Module 3: Overview of Building Energy Audits

Learning Objectives

After completing this module, you will be able to
- Describe the theoretical framework for a building audit;
- Identify the information that should be collected and analysed before the site visit;
- Develop a building audit plan and schedule;
- Identify the steps involved in conducting a building audit.

3.1 A Systems Approach to Energy Auditing

"An energy audit is developing an understanding of the specific energy using patterns of a particular facility."

Carl E. Salas, P.E.

3.1.1 Energy management in buildings

Controlling costs in today's public sector environment has become a critical priority that requires clear strategies for managing the variety of expenses incurred on a daily basis. Improving the energy efficiency of your organization offers many cost reduction opportunities. Energy management—the process of understanding and managing energy costs through energy efficiency and energy purchase strategies—has become a management issue.

As a management issue, the achievement of energy efficiency with the associated cost savings involves many aspects of your organization. Clearly, there are technical issues because energy is consumed by technical systems. But technical systems are operated by people, and people can dramatically influence the level of energy consumption. As well, a strong organizational commitment is necessary to ensure the success of any business undertaking — energy efficiency included.

There are several characteristics of organizations that successfully manage their energy use that can serve as a guide. Typically they:
- exhibit a broad awareness of the benefits of energy efficiency throughout the organization;
- collect and utilize information to manage their energy use;
- have an energy management plan--short term and long term;
- integrate the task of managing energy into the overall management structure of the organization;
- provide leadership for energy management through a "champion" or group of committed staff—an energy management team;
- and, have top-down commitment expressed in the form of an energy efficiency policy.

The term "energy management" means many things to different people. As a general rule, it involves the application of principles:

1. **Purchase energy supplies at the lowest possible price.**
2. **Manage energy use at peak efficiency.**
3. **Utilize the most appropriate technology.**

It is a useful exercise to take a few minutes to develop a list of the actions or measures associated with each of these principles in your organization.

In considering Principle 1, energy purchase, the building operator needs to assess price, availability, and energy content (in fact, the cost per unit of energy available from the source), as well as those issues that influence his ability to negotiate favorable energy purchase agreements.

Consideration of Principle 2 should allow the operator to generate a list of management actions that he or someone else in the organization can take now to ensure that energy is used as efficiently as possible.

Principle 3 may be the most difficult one to deal with right now. However, in thinking about the technological aspects of energy use, it is helpful to categorize measures as

- **No cost** – that is, housekeeping and operational changes
- **Low cost** – that is measures that may require some investment in technology, but that rely extensively on input from people
- **High cost** – those measures that require significant investments of capital for the acquisition and installation of new technology.

3.1.2 The structure of energy consuming systems

An energy consuming system is a collection of elements that consume energy. Energy audits are usually concerned with systems that may be as extensive as a building complex such as a multi-building hospital, or as narrow as a single piece of equipment such as a heating plant.

Figure 3.1 illustrates the generic structure of an energy consuming system, as it may exist in a building site.

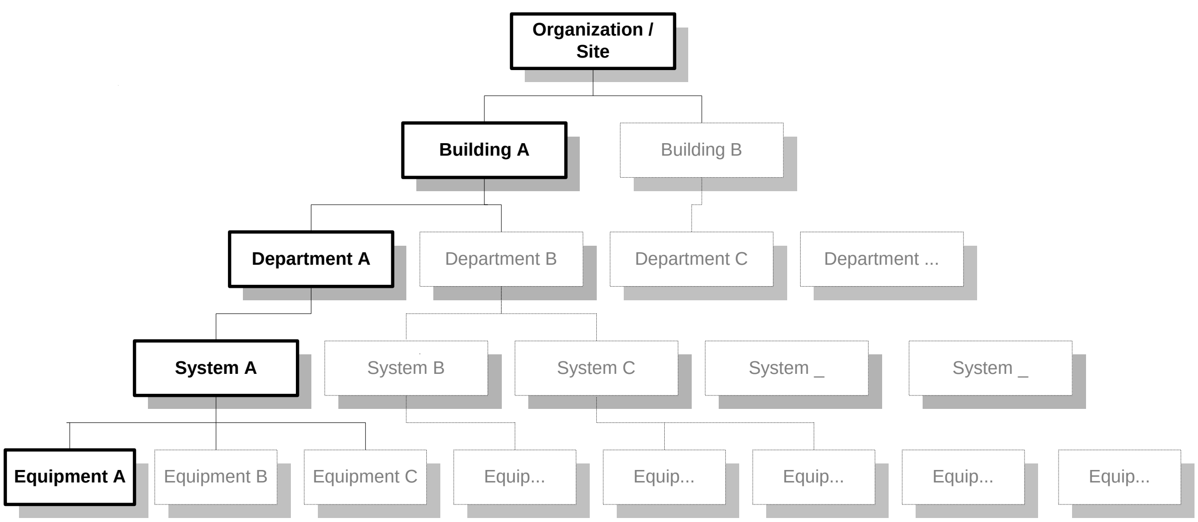


Figure 31: The Structure of Energy Consuming Systems

For simplicity, Figure 3.1 only shows one branch to each subordinate level in the systems hierarchy. Real systems would have many branches from each component to various lower levels. In this Guidebook, the term "energy consuming system" may refer to a site, building, department, system or piece of equipment or any combination of these.

3.1.3 A basis for the energy balance – the Law of Conservation of Energy (First Law of Thermodynamics)

> ***Question: What is the theoretical basis for conducting an energy audit?***

Conceptually, energy auditing is an application of a very simple natural law, **the First Law of Thermodynamics**, commonly known as the "law of conservation of energy". It simply means that we can account for energy; since it is neither created nor destroyed in the facilities and systems we operate.

Translated into practical terms, what this law means for energy is:

what comes in = what goes out.

The challenge of the audit involves:

- To specifically define the system being considered;
- To quantify energy flows into and out of that system.

The first of these challenges involves defining a ***system boundary***. As noted above, by "system", we mean any energy consuming building, area within a building, operating system, collection of equipment, or individual piece of equipment—around which we can, figuratively, place a boundary. On a schematic diagram, as in Figure 3.2, a pencil line encircling our "system" serves as the boundary.

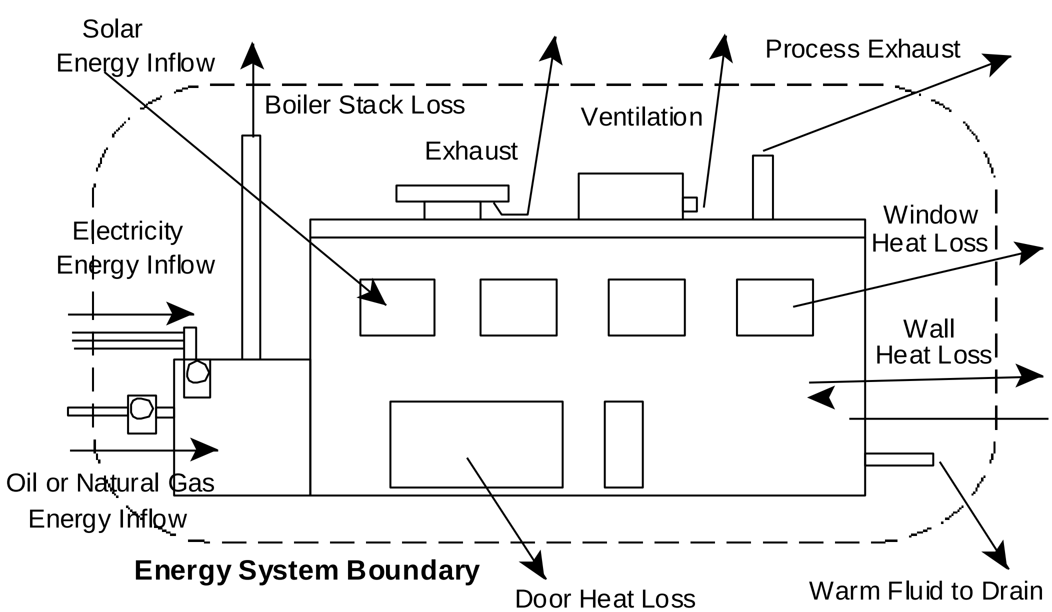


Figure 3.2: Facility Energy System

What happens within the boundary is of little concern from an energy accounting point of view. It is energy streams that cross the boundary that must be accounted for. **It is essential that the system boundary be defined in very specific terms.** Many audits will involve “layers” of assessment, with the scope focusing from the facility level inwards to specific pieces of equipment.

The second of these challenges is the more technically difficult one, as it involves the collection of energy flow data from various sources, including direct measurement. It likely also involves the estimation of energy flows that cannot be directly measured, such as heat loss through a building wall, or in vented air. Remembering that the only energy flows of concern are those that cross the system boundary as we have defined it, considerations in quantifying energy flows are:

- Select convenient units of measure, and be able to convert the various units to one selected unit for consolidation of data (for example, express everything in equivalent kWh or MJ);
- Know how to calculate the energy contained in material flows—as in hot water to drain, cooled air to exhaust, etc.;
- Know how to calculate heat from the various precursor energy forms, as in electricity converted to heat through the operation of an electric motor.

3.2 Defining the Energy Audit – from Preliminary to Detailed Audit

There is no one agreed upon set of definitions for the various levels of facility and system energy audits. The terms **preliminary audit** and **detailed audit** refer to the level of detail with which the audit is concerned. Figure 3.3 shows the steps involved in DME’s audit methodology.

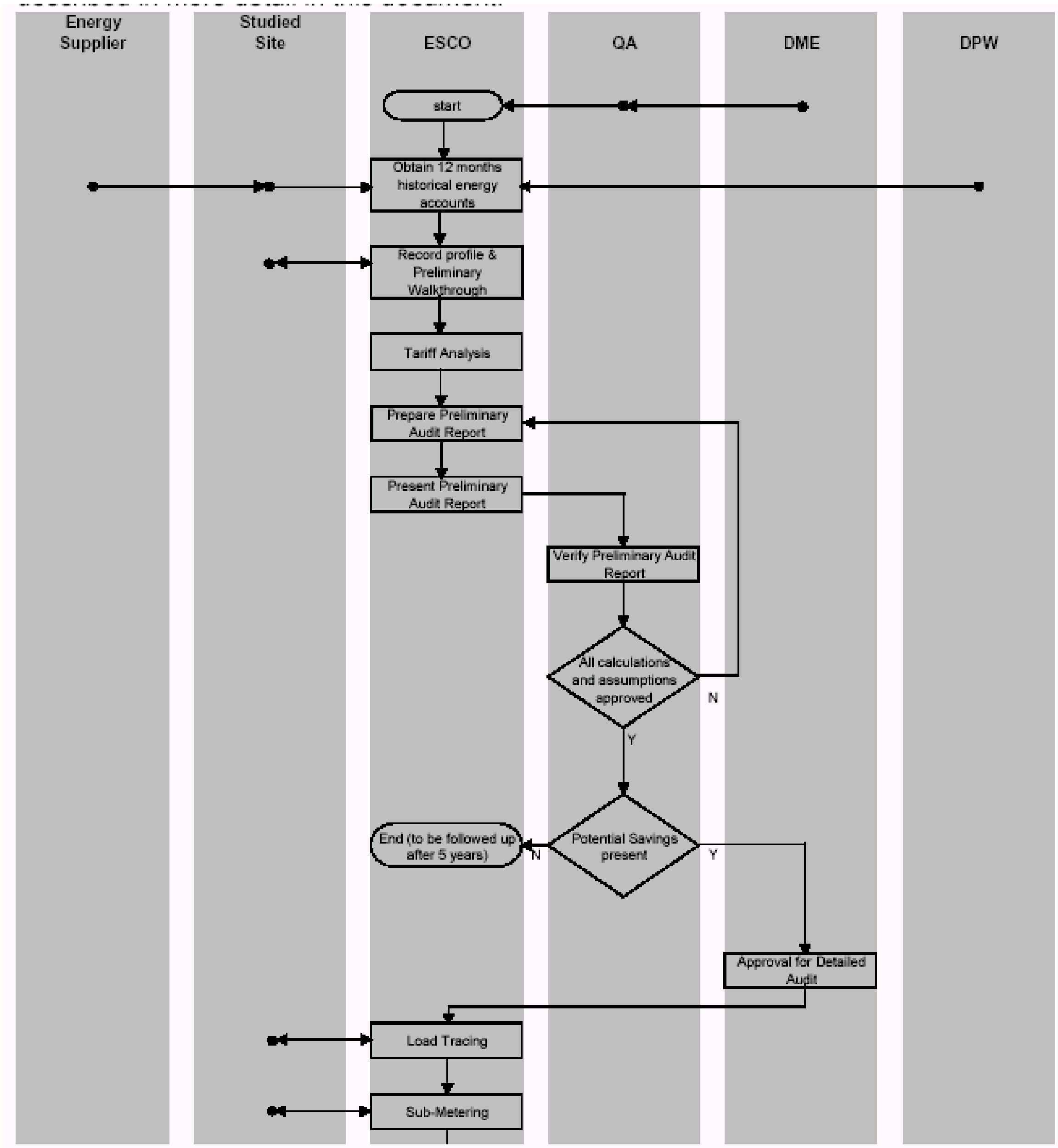
Level of detail considered is the first significant measure of an audit. The second significant measure of an audit is the physical extent or scope with which it is concerned. By physical extent we mean the size of the system in terms of the number of sub-systems and components that comprise it.

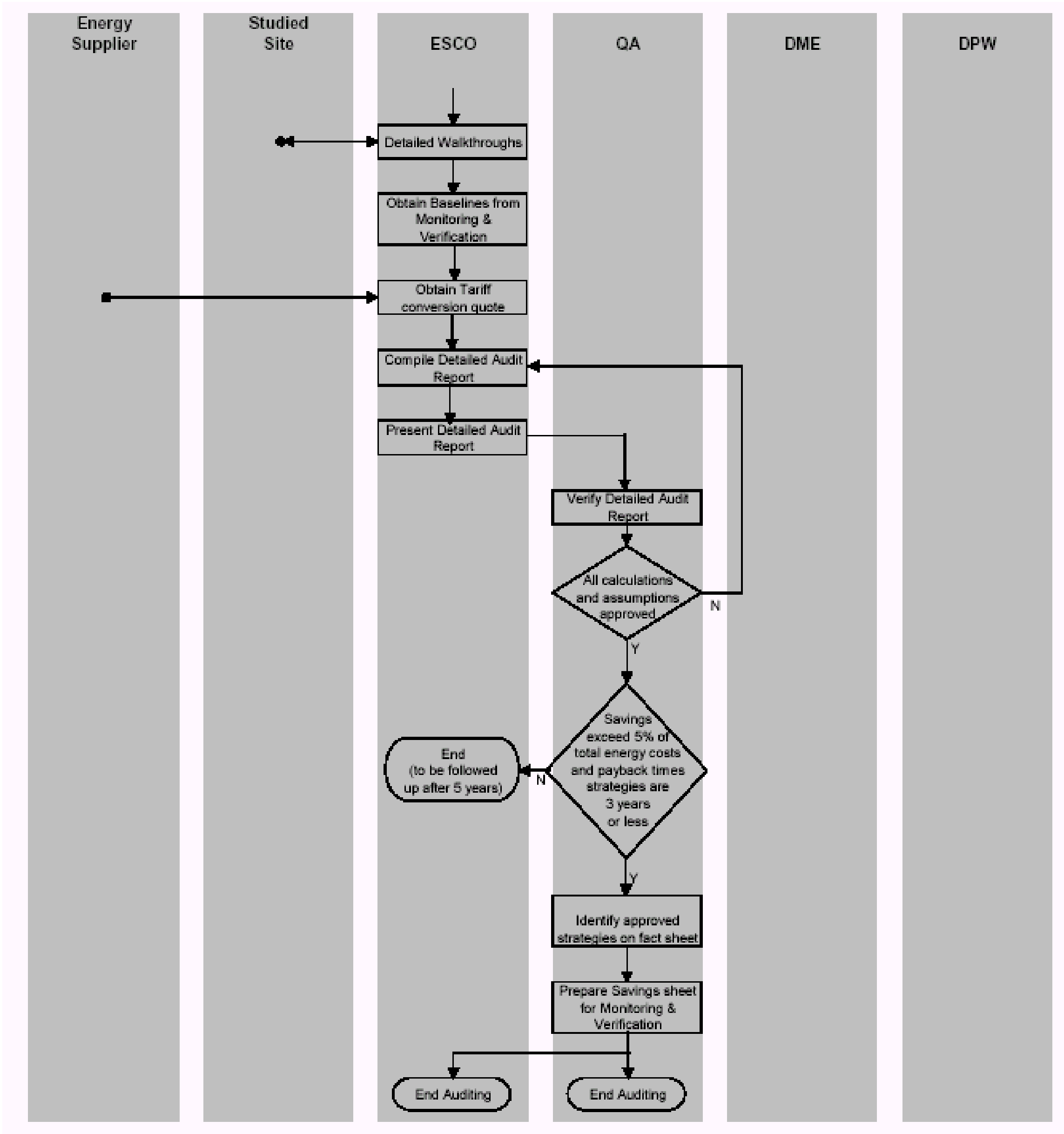
- The **Preliminary Audit** starts at a relatively high level in the structure of energy consuming systems—perhaps the entire site or facility—and addresses a level of detail that permits at minimum the identification of areas of the building that potentially may yield energy management opportunities; preliminary audits have broad physical extent and lower level of detail.
- The **Detailed Audit** begins where the preliminary audit ends and works through analysis to greater levels of detail; the focus of a detailed audit might be the entire building if that is warranted by the findings of the walk-through, a specific energy consuming system such as building lighting, or an individual piece of equipment such as a chiller.

  Generally, as the level of detail of the audit increases, the physical extent would decrease. The opposite is also true; if the extent were increased, the level of detail of the analysis would tend to decrease.

  The audit methodology presented in this Guidebook addresses the Preliminary Audit and the Detailed Audit in sequence.

Figure 3.3: DME Audit Process Flow Chart





3.2.1 Information required before the site visit

As prescribed in the DME audit process, the auditor needs to obtain some data from the facility prior to the site visit. As a minimum, it is suggested that this include:

- Historical energy and water consumption and billings data for at least 12 months, preferably multi-year;
- Basic building configuration information, including at least conditioned floor area;
- Building schedule and occupancy data;
- Breakdown of building uses by area (i.e. general office, computer facilities, library, cafeteria, etc.);
- Any other energy assessment data that may be available, including demand profiles, equipment inventories, etc.
- Degree-day information applicable to the building location.

3.2.2 The Client Meeting

It is important to have a clear understanding between the auditor and the client before the work is undertaken. This understanding may include:

- the cost of the audit, both for the preliminary audit and the detailed assessment, and how that cost will be paid;
- commitment to proceed on the implementation of measures that are shown to have a favourable business case;
- the initial schedule for the preliminary audit and reporting milestones;
- points of contact between the auditor and the organisation.

3.2.3 Historical data analysis before the site visit – an introduction to energy monitoring

An examination of climatic data for South Africa indicates that there are significant regional differences in weather that will have an impact on building energy consumption. Energy management practitioners may have typical average energy intensities (energy consumed per unit floor area) for buildings region by region; however, a more thorough assessment of the impact of variables such as occupancy rates and, in particular, weather can be done fairly easily using linear regression analysis.

The purpose of this analysis is to determine a functional relationship (i.e. a mathematical statement) between energy consumed and weather. The impact of weather is expressed in terms of heating degree days (HDD) or cooling degree days (CDD). These factors quantify the difference between the average ambient temperature per day and a specified base temperature (usually 18^oC for HDD and 22^oC for CDD). For example, the number of cooling degree days in one 24 hour period is the difference between the average daily temperature for that day and 22^oC).

As we shall see later in this course, energy can be related to weather by an expression similar to the following:

Energy consumed = non-space conditioning energy (e.g. for domestic hot water) + space conditioning incremental energy factor x HDD or CDD.

3.2.4 A practical auditing methodology – ten steps

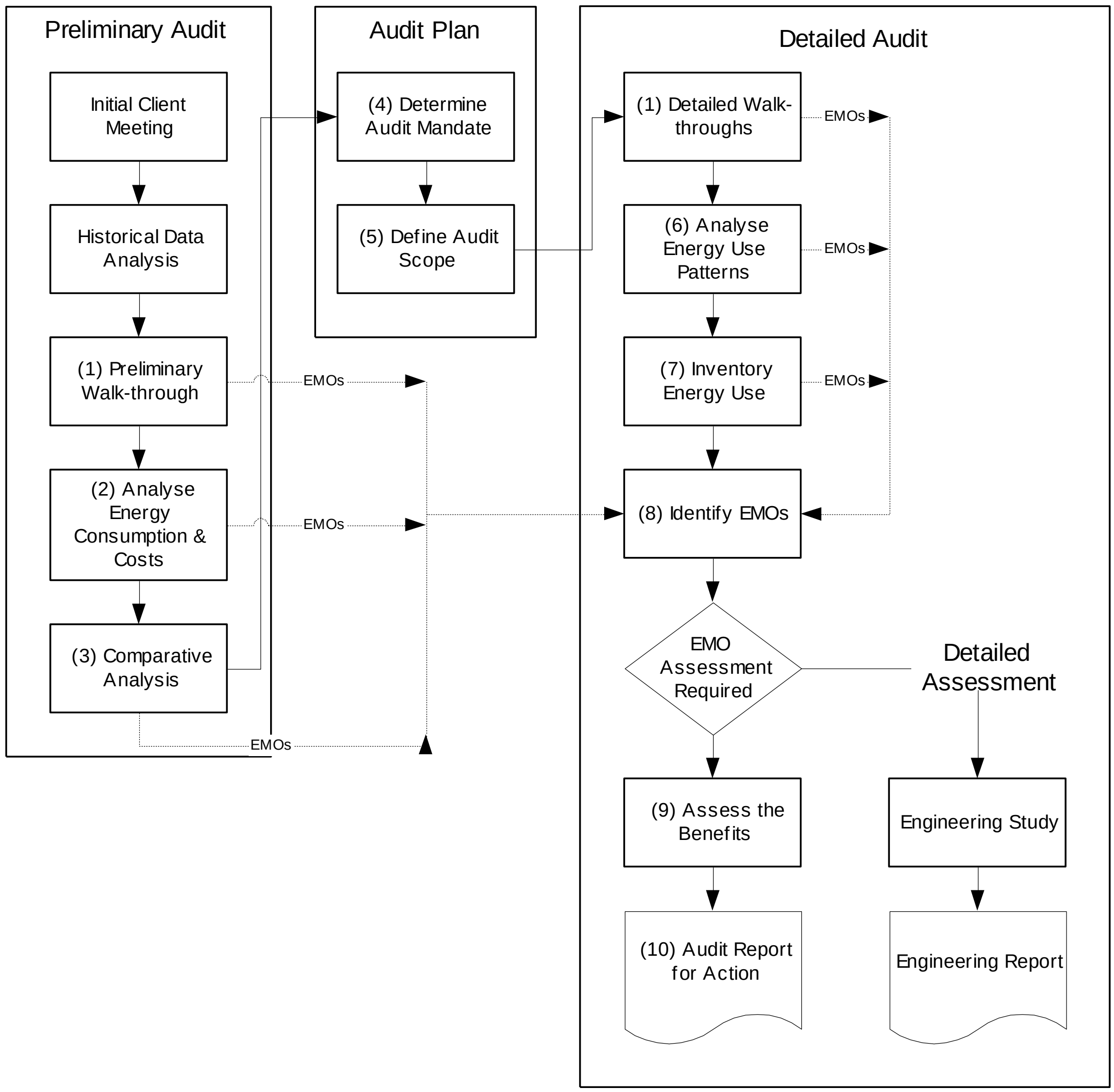
The methodology described in this and the subsequent sections is adapated from a similar approach described in *the Industrial Energy Auditing Guidebook*, currently in preparation for Natural Resources Canada. Audit Mandate and Audit Scope templates are taken from NRCan's previous Energy Auditing Guide, now out of print.

The Energy Audit is a systematic assessment of current energy use practices, from point of purchase to end-use. Just as a financial audit does for dollars, the energy audit identifies in quantitative terms:

- How and where energy enters the facility, department, system or piece of equipment;
- Where it goes and how it is used;
- Any variances between inputs and uses;
- How it can be used more effectively or efficiently.

Figure 3.4 summarizes the sequence of steps involved in the audit methodology.

Figure 3.4: Audit Process Flow Chart



The key steps in the Audit, after the initial client meetings and historical data analysis, are:

1. **Conduct a Walk-through Inspection** – to assess the general level of repair, housekeeping, and operational practices that have a bearing on energy efficiency, and to flag situations that have merit for further assessment as the audit is implemented; walk-through inspections will also be carried out to verify the findings of other analysis steps, as indicated in the flow chart;

2. **Analyze Energy Consumption and Costs** – collect, organize, summarize and analyze historical energy billings and the tariffs that apply to them;

3. **Compare Energy Performance** – determine energy use indices and compare them internally from one period to another, one facility to a similar one within your portfolio, one system to a similar one; or externally to measures of good practice within your industry;

4. **Establish the Audit Mandate** – secure commitment from management and define expectations and outcomes of the detailed audit;

5. **Establish the Audit Scope** – define the energy consuming system to be audited.

6. **Profile Energy Use Patterns** – determine the time relationships of energy use, as in the electricity demand profile;

7. **Inventory Energy Use** – prepare a list of all energy consuming loads in the audit area, and quantify their consumption and demand characteristics;

8. **Identify Energy Management Opportunities** – including operational and technological measures to reduce energy waste.

9. **Assess the Benefits** – quantify the level of energy and cost savings, along with any co-benefits.

10. **Report for Action** – report the audit findings and communicate as required for implementation.

Each step involves a number of tasks that are described in the following sections. As suggested by the flow chart, several of the steps may result in the identification of potential EMOs.

Final Steps

A wide range of potential EMOs may be identified by the audit. It may be that the assessment of some of the EMOs will be beyond the scope of the audit, requiring a more detailed engineering study. Other EMOs will not require further study and the savings will likely be significant and rapid; in these cases immediate implementation will be the logical course of action.

3.3 Planning and Implementing the Audit

3.3.1 Developing the audit plan and schedule

An audit plan is a “living” strategic document that outlines the audit process. Although rigid enough to keep the audit “on track”, it must also be flexible enough to permit adjustments during the audit to allow for information gathered or changed conditions. It is also a vital communication tool that ensures consistency and completeness of audit coverage and effective use of the resources involved in the audit process.

The audit plan should provide the following:

- Audit mandate and scope
- Dates and places where the audit is to be conducted
- Details of the organizational and functional units to be audited and contacts
- Identification of the energy audit elements that are of high priority
- Expected time and duration for major audit activities
- Identification of audit team members
- Audit report content and format, expected date of issue and distribution.

3.3.2 Audit guidelines

DME lays out the audit process in **Report 1.0 Auditing (Draft) under the Capacity Building in Energy Efficiency and Renewable Energy Program.** The steps explained in this course are insofar as possible consistent with the DME process. A more detailed discussion of the DME methodology is given in the Supervising Engineers Course Module 9.

3.3.3 Coordination with O & M personnel and building occupants

Coordination with organisational departments, engineering, building operations and maintenance, etc. is critical to a successful audit. A good opening meeting with staff, representing all of the departments involved in the audit, can form a foundation of confidence about the process and ultimately, the audit findings.

Coordination with the various departments should include the following considerations:

- Review the purposes (objectives), scope and plan of the audit
- Make changes to the audit plan as required
- Describe and understand audit methodologies
- Define communication links during the audit
- Confirm availability of resources and facilities
- Confirm the schedule of meetings with the management group (including the closing meeting)
- Inform the audit team about relevant site health, safety and emergency procedures
- Answer questions
- Establish a comfort level with the audit purposes and outcomes.

Another option is to create an "Audit Team", at the outset, to not only solicit input at the planning stages but to garner support and resources throughout the audit. Regardless of the method used, the key is to distribute ownership of the audit results to all of the affected departments, by encouraging their involvement in the audit process.

3.3.4 References

Energy Auditing and Conservation, Methods, Measurements, Management and Case Studies. Yacov Y. Haines, Hemisphere Publishing Corporation, Washington, 1979

Handbook of Energy Audits, Albert Thumann, 3rd Edition, Chapter 10, The Fairmont Press, Inc. Lilburn GA, 1991

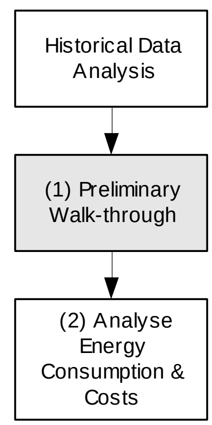
CIPEC Energy Efficiency Planning and Management Guide, Lom & Associates, Natural Resources Canada, 2002

Energy Management, A Comprehensive Guide to Reducing Cost by Efficient Use, Paul O.Callaghan, McGraw Hill Book Company, London, 1993

Guide to Energy Management, 2nd Edition, Capehart, Turner and Kennedy, The Fairmont Press, Lilburn GA, 1997

3.4 The Steps in the Audit

3.4.1 Step 1: The Walk-through—a building condition survey



The initial walk-through of the facility, or condition survey, is basically an inspection tour of the facility in which attention is given to:

- Where energy is quite evidently being wasted;
- Where repair or maintenance work is needed;
- Where capital investment may be needed in order to improve energy efficiency.

The walk-through serves at least three purposes:

1. it provides an orientation to the entire facility for the more detailed audit, specifically in regard to major uses of energy and the influencing factors;

2. it helps to identify areas within the facility that warrant further examination for potential energy management opportunities as a precursor to establishing the audit mandate and scope;

3. it identifies obvious opportunities for energy savings that can be implemented with virtually no further assessment; often these are issues of poor repair or housekeeping measures that do not involve significant expenditures of capital.

3.4.1.1 A Systematic Approach

It is important that the walk-through be both comprehensive and systematic. Although the information generated is mainly qualitative, it is helpful to attribute quantitative scores to the observations as an indication of the severity of the situation and the urgency of corrective action.

Towards that end, a checklist approach to information collection is suggested, together with a condition rating point count system. The checklist template can be readily modified and adapted to the specifics of your facility; for example, in a survey of lighting, a line for each room or distinct area in the facility can be created.

The rating system for use with the walk-through checklist is based on a 3 point count system, in which

- 3 represents a condition that is highly energy efficient,
- and 0 represents a condition that is very poor from an energy efficiency point of view.

The rating score indicates the urgency of corrective action.

Date: 31 May 2002

Auditor: _________

Comments:

No.	Location / Points	Insulation Good	Insulation Average	Insulation Poor	Flanges Insulatied	No Leaks	Some Leaks	Many Leaks	Automatic Controls	Std Operating procedure	Steam Meter	Fuel Meter	Make-Up Water Meter	Preventative Maintenance	Fix as Required	Energy Recovery	Economizer Controls	Total Points
		2	1	0	2	2	1	0	1	1	1	1	1	1	0	3	2	
	Maximum Score	2			2	2			1	1	1	1	1	1		3	2	15
1.	Main Boiler Room		1				1		1		1	1		1		3		9
2.	West Plant Boiler		1					0						1				2
Total Points for Section																		**11**
Rating for Boiler Plant Systems = (100 x Total Points) / Number of Items x Maximum Score = (100 x 11) / (2 x 15)																		**37 %**

After each checklist is completed, a "Rating Score" is calculated, according to the following formula and the example given above

This rating score is then used to indicate the urgency of corrective action, according to the following scale:

Range of Rating Score	*Action Required*
0 – 20	Immediate corrective action required
20 – 40	Urgent corrective action required
40 – 60	Corrective action required
60 – 80	Evaluation for potential improvement required
80 - 100	No corrective action required

The Checklists that are provided in the **Appendix** address the following facility systems:
1. Windows
2. Doors
3. Ceilings
4. Walls
5. Roofs
6. Storage Areas

7. Shipping and Receiving Areas
8. Lighting Systems
9. Food Areas
10. Heating Plant
11. Heating Distribution Systems
12. Cooling Plant
13. Cooling Distribution Systems
14. Electrical Power Distribution Systems
15. Hot Water Service
16. Cold Water Service

In each case, only the template headings are shown, along with the scoring structure. At the end of the section is a blank template that can be customized to these specific systems in your facility and others not included in this list. In the latter case, thought should be given to a scoring structure similar to that shown for these systems.

3.4.1.2 Finding Energy Management Opportunities

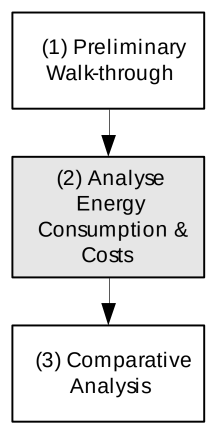
While the Condition Survey precedes the detailed audit process, it can identify energy management opportunities as well. The survey rating system helps to identify and prioritize areas of the facility that deserve more extensive assessment. However, direct observations of housekeeping, maintenance, and procedural issues can lead to EMOs that need no further assessment prior to acting on them. For example, leaks in the steam system, broken glazing, loading dock doors that won't close, and so on are "no brainers"; they need to be fixed, and they will pay off in reduced energy consumption.

References

Handbook of Energy Audits, Albert Thumann, 3rd Edition, Chapter 10, The Fairmont Press, Inc. Lilburn GA, 1991

CIPEC Energy Efficiency Planning and Management Guide, Lom & Associates, Natural Resources Canada, 2002

3.4.2 Step 2: Analyse energy consumption and costs



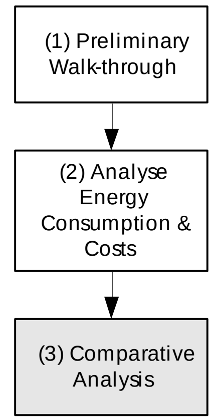
There is information in energy billings and cost records—especially when viewed against key energy use drivers such as weather—that can lead the auditor to energy management opportunities. The analysis of energy consumption and costs historically precedes the comparison of energy performance to internal and external benchmarks. Tabulation of historical energy consumption records provides at a glance a summary of annual consumption.

The opportunities that are identified at this step in the audit may involve the reduction of energy consumption and/or cost—both being important outcomes for the audit.

The information found in energy billings begins with the rate structures or tariffs under which energy is purchased. It is important for the auditor to fully understand the structure of tariffs and the cost components since these will greatly influence savings calculations when EMOs are being assessed. Since several energy sources may be utilized in the facility, it is also important to understand the **per unit energy cost** of these sources, and the incremental cost (as opposed to just the average cost of energy).

In Section 5.2, we explore the analysis of the energy tariff and the billings history, and demonstrate the tabulation of billings for the purpose of quantifying historical consumption levels and beginning the process of identifying consumption patterns.

3.4.3 Step 3: Comparative analysis



How does the level of energy consumption compare to other similar facilities and sites? What level of consumption is achievable with the best operating practices and performance benchmarks? How does energy consumption this year compare to last year? How does site A compare to site B on an energy performance basis?

The historical analysis of energy consumption and costs done in the previous step is "the tip of the iceberg" in the sense that it organizes billing information and provides a basis for more in-depth analysis of energy performance. In particular, it provides the data needed for comparison of performance:

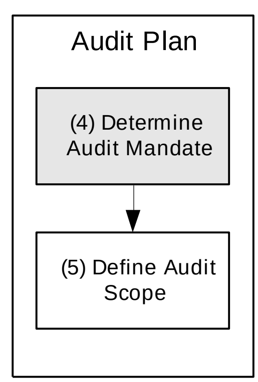
- internally, period to period, site to site;
- and, externally, to standards of performance established in the buildings sector.

The approach to comparative analysis developed in this section is based on the technique known as Monitoring & Targeting (M&T), as introduced in Section 3.2.2 and developed in more detail in Section 5.6. This method of statistical analysis of energy consumption in view of energy use determinants, such as occupancy and weather factors, generates very useful management information regarding the energy use trends and relationships that can be used to analyze performance historically, and control performance into the future.

A convenient basis of comparing the energy performance of buildings—if the impact of weather and occupancy and other unique uses of the building can be eliminated as a variable—is the **consumption index**: this is the total energy consumed per year per unit of occupied and conditioned floor area, expressed as **$MJ/m^2/year$.**

If electrical demand is a concern, the index that is used for comparison is the **demand index** which is the monthly average peak demand per unit area, expressed in **$VA_{average}/m^2/month$**.

3.4.4 Step 4: Defining the audit mandate



It is tempting to move quickly into the detailed audit itself, especially for those auditors who have a technical orientation. However, knowing the "ground rules" in advance, as in any enterprise, will contribute greatly to the most effective use of time, and provide assurance that the needs of those commissioning the audit are met.

The "terms of reference" presented to the energy auditor are:

- The **audit mandate**—clarification of the goals and objectives of the audit, and the key constraints that will apply to actions on its recommendations;

- The **audit scope**—specification of the physical extent of the audit focus, and the identification of the kinds of information and analytical approaches that will comprise the auditor's work.

The following checklist offers some guidance for articulating a clear and concise audit mandate. A similar approach to the audit scope follows in Section 3.4.3.

Audit Mandate Checklist

Audit Objectives: Investment and Operational Needs/Desires:

- ❑ To save:
  - ❑ Energy Consumption/Costs
  - ❑ Specific fuel type (details):
  - ❑ Maximum demand
- ❑ To accommodate increased load in building
- ❑ To pass energy costs directly to tenants/departments
- ❑ To limit manual operation of facility/processes
- ❑ Other (Specify):

Time Line:

Completion date required:____

Preliminary findings required:____________________________________

Building Conditions:

Note all problems related to:

- ❑ Comfort
- ❑ Breakdowns
- ❑ Lack of Capacity
- ❑ Appearance
- ❑ Noise
- ❑ Operational Practices
- ❑ Maintenance Practices
- ❑ Other (Specify):____

  ____

  ____

  ____

Implementation Factors and Constraints:

Housekeeping EMOs time line:_______________________________________

Low-cost EMOs time line:____

Financial Constraints:____

Retrofit EMOs time line:____

Financial Constraints:____

Applicable Grants, Subsidies and Tax Advantages: ____________________

____

____

Possibility of Audit Recommendations being applied to other buildings/areas:

- ❑ Yes
- ❑ No

Details: ____________________

____

____

Reporting Format Required:

Level of detail: ____________________

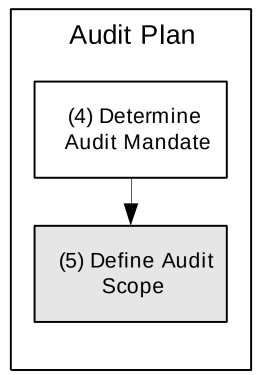
Financial analysis/criteria required: ____________________

____

Payback period/criterion acceptable: ____________________

____

3.4.5 Step 5: Defining the audit scope



A systematic approach to energy auditing requires the specific definition of the boundaries that apply (as we defined system boundaries in our exploration of the thermodynamic basis for energy auditing). It is the Audit Scope that provides this detailed definition of the “system” to be audited.

As well, the Audit Scope is a “scope of work” statement; that is, it defines the sources of information and the analysis that will be applied to them. The sample scope description provided below illustrates this point.

As noted earlier, the system may be anything from an entire plant to a piece of processing equipment.

3.4.3.1 Define the physical extent of the audit

This step entails the definition of the audit boundary, and the specifics of the energy systems within it. Although the details of the energy load inventory will emerge from the audit process itself, it is useful to define the areas to be examined as illustrated in the Audit Scope Checklist.

3.4.3.2 Identify the Energy Inputs and Outputs

Using a schematic diagram of the area being audited, you should be able to list the energy inputs and outputs. It is important to identify all flows, whether they are deliberate, by design and measurable, or unintended, wasteful and immeasurable directly. The obvious energy flows will be electricity, fuel, steam and other direct energy inputs; and flue gas, water to drain, vented air and other apparent outputs. A less obvious energy flow may be heat loss or gain though the building envelope.

3.4.3.3 Identify Sub-Systems

As outlined in the audit scope checklist, each of the systems to be considered in the audit are identified.

Audit Scope Checklist
Areas to be Examined: ❑ Whole site ❑ Individual buildings (details):______________________ ______________________ ______________________ ❑ Department (details):______________________ ______________________ ______________________ **External site sub-systems:** ❑ Lighting ❑ Heating mains ❑ Other (describe):______________________ ______________________ ______________________ **Individual sub-systems:** ❑ Boiler plant ❑ Cooling system ❑ Steam distribution ❑ Domestic water ❑ Refrigeration ❑ Lighting ❑ HVAC ❑ Building envelope ❑ Other (details):______________________ ______________________ ______________________
Types of Information: ❑ Electricity Billings ❑ Fuel Billings

- ❑ Weather Data
- ❑ Facility Specifications and Drawings
- ❑ Benchmarks
- ❑ Other (Specify):

____
____
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Analysis:

- ❑ Correlation of Consumption with Weather
- ❑ Internal/External Benchmark Analysis
- ❑ Electrical Demand Analysis
- ❑ Load Inventory Analysis
- ❑ Payback Analysis of EMOs/other financial criteria
- ❑ Other (Specify):

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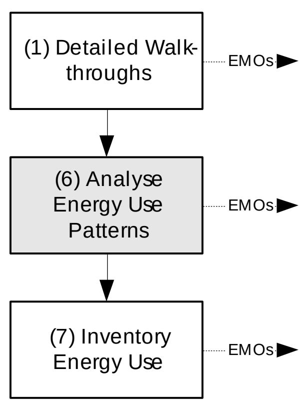
3.4.6 Step 6: Profile energy consumption—energy use as a function of time



A considerable amount of intelligence about the operation of your facility can be derived from the electrical demand profile. This time record of electrical energy consumption provides a record of the loads that are operating at any time, and the aggregate demand that they represent. Since the cost of electricity is