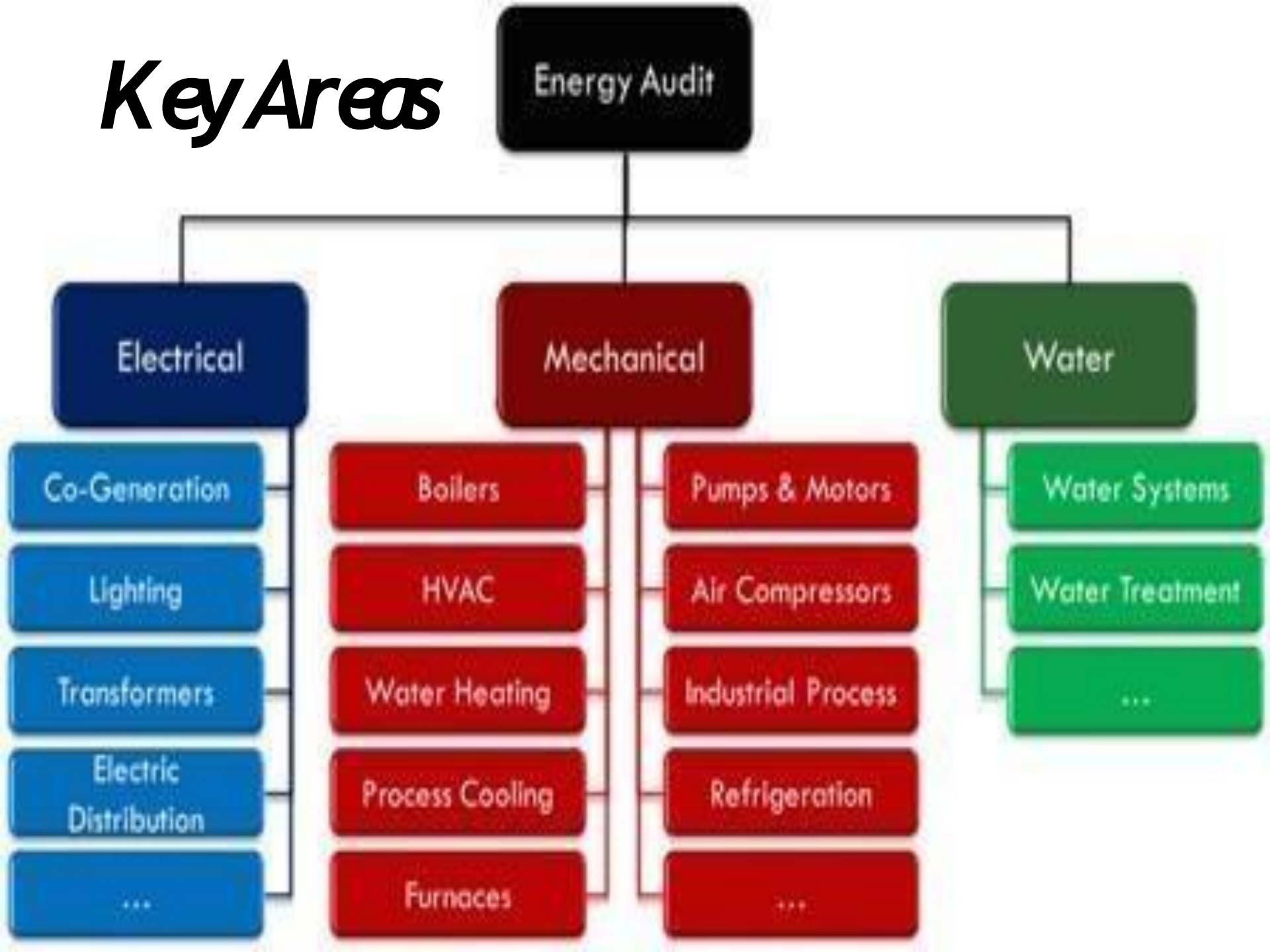
AIMS OF ENERGY AUDIT

- Reducing peak demand of energy (e.g. electricity or steam etc.)
- Reducing visible waste of energy
- To construct an efficient energy conservation plan called as ‘Action Plan’
- Finding alternate methods for low energy consumption

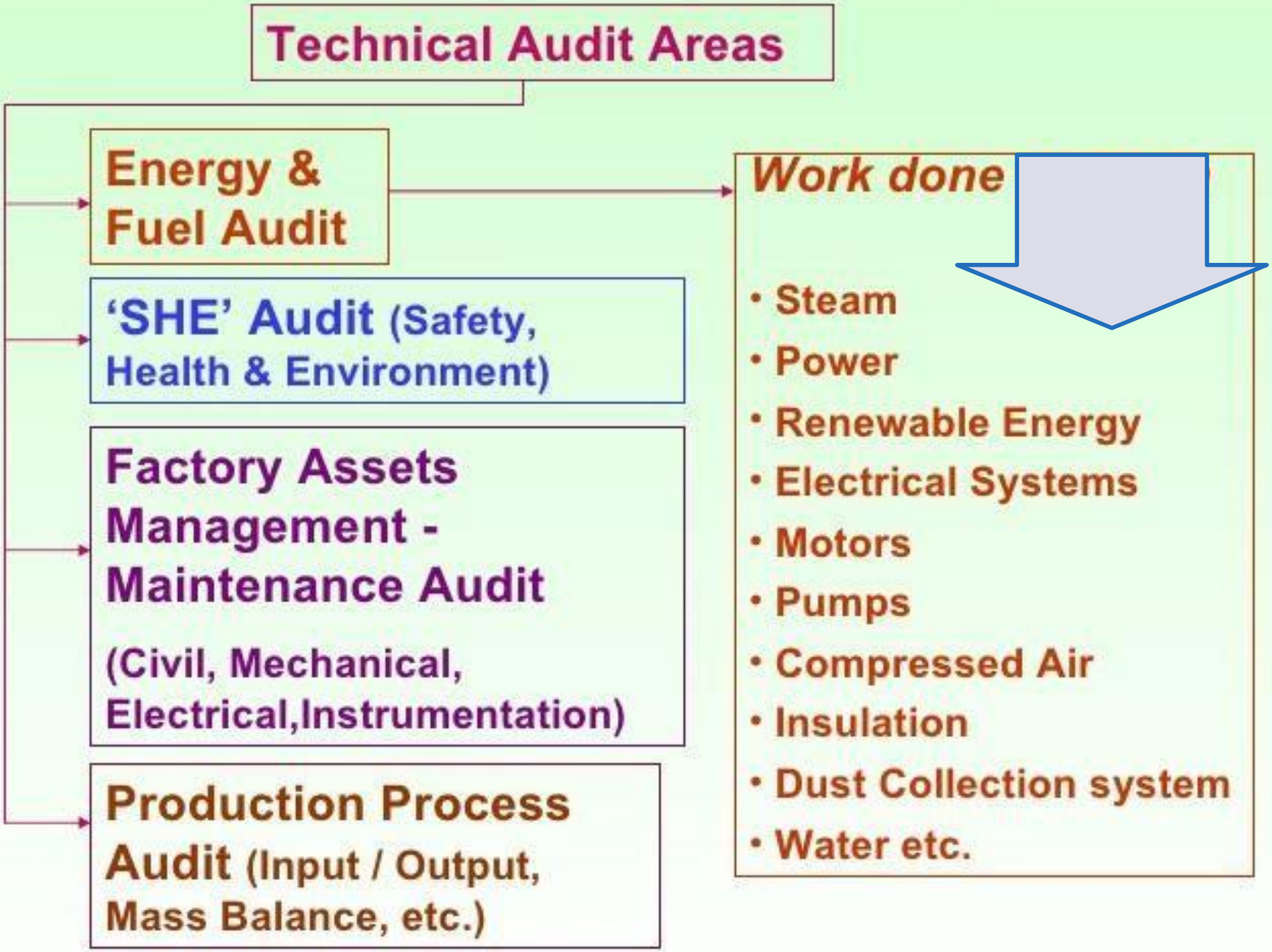
AIMS OF ENERGY AUDIT

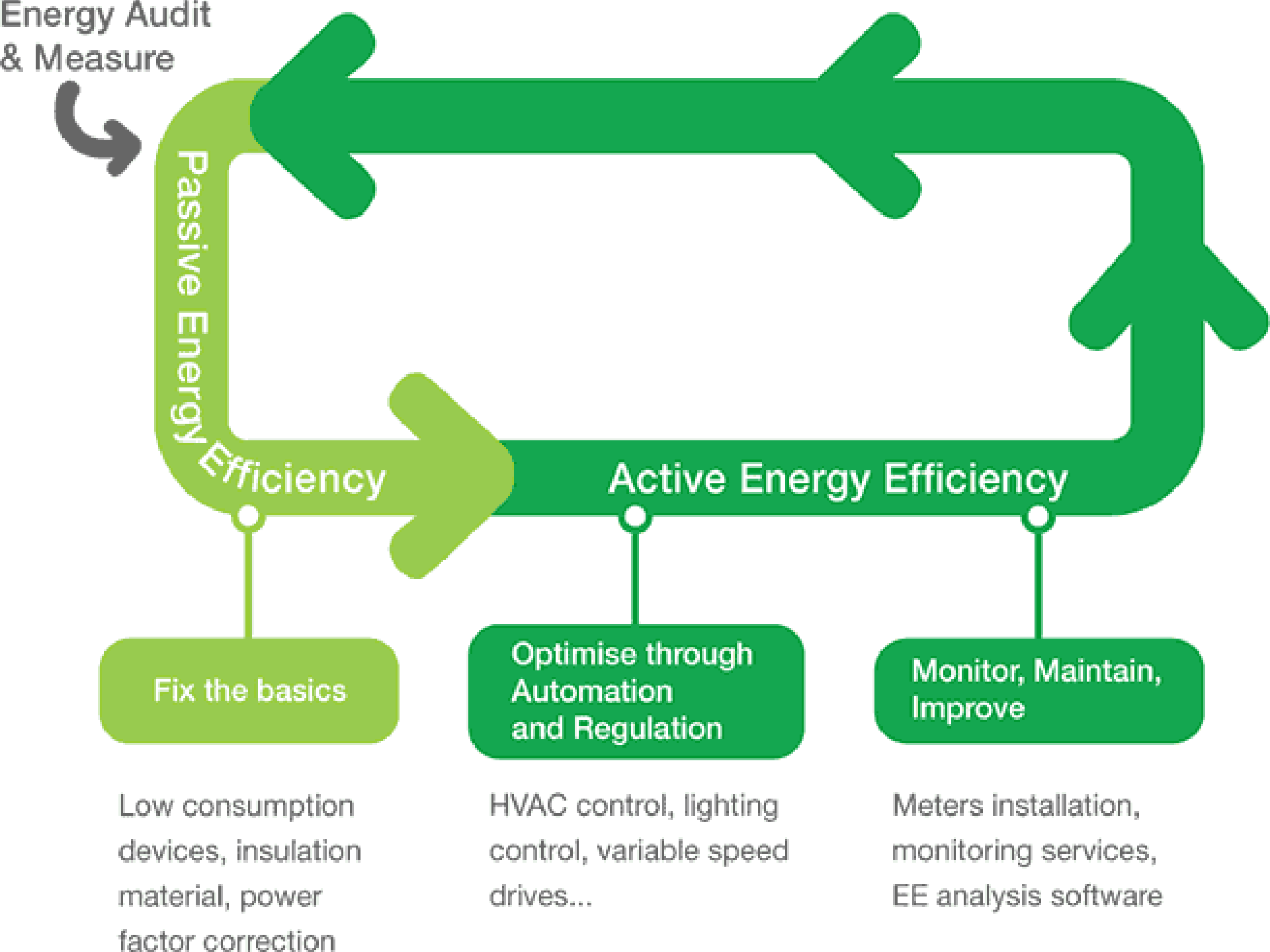
- Finding Energy Conservation Opportunities (ECOs)
- Implementation of Action Plan should be eco-friendly
- It should not affect the economical & industrial growth
- The suggestions should be economically viable
- It should consider the future plans of the firm/ company

Key Areas


Energy Audit
Electrical
Mechanical
Water
Co-Generation
Lighting
Transformers
Electric Distribution
...
Boilers
HVAC
Water Heating
Process Cooling
Furnaces
Pumps & Motors
Air Compressors
Industrial Process
Refrigeration
...
Water Systems
Water Treatment
...

Technical Audit Functional Chart



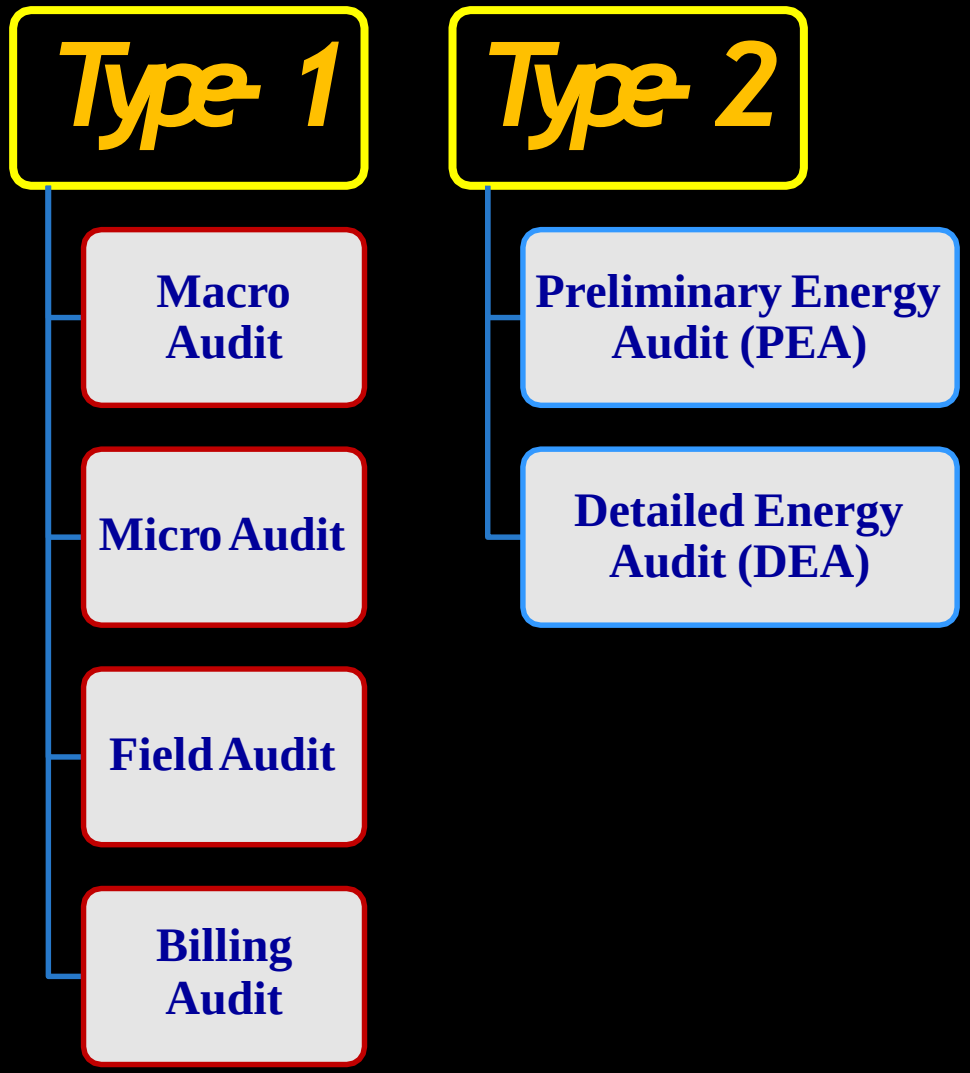

Energy Audit
& Measure
Passive Energy Efficiency
Active Energy Efficiency
Fix the basics
Optimise through Automation and Regulation
Monitor, Maintain, Improve
Low consumption devices, insulation material, power factor correction
HVAC control, lighting control, variable speed drives...
Meters installation, monitoring services, EE analysis software

ENERGY CONSERVATION OPPORTUNITIES

- Good house keeping
- Installing additional equipments
- Equipment replacement
- Operating strategy
- Process changes

Types Of Energy Audit

- Type depends on:
  - Function & type of industry
  - Depth to which final audit is needed
  - Potential & magnitude of cost reduction desired



MACRO AUDIT

- Rough estimates of energy purchase, production, utilization and wastage
- To get the feel of the problem and to decide the priority
- The priority is based on maximum utilization of energy
- Records of two years are checked
- No actual measurements and calculations

MICRO AUDIT

- Actual calculations are done by measurement
- It is carried out unit or division wise for which the priority is decided in Macro Audit

BILLING AUDIT

- Collecting and analyzing bills of raw materials or energy itself

FIELD AUDIT

- Data is collected by auditors who actually visit the sites, measure and collect data for calculations of various aspects of energy production, utilization and losses
- The PEA is same as Macro Audit and DEA is same as Micro Audit

PRELIMINARY ENERGY AUDIT (PEA)

PEA is a relatively quick exercise to:

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a ‘reference point’
- Identify areas for more detailed study/measurement
- ***PE***A uses existing, or easily obtained data

DETAILED ENERGY AUDIT (DEA)

- Offers the most accurate estimate of energy savings and cost
- Evaluates all major energy using systems
- One of the key elements is the energy balance
- Carried out in three phases:
  - Phase I - Pre Audit Phase
  - Phase II - Audit Phase
  - Phase III - Post Audit Phase
- Ten Steps Methodology for Detailed Energy Audit

STEPS IN ENERGY AUDIT

- Planning/ Pre-Audit study
- Basic data collection
- Equipment test data
- Data analysis
- No/ low cost recommendations
- Capital investment
- Action plan
- Report

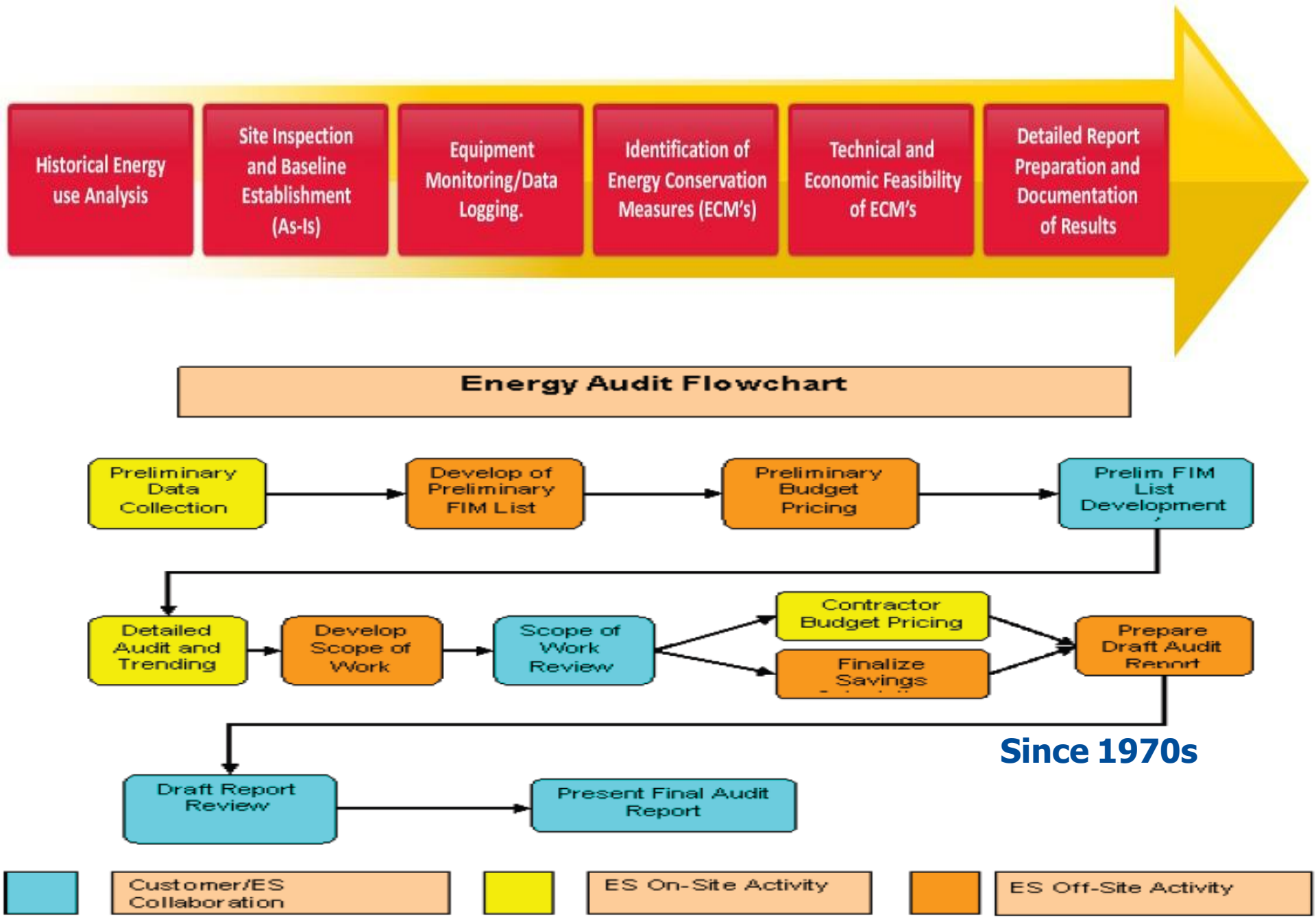


Fig.4 Energy Audit Flow Chart

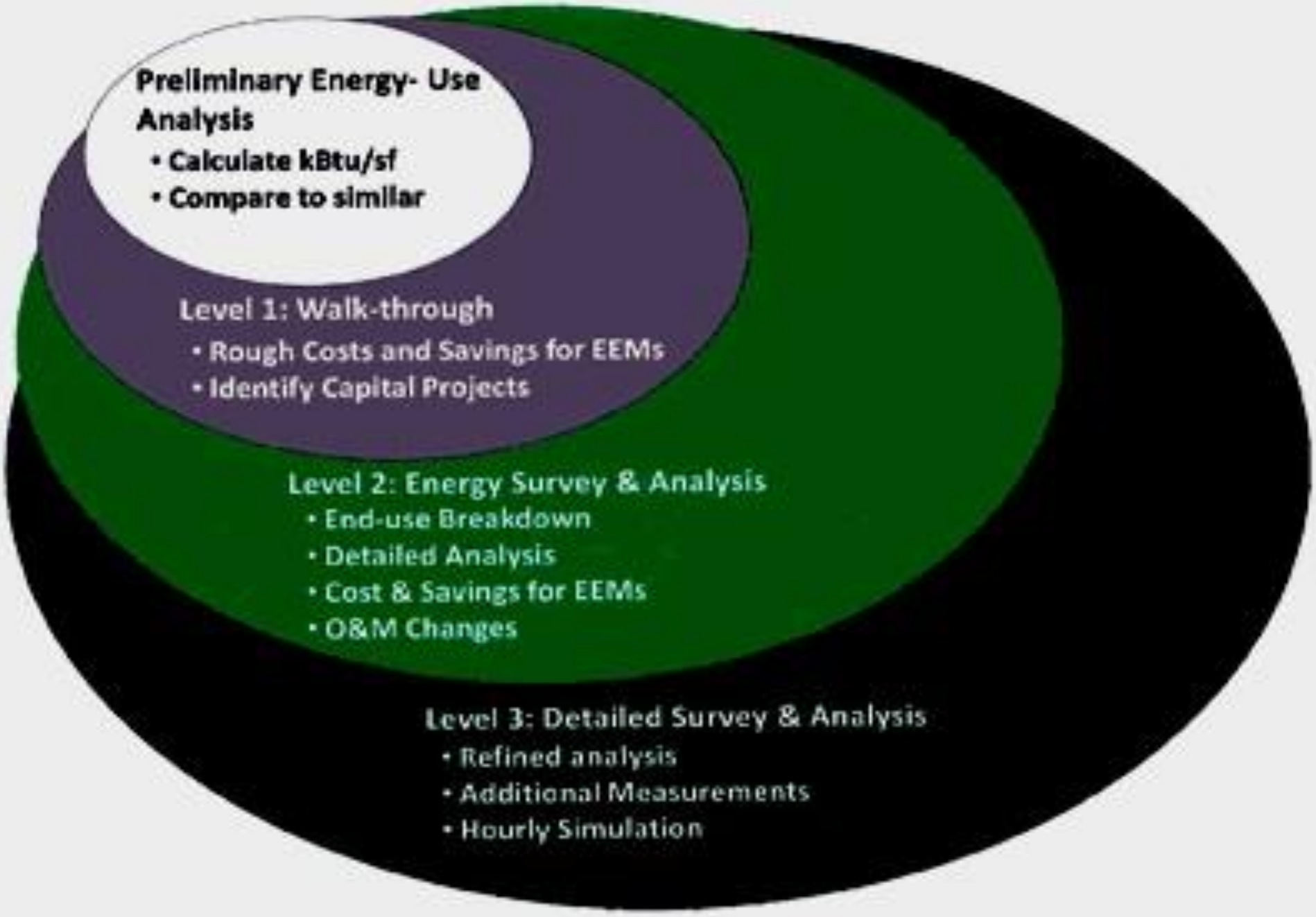


Fig.5 Steps in Energy Audit

Conducting of Energy Audit

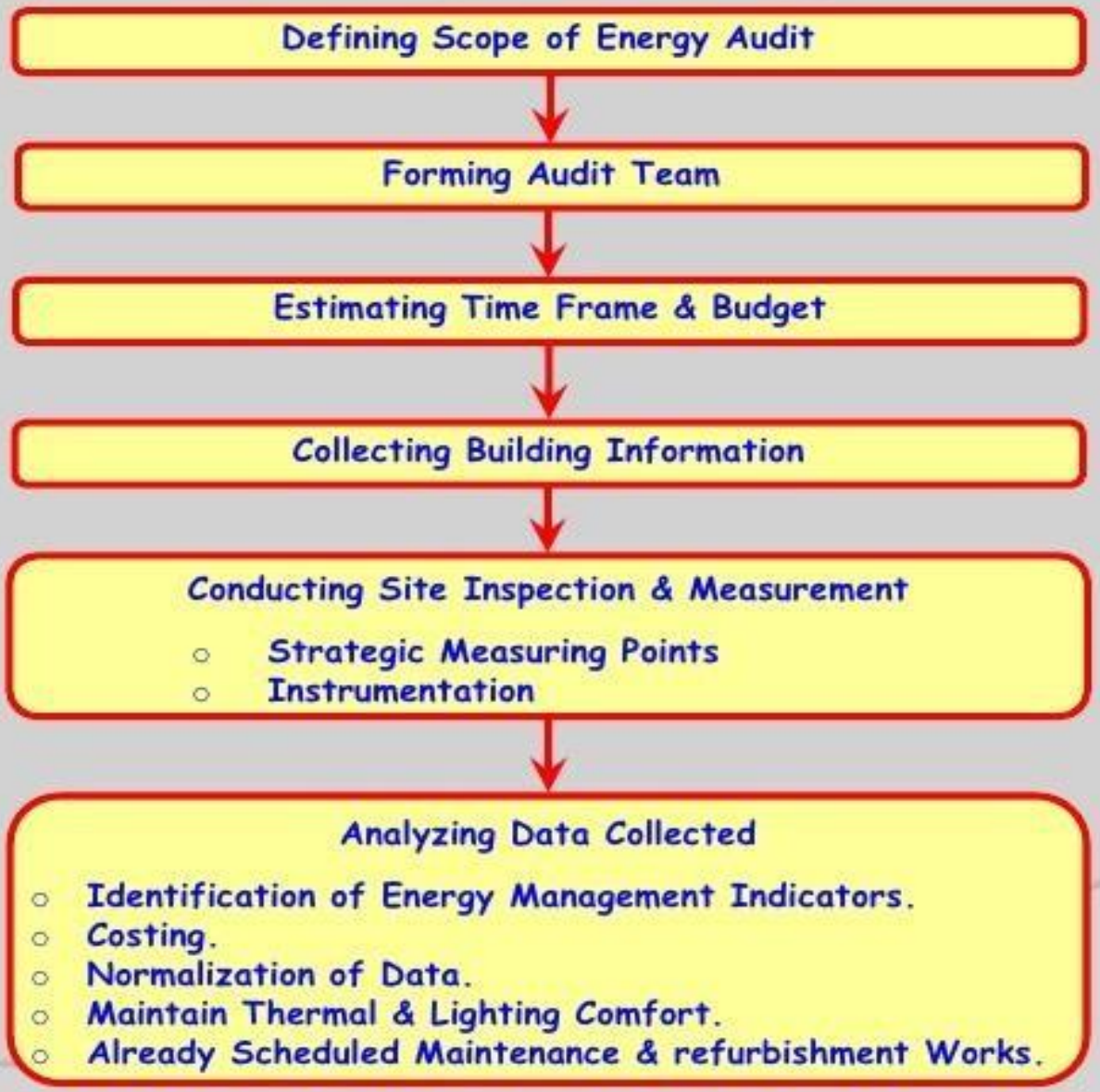


Fig.6 Conducting Energy Audit


Pre Audit Phase
Plan & Organize
Walk through Audit
Informal Interview with Client
Brief meetings and awareness programs
Audit Phase
Primary Data Gathering, Process flow and Energy utility diagram
Conduct, Survey & Monitoring
Analysis of Energy use
Identification and ENCON opportunities
Cost & Benefit Analysis
Reporting and presentation
Post Audit Phase
Implementation and Follow up
Monthly Monitoring
Energy performance Contract

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

PREPARING FOR ENERGY AUDIT

- Rate structures
- Geographic location/ Weather data
- Facility layout
- Operating hours
- Equipment list
- Safety considerations
- Introductory meeting
- Audit interviews

CONTENTS OF ENERGY ACTION PLAN

- Executive summary
- Table of contents
- Introduction
    a. Purpose of audit
    b. Need for audit
    c. Programme
- Facility description
- Energy bill analysis
- ECOs
- Action plan
- Conclusion

BARRIERS IN ENERGY AUDIT

- Data insufficiency
- Data inconsistency
- Incomplete evaluation of options

BENEFITS OF ENERGY AUDIT

- Saving of valuable energy
- Saving of money

Energy Utilization Index

A very basic measure of a facility's energy performance is called the Energy Utilization Index (EUI). Energy auditors use EUI to enable comparisons between different buildings and energy types. EUI is calculated by converting all energy used in a building to a common unit, and then dividing it by the square footage of the heated/cooled space in the building. The Energy Use Index (EUI) is the most common means of expressing the total energy consumption for each building.

Energy Cost Index

Another useful performance index is the Energy Cost Index (ECI). To compute ECI, all of the energy used in the facility must be identified, the total cost of that energy tabulated, and the total number of square feet of conditioned spacedetermined. The ECI is then found as the ratio of the total annual energy cost for a facility to the total number of square feet of conditioned floor space of the facility.

Pie charts

- can offer compelling documentation of overall energy use and expenses
- Energy usage is plotted on a circular chart where the quantity of a particular type is represented as a segment of a circle.
- The size of the segment is being proportional to the energy consumption using a particular fuel relative to total fuel usage
- The pie chart shown in fig. 7 illustrates how much energy is used by fuel type and its relative percentage
- The pie chart below the energy use profile shows how much is spent for each fuel type
- Using a pie chart representation can be very helpful in visualizing how energy is being used and how costs are distributed for those fuels.

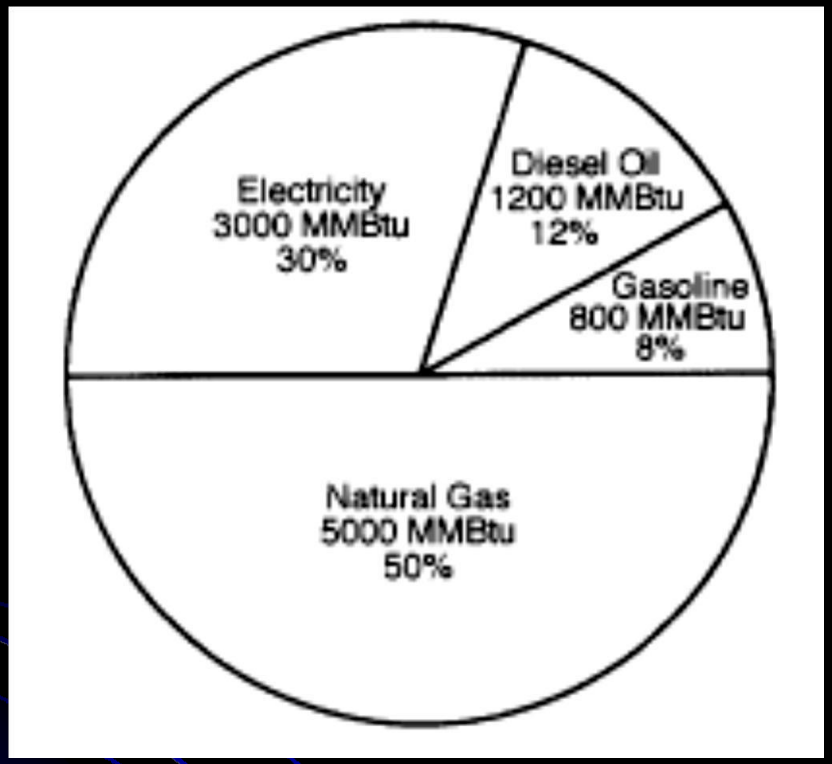


Fig. 7 (a) Energy Use Profile

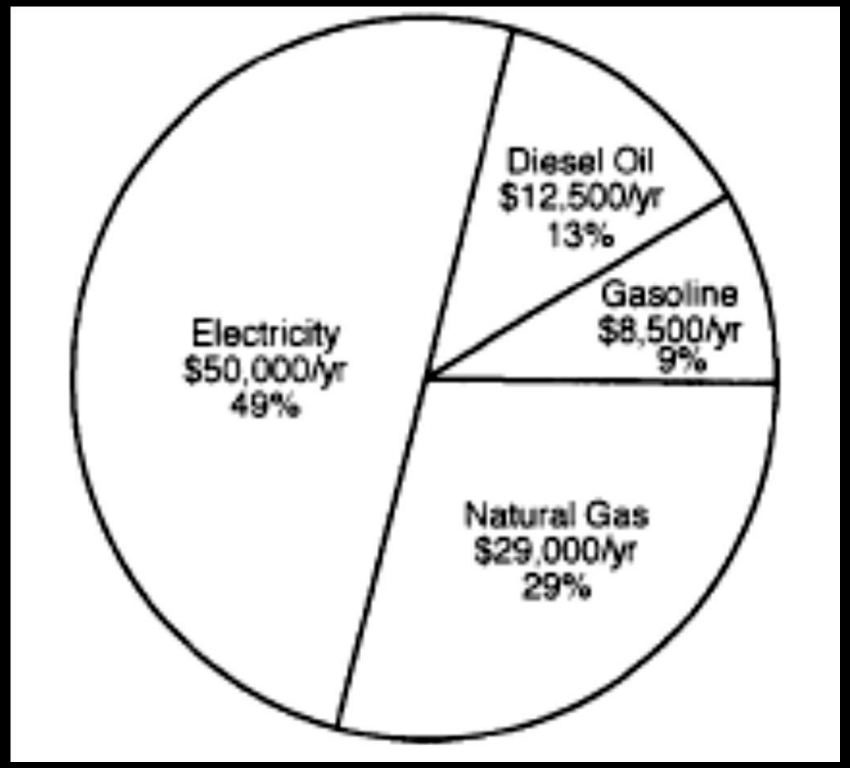


Fig. 7 (b) Energy Cost Profile

Sankey diagrams

- Energy flow, from its internal distribution to its final consumption per use & per energy system, can be easily understood
- Energy losses-outflows, the energy gains-inflows, as well as the useful energy in every energy system, are represented quantitatively and in proportion to the total energy inflow, according to existing data of the building/unit
- Helps to locate the more critical energy consuming areas of the building, unit or building block, and, at the same time, to identify the sources that lead to energy losses
- This ascertainment leads to a sound evaluation of each system's behaviour, as well as to a better scheduling of the proposed energy saving measures
- The Sankey diagram shown in fig. 8 represents the flow of the primary energy used for space and water heating in a residence.

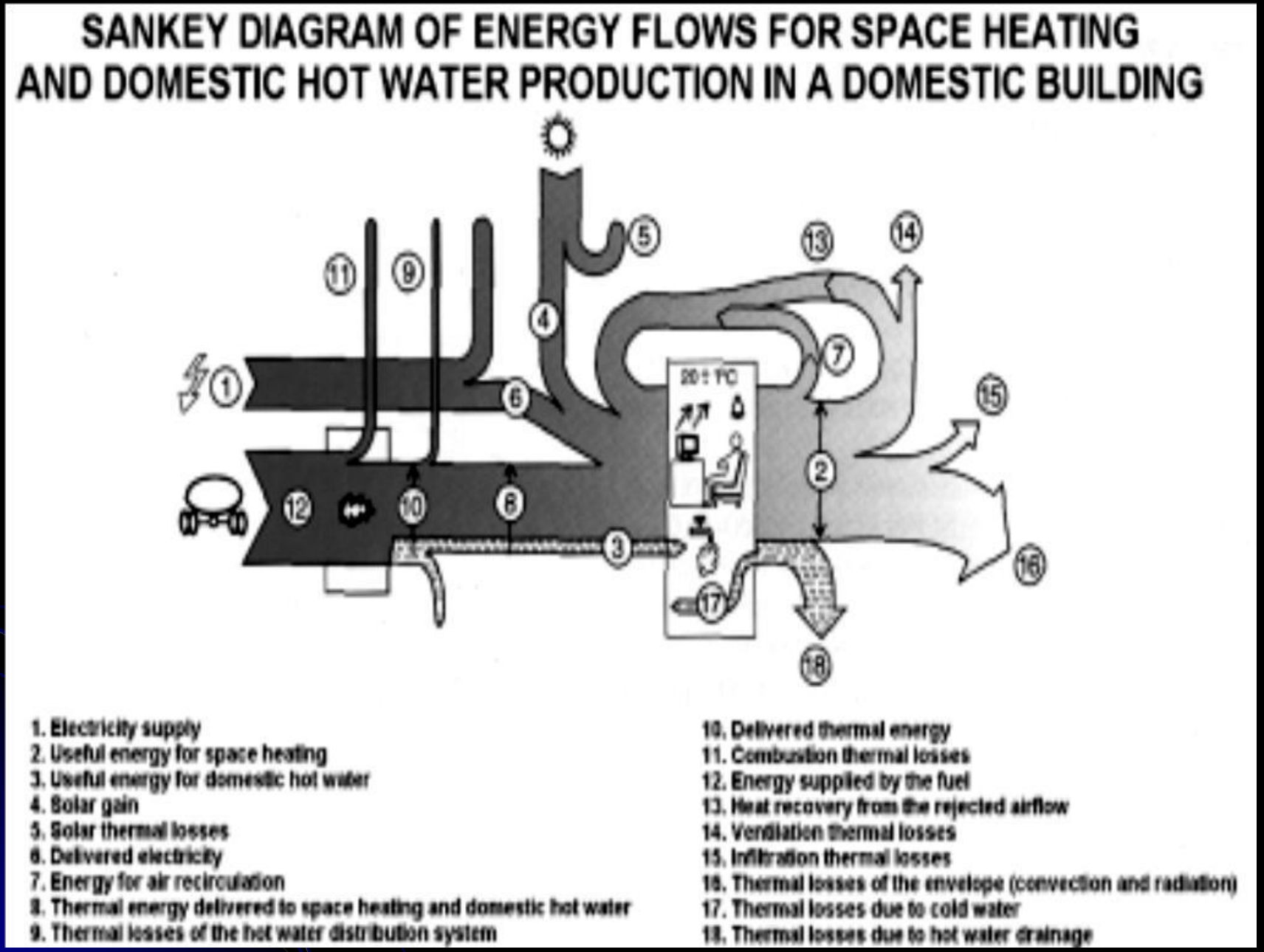


Fig. 8 *Energy flows in the case of residential space heating*

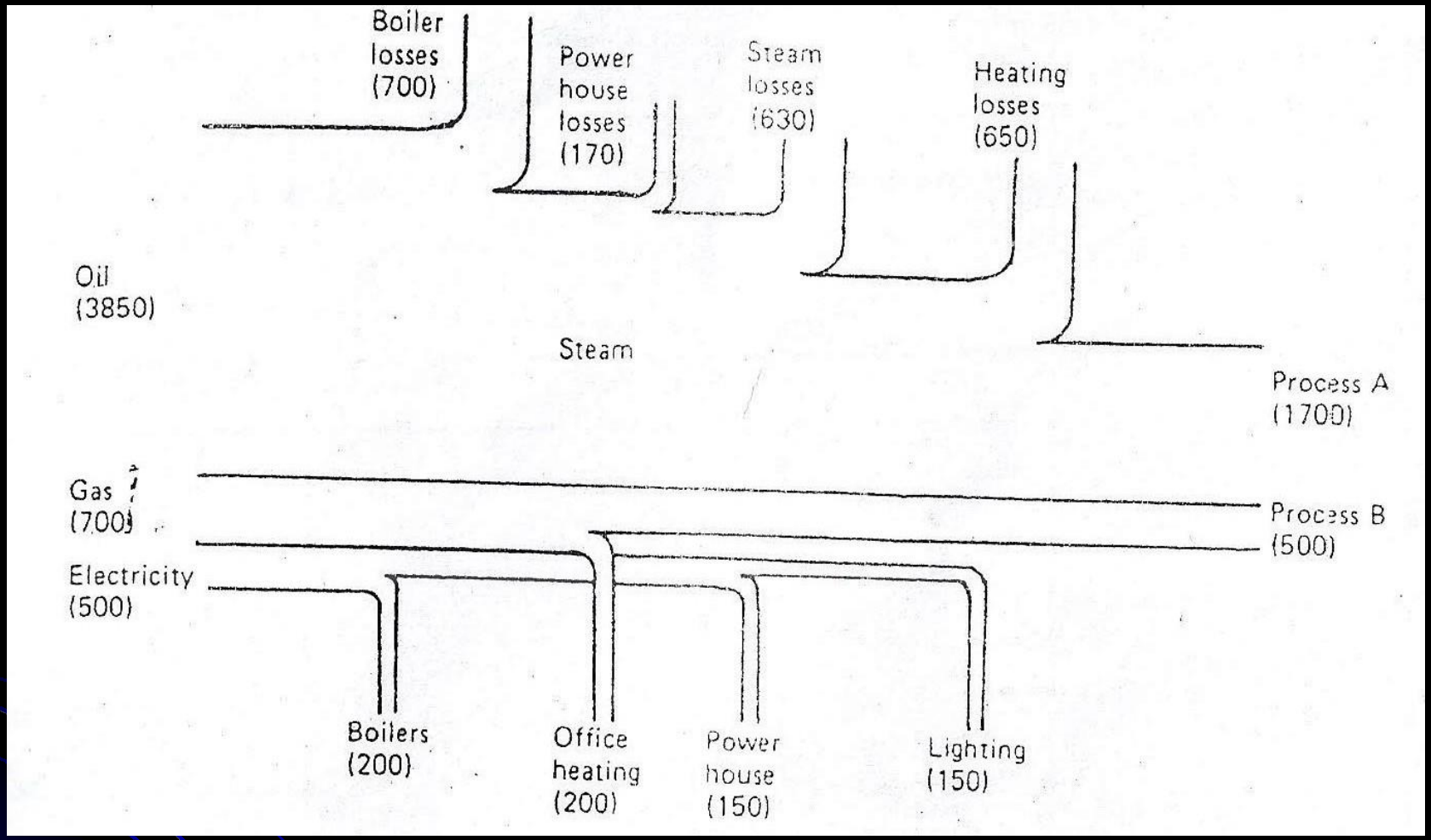


Fig.9. Sankey diagram representing energy usage *(10^6 J per hour)*

Figure 9.3 shows a Sankey diagram which represents all the primary energy flows into the factory. The widths of the bands are directly proportional to energy production, utilisation and losses. The primary energy sources are gas, electricity and oil (for steam generation) and represent energy inputs at the left-hand side of the Sankey diagram.

Sankey diagrams are quite difficult to construct as measurements must be made for all energy flows and this will involve considerable metering and instrumentation. However, the picture can be gradually built up starting from gas and electricity before going on to steam. The construction of a Sankey diagram is an excellent exercise in energy management and its value is in highlighting losses which one never knew existed.

For the purpose of monitoring and checking energy consumption and usage on a weekly or monthly basis, pie charts and Sankey diagrams are rather laborious. An alternative method of monitoring energy consumption on a time-dependent basis is to use load profiles.