CHAPTER II

CONCEPTS IN ENERGY CONSERVATION MANAGEMENT

Introduction

Energy management is a continuous planning process that is used to develop the efficient use of energy in a building or system. It is a combined design and management function which embraces the disciplines of engineering, mathematics, economics, accounting, operational research and computer programming, as well as the day-to-day management of fuels, equipment, and personnel that influence the rates, direction and modes of energy flow. The scope of the energy managent is vast. The use of energy is involved in all aspects of endeavour. In producing an artefact, energy is consumed during the exploration for raw materials, the extraction, transportation as well as during particular manufacturing processes inside the factory. The finished product must be packaged, advertised and marketed, distributed to wholesale and retail outlets, sold, utilized by the consumer, and finally rejected as waste.
All stages along this production, utilisation and disposal chain are accompanied by further indirect energy expenditure in maintaining services such as heating, lighting, personal transportation, catering, and welfare and for personnel associated with production and service sector.

Further indirect energy is consumed in other external activities, such as educational and recreational systems, hospitals and medical services and tele-communications networks. The spiral emanating from any particular activity or product is endless. Thus the energy manager must take great care to define clearly the extent and scope of the system under examination.

In the majority of cases, the system investigated may represent either (a) the historical (or projected during design) "energy cost" of product, or (b) the energy consumption by the manufacturing process, or (c) the energy requirements of a facility or service.

A Company-wide Energy Conservation Process

Energy management programs, when admimistered properly, can effectively reduce the amount of energy used in the system involved. In order to implement the energy program successfully, eight major phases must be considered.

1. Recognzing the problem.
2. Planing to take action.
3. Conducting energy audit.
4. Identifying and analyzing the energy conservation opportunities (ECOs).
5. Energy reporting to management.
6. Monitoring and following-up
7. Establishment of reporting and control systems.
8. Analyzing variances to the problem.

These activities are illustrated in Figure 2.1.

1. Recognizing the Problem

This is the phase of getting the top management support. It is quite important for top management to emphasize the economic reasons to conserve energy as well as employee's responsibility for suggesting and implementing energy saving ideas, proposals, measures within the areas of their concern. Top management shall initiate

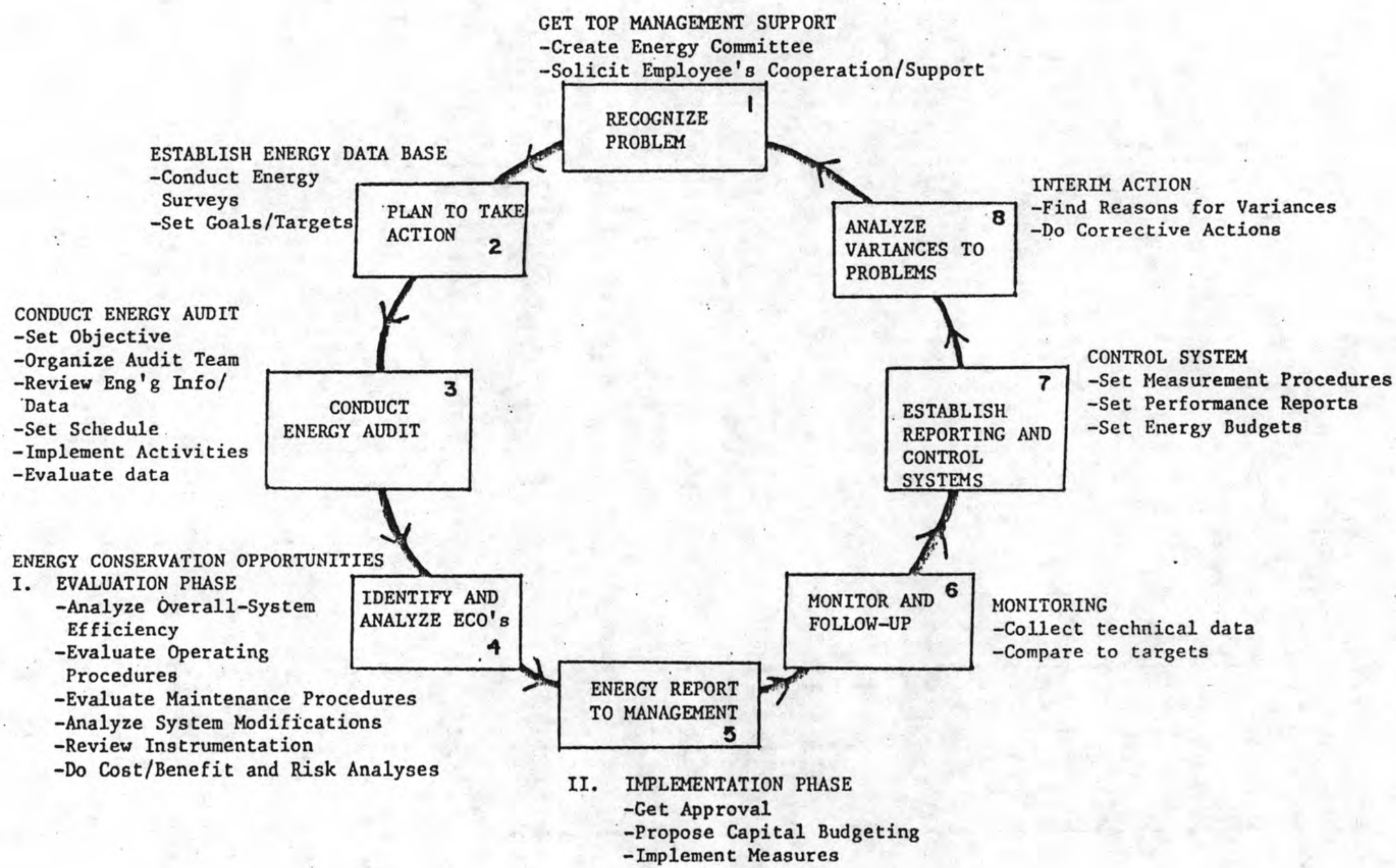


Figure 2.1 Diagram Showing a Company-Wide Energy Conservation Process

establishing an energy conservation (enercon) committee consisting of representatives from each operation areas with an "enercon manager" appointed by and reporting to management and then solicit employee's cooperation and support.

2. Planing to Take Action

In this step, an energy data base is established to help management understand the urgency of undertaking an energy conservation program, focus attention on activities that explore potential energy saving areas, or justify actions for the productive use of limited manpower and capital resources.

Measurement of all the energy that enters and leaves a plant is necessary to a meaningful energy conservation program. Initially, this measurement can be an approximation but the measurement should improve with experience and with the acquisition of additional monitoring equipment.

With the proper data record, the management will be in a position to do the followings.

2.1 Pinpoint which raw materials contain and which manufacturing processes use large amounts of energy.

2.2 Justify replacement of obsolete machinery.

2.3 Improve the current maintenance program and emphasize the need of a good preventive maintenance program.

2.4 Suggest system modifications that would lessen repeated heating or cooling operations.

2.5 Incorporate a better temperature control system.

2.6 Propose dropping non-profitable products.

Table 2.1 Energy Audit Form for Historical Energy Consumption and Costs

Item	Quantity Usage	Percent of Total
Energy Types:		
Petroleam		
Non-petroleam		
Electricity		
others		
Utilization:		
Production		
- By Process Unit		
- By Department		
- By Major Equipment		
Power Generation		
Non-Production		
- Tranportation		
- Administration		

Table 2.2 Energy Audit Form for Energy Utilization

Item	Plant Wide (%)	By Department/Division (%)	By Major Equipment (%)
Petroleam Fuels			
Oil			
Gasoline			
LPG			
Solid Fuels			
Coal			
Bagasse			
Briquettes			
Electricity			
Total Energy			
Raw Materials			
A			
B			
C			
Outputs			
A			
B			
C			

Table 2.3 Calculation Form for Energy Content of a Product (23)

For the Period Beginning_______________, Period Ending_______________

Company	Responsible Manager
Product 1	Product I.D. No. 2

RAW MATERIAL ENERGY (List Major Raw Materials)

4 Raw Material	5 Total Units	x 6 Kj/Unit	= 7 Total Kjs
A:			
B:			
C:			
D:			
E:			
		Total Kjs	8

Total Units Produced 3
Units of Production (Kg, Kl, Piece, etc.)

CONVERSION ENERGY (List All Major Utilities)

9 Utility	10 Total Units	x 11 Kj/Unit	= 12 Total Kjs
A:			
B:			
C:			
D:			
E:			
		Total Kjs	13

WASTE DISPOSAL ENERGY

14 Waste	15 Total Disposal Kj's	17 Total Wasted Units
A:		
B:		
C:		
D:		
E:		
Total Kj's	16	

CROSS ENERGY CONTENT OF PRODUCT (Sum of Items 8, 13 and 16) Kj's — 18

BY-PRODUCT ENERGY CREDIT (List All Major By-Products)

19 By-Product	20 Total Units	x 21 Kjs Unit	= 22 Total Kj's
A:			
B:			
C:			
D:			
E:			
		Total Kj's	23

NET ENERGY CONTENT OF PRODUCT (Item 18 Less Item 23)	24 Kj's
ENERGY CONTENT PER UNIT OF PRODUCTION (Item 24 Divided BY Item 3)	25 Kj's/Unit
GOAL (TARGETED ENERGY CONTENT FOR THIS PERIOD) Kj's/Unit	26
IF ITEM 26 IS EQUAL TO ITEM 25, GOAL WAS MADE (Check Item 27)	27 Made Goal
IF ITEM 26 IS NOT EQUAL TO ITEM 25, COMPUTE DEVIATION FROM GOAL	

Kj-means Kilojoules

Sources: Energy Conservation Program Guide
For Industry & Commerce,
NBS Handbook 115

GUIDE FOR FILLING OUT FORM FOR CALCULATING THE ENERGY CONTENT OF A PRODUCT [23]

1. Finished product ready for shipment.
2. Product I.D. No. is the numerical identification of the product.
3. Units of the product (item 1) made during this time period.
4. The material that goes into producing and packaging the product (includes fuels used as raw materials).
5. Units of the raw material (item 4) that were used during this time period.
6. Every material has a specific energy content. Energy content is measured in terms of Kilojoules (Kj's). Raw material supplier may provide this number or an approximation is available for most materials, from the government (Department of Commerce or Trade). If unavailable from these sources, it can be estimated as the heat of combustion of the material. This estimate is always low.
7. (Item 5) multiplied by (Item 6).
9. Utilities include primarily electricity, fuel oil and petroleum.
10. Units of utility (item 9) used during this time period.
11. For fuel, this is the heat of combustion of the fuel. This number is available from supplier. For other utilities, this is the energy necessary to generate one unit of the utility (e.g., 1Kwh). Use 10,909 Kj's per Kwh unless your supplier has a better number.
12. (Item 10) multiplied by (item 11).
14. Waste is that material which has no economic value and which requires additional Kilojoules to dispose of.
15. Estimated energy to dispose of the waste (item 14). This may be the energy to truck away and dump a solid, the energy to burn some scrap or the energy to run a waste disposal plant.
17. Units of waste produced during this time period. Units of waste is not needed for the calculation, but may be recorded for later reference.
19. By-products are those saleable materials which are made incidental to the production of the desired product or products.
20. Units of by-product (item 19) made during this time period.
21. The usable energy in the by-product. As an approximation, use the ratio of the value of the by-product to the value of product multiplied by the gross energy content of the product (item 18).
22. (Item 20) multiplied by (item 21).

Source: NBS Handbook 115

Table 2.1 to Table 2.3 are suggested forms for energy data base.

3. Conducting an Energy Audit

An energy audit is an in-depth examination of an energy consuming system or facility. The energy audit is usually categorized into three levels of activity: primary or preliminary audit, detailed or maxi-audit, and plant survey or mini-audit.

The primary audit consists of recording and analyzing the energy use by cost center over a fixed period of time. This can be performed by a quick walk-through of the facilities and by analysis of utility and fuel bills. A visual inspection is made to determine broad energy saving opportunities, i.e. maintenance and operations, and establish the need for a more detailed analysis. It takes 1-3 days depending on plant complexity.

In a maxi-audit complete "energy use data" for every cost center over a fixed period of time is collected. Energy balances and efficiencies can then be calculated. This may necessitate back-up portable measuring and monitoring instruments. The procedure takes weeks, sometimes months, to finish.

The plant surveys or mini-audit consists of identifying obvious energy wasting situations and recommending measures through improved maintenance and operating practices. This requires tests and measurements to quantify energy uses and losses. Activities at this level may also involve recommending and analyzing energy conservation opportunities which require minor expenditures upto major capital investments. Time spent varies depending upon the related project.

Normally, an energy audit at the plant level is analyzed through the operating facilities, systems or cost centers. The emphasis is on material flow and energy flow.

Before pursuing a detailed energy audit, particularly if external assistance is being considered, it is suggested that an in-house study be performed. Typical forms are shown in Table 2.4 through 2.8 to facilitate the work.

After improving the plant's energy use efficiency thru housekeeping measures (better operating and maintenance practices, load scheduling, etc.) and simple retrofitting measures, a more detailed energy audit is recommended. A diagram illustrating the energy audit process is shown in Figure 2.2

It is imperative that a detailed energy audit focus on specific systems and major equipment, such as: steam system, compressed air system, pump system, heat generator, air conditioning system, system modification, integration of several process streams, etc.

The procedure in a detailed energy audit consists of the followings:

3.1 Set objective (s) as specific as possible with due consideration to limited resources available.

3.2 Organize an energy audit team with members having adequate technical knowhow and expertise on the specific system, equipment, and unit operations under study.

3.3 Establish the urgency of the task and the support manpower required.

Table 2.4 Energy Saving Survey Form.

DEPARTMENT:________________ SURVEY BY:________________
DATE________________

Fuel Gas or Oil Leaks	Steam Leaks	Compressed Air Leaks	Condensate Leaks	Water Leaks	Damaged or Leaking Insulation	Excess Lighting	Excess Utility Usage	Equipment Running & Not Needed	Burners Out of Adj.	Leaks of Excess of AC	Location	Date Fixed

Table 2.4 (Con't)

High Exit Gas Temp.	Product Rejects	Unnecessary Handling of Materials	Production Interruptions/ Shutdowns	Unnecessary Pressure Reducing Stations	Defective Control Instruments	Defective Steam Traps	Plug-up Filters of Blowers/ Compressors	Excess A/C Heat	Date Fixed

Table 2.5 The Lighting Audit Form.

1. TASK AREA	2. LENGTH	3. WIDTH	4. AREA 2X3	5. FIXTURE INFO.	6. LIGHT SOURCE	7. NUMBER OF L.S.	8. WATTS* PER L.S.	9. TOTAL WATTS(LS)	10. NUMBER BALLAST	11. TOL. BAL. WATTS	12. TOTAL WATTS
TOTALS											

TOTAL AREA ________ TOTAL WATTS ________ WATTS PER SQ. METER ________

*Watts for light source and ballast should be verified in the installation.

$$\text{TOTAL WATTS} \times \frac{\text{HOURS OF OPERATION}}{1000}\text{(PER MONTH)} = \text{KILOWATT HOURS/MONTH}$$

Table 2.6 Air Ventilation Audit Form.

JOB NAME ______________________________ DATE ____________________

PREPARED BY ______________________________ PROJECT NO. ____________________

SYSTEM NUMBER	DESIGN		ACTUAL		REMARKS:
	TOTAL CFM	OUTSIDE AIR	TOTAL CFM	OUTSIDE AIR	

Note: These readings should be obtained by traverse and O.S. setting kept on minimum position ONLY.

Table 2.7 Building Occupancy Survey Form.

DATE________________ PREPARED BY________________ PROJECT NO.__________

JOB NAME:			WEEKDAYS			SATURDAYS			SUNDAYS/HOLIDAYS		
AREA SERVED	GROSS SQ. METER	SYSTEM SERVING	NO. OF OCCU-PANTS	OCCUPANCY TIME A.M.	P.M.	NO. OF OCCU-PANTS	OCCUPANCY TIME A.M.	P.M.	NO. OF OCCU-PANTS	OCCUPANCY TIME A.M.	P.M.

Table 2.8 Preventive Maintenance Survey Form

MAINTENANCE DEPARTMENT

OPERATION NO.__________

ITEM	LOCATION OF ITEM	CODE	FREQUENCY OF MAINTENANCE	EST. TIME REQUIRED	TIME OF DAY	DESCRIPTION OF MAINTENANCE

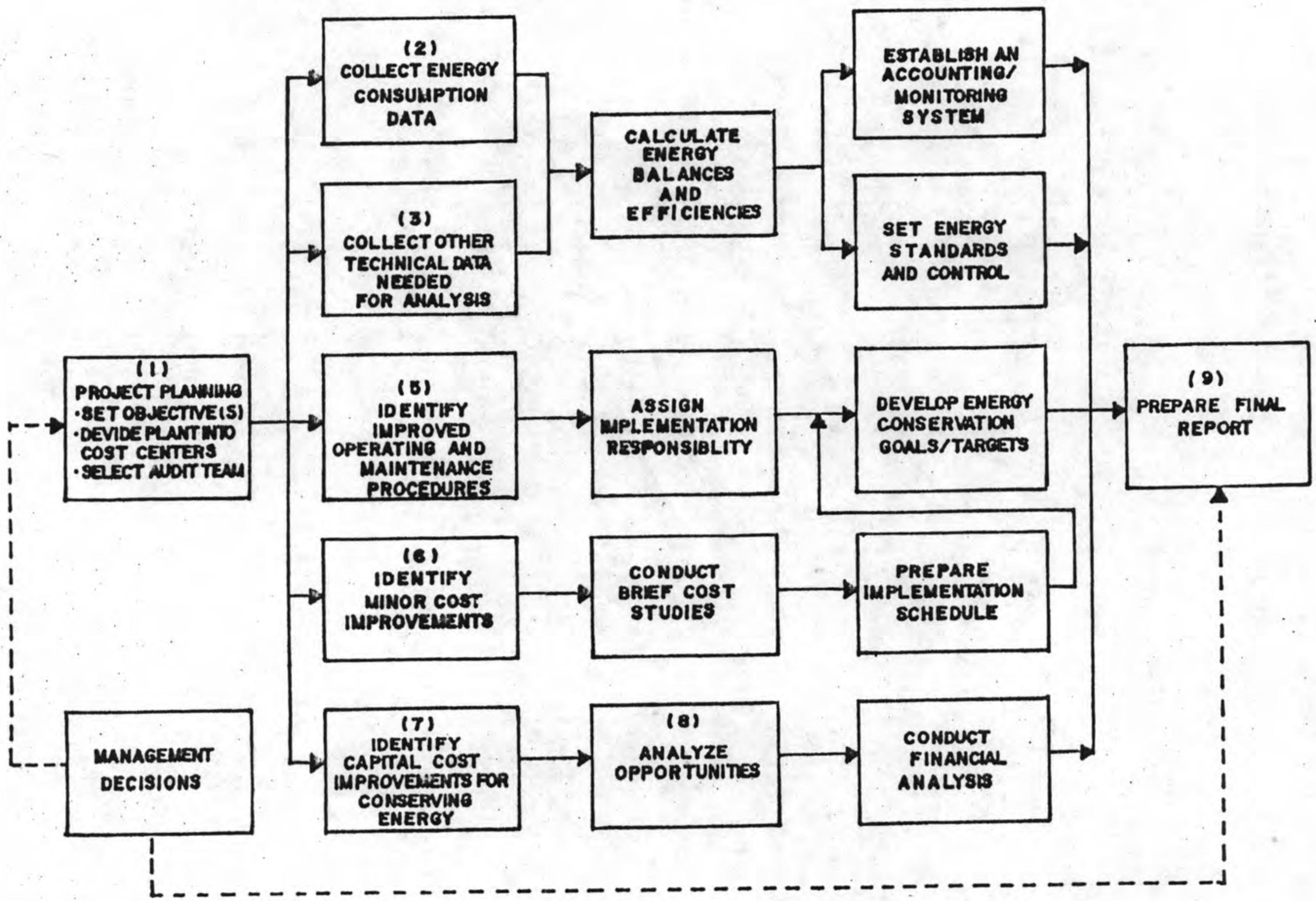


Figure 2.2 Diagram Showing the Energy Audit Process

3.4 Initiate quick review and evaluation of existing informations, current activities and operating practices.

3.5 Prepare the plant facilities for actual data gathering and runs, if necessary.

3.6 Establish proper timing and duration of the exercise to ensure desired test conditions.

3.7 Before proceeding to actual data gathering and verification, make sure that:

1) all necessary field and panel board instruments are properly calibrated,

2) portable instruments for comparative check are calibrated,

3) standard reference gases and recalibrating devices are available,

4) maintenance and instrument personnel are around for back-up service.

3.8 Prepare all worksheets, survey forms, operating logsheets, reference drawings like the process flow and instrument diagrams.

3.9 Based on the objective (s) of the energy audit, try to summarize data, as applicable:

1) Energy input in raw materials and utilities.
2) Net energy charged to the main product.
3) Energy credit for by-product.
4) Energy dissipated or wasted.
5) Energy consumed in waste disposal.
6) Energy per unit output.

7) Net energy saved, expressed in aggregate amount as equivalent currency savings, or as percent (%) of total energy-use.

4. Identifying and Analyzing Energy Conservation Opportunities (ECOs)

Followings are activities related to this phase.

4.1 List down and classify energy saving opportunities into procedural and maintenance or modifications requiring small expenditures, modest expenditures, or extensive capital investment.

4.2 Describe briefly engineering concept /scheme.

4.3 Prepare financial evaluation showing the savings, funding requirement, return on investment or the payback, risk, etc.

4.4 Review past project proposals which were not considered for implementation or for further study.

Table 2.9 to Table 2.11 are suggested forms for activities mentioned above.

5. Energy Reporting to Management

An energy audit exercise is not complete without a comprehensive report to management. In order to prepare a good report, the following items should be given.

5.1 An executive summary highlighting the program objective.

5.2 Purpose of the audit.

5.3 Audit findings indicating potential savings.

5.4 Financial and manpower requirements.

5.5 Effects both positive and negative.

5.6 Overall implications and proposed course (s) of actions.

Table 2.9 Energy Conservation Project Evaluation Form.

PROJECT NO.	PROJECT DESCRIPTION	ENERGY SAVINGS	INVESTMENT COST	PAYBACK/ ROI	PRIORITY	STATUS REMARKS

Table 2.10 Analysis Form for Energy Conservation Measures

1 Process Unit	2 Current Energy Used in Process Unit (KL)	3 Description of Energy saving Concept	4 Calculated Energy Saved (KL)	5 Percent Energy Saved in Process Unit (Col 4÷Col 2x100)	6 Net Annual Savings (Baht)	7 Investment (Baht)	8 Simple Payback Period

Table 2.11 Summary Form for Energy Conservation Project

ENERGY CONSERVATION PROJECT
EVALUATION SUMMARY

Capital__________or Expense__________

Department______________________________

Date______________________

Project No.________ Person Responsible______________________

Project Titles______________________________

Description of Projects______________________________

____

____

____

____

Location:______________________________

Financial Evaluation: ______________________________

Estimated

Energy saving (electric power kWh/yr steam lb/yr etc)

Utility or Raw Material	Saving
______________	______________/yr
______________	______________/yr
______________	______________/yr
Total energy saving	______________KJ/yr
Total energy cost saving	______________/yr
Other cost saving due to:	
______________	______________/yr
Additional cost due to:	
______________	______________/yr
Net cost saving	______________
Cost of project	______________

Table 2.11 (Con't)

ENERGY CONSERVATION PROJECT

EVALUATION SUMMARY

Calculated

Return on investment ____________ %

Pay back period ____________ months

Other ____________ ____________

BTU/unit of production: Now ______ After project implemented ______

Benefits/Problems:

Product quality ____________

Product yield ____________

Production rate ____________

Safety ____________

Pollution ____________

Maintenance-manpower/materials ____________

Utilities ____________

Working conditions ____________

Employee attitude ____________

Community ____________

Other benefits/problems connected with implementation:

____

____

____

Comments: ____________

____

Project rating: ____________

____

Planned authorization request date: ____________

Moreover, a comprehensive technical report of the energy audit exercise should also be provided. The report shows the following

5.7 Background information, i.e. plant overview and energy overview.

5.8 General approach.

5.9 Description, as applicable, of

1) general condition of operating facilities,
2) energy consumption,
3) energy distribution,
4) specific energy consumption,
5) major energy consumers,
6) fuel storage and distribution system,
7) boiler system,
8) furnace and drying system,
9) generator system,
10) water treatment,
11) process operation.

5.10 Findings, in specific terms, for each identifiable system, division, or cost center.

5.11 Energy data analysis.

5.12 Recommendation, in specific terms, for each system.

5.13 All relevant informations, test data, references, calculations, detailed analysis under appendices

At this point, it should be noted that the energy audit may result in a report that does not follow the proposed format. In some situations, the energy audit may have to be stopped during the course of the exercise for justifiable reasons. Thus, the report would then focus on what actually transpired, the revisions for the proposed work plans and follow-up actions required.

6. Implementing Energy Conservation Measures

6.1 Stopping energy wastes identified by taking corrective actions.

6.2 Seeking management approval for project proposal(s) as well as corresponding investment request.

6.3 Reviewing design of all new capital projects to ensure that efficient utilization of energy is incorporated in the design.

6.4 Implementing authorized project(s).

7. Monitoring, Evaluating, and Following-up Effects of the Energy Saving Program

In general, this phase is not given much emphasis by the company. It is only when measures go wrong, quite badly, that the management pays attention and begins asking for some details.

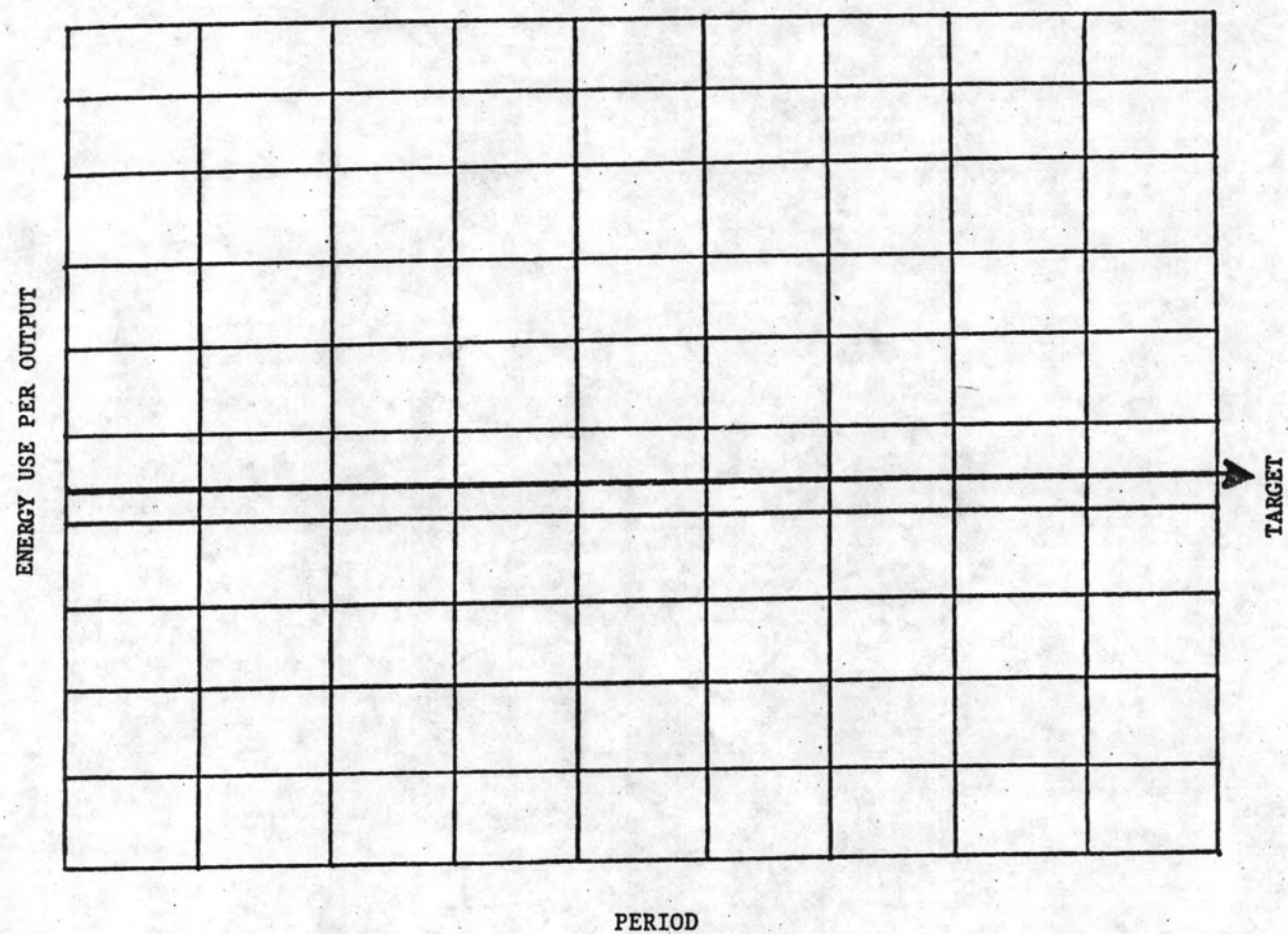
The energy manager, notwithstanding the results, must monitor and measure the effects of energy saving measure(s). One way is to track energy use per unit of production by cost center or plant-wide. Figure 2.3 shows a typical tracking chart.

Further, considering the effects of complicated variables, monitor and analyze the energy per unit of production by:

1) comparing energy per unit output with past performance and theoretical one.

2) observing impact of energy saving measures on the decreasing energy per unit of production.

Figure 2.3 A Tracking Chart of Energy Use per Output.



1. BY PLANT
2. BY DEPARTMENT
3. BY MAJOR EQUIPMENT

3) investigating, identifying and correcting the cause (s) for increases that may occur in the energy per unit of production, if possible.

Above all, the energy manager must ensure that the channel of communication is always open both to top management and to those at the lower levels of the organization. A periodic progress report must reach the top management.

8. Evaluating Energy Conservation Program

As experience is gained in energy audit work and the energy use efficiency improves, consider the followings:

8.1 Reviewing the progress or accomplishment in energy saving.

8.2 Evaluating original goals and revising them as necessary

8.3 Modifying the program.

8.4 Maintaining close cooperation with trade associations or industrial groups for technical assistance.

8.5 Financial incentives for energy-saving equipment and processes as use of waste heat and waste products, increase system productivity, combined heat and power systems, etc.

8.6 Coordinating with institutions and government agencies for information on the opportunities, benefits, and technologies, infrastructures, licensing procedures, incentives associated with fuel-substitution.

Instruments for Energy Auditors

In conducting an energy audit, the principal measurements made are usually of temperatures, pressures, flow rate, and the oxygen and carbon dioxide contents of waste gases. Measurements must be reliable and accurate. Table 2.12 provides instruments for energy auditors.

Table 2.12 Suggested Instruments for Energy Auditors.

Parameter Measured	Item Description
1. Temperature	a) Thermometer, digital or analog type, hand held, battery operated, with measuring ranges: a) up to 100°C - for air conditioning, ventilation, heating hot water service, steam condensate b) up to 500°C - For hot flue gases c) up to 1,300°C - for very hot conditions Sensor probes available are thermocouples, thermistors or Resistance type. Use may be for general applications, immersion, or air/gas.
	b) Surface Pyrometer, non-contact type, handheld, battery operated, with measuring range of up to 1,100°C. These are suitable for general work and for measuring surfaces or conditions which are not physicallly accessible, rotating, unsafe at close range.
	c) Psychrometer, sling, in strong plastic frame with built-in water reservior to keep wick wet, has slide rule to provide relative humidity readings from wet and dry bulb temperatures.
	d) Relative humidity meter, handheld, digital type.

Table 2.12 (Con 't)

Parameter Measured	Item Description
2. Flow	a) Pitot tube for determining air velocities, stainless steel tubes complying with ASHRAE specifications. Sizes available 12" to 60" long, hand mounting type, with inclined tube manometer; air velocity slide calculator included.
	b) Flow meter for steam application, portable type, consisting of differential pressure transmeter, flow indicator/recorder and totalizer, (Suggested model: GILFLO Linear Steam Metering System).
3. Pressure	Draft gauge, portable type, for measurement of pressure at low static pressure differential.
4. Lighting Level	Luxmeter, portable type, measuring ranges: 0 to 300, 0 to 1,000 and 0 to 3,000 lux (switch selectable)
5. Flue Gas Analysis	a) Wet chemical type for analysis of CO_2, CO, and O_2 in Flue gases; utilize Orsat method of volumetric analysis involving chemical absorption of a sample gas; absorbing fluid is used also as the indicating fluid.
	b) Orsat Analyzer, electronic type, for analysis of CO_2, CO, and O_2 in flue gases, include appropriate span gases for calibration; high sensitivity and accuracy, rapid response, powered by NiCd rechargeable batteries.

Table 2.12 (Con't)

Parameter Measured	Item Description
6. Electrical	
Ampere	a) Ammeter, Clip-on type, digital
Voltage	b) Voltmeter, Clip-on type, digital
Power	c) Power Meter, Clip-on, type, digital
Power Factor	d) Power Factor Meter, clip-on type, digital for direct reading of power factor in single and poly phases; with built-in alligator clips to monitor volts;
7. Others	
Steam Traps	Steam Trap Checking Device, electronic type, handheld, with light indicators indicating whether steam trap is working or not. Suggested brand : SPIRA-TEC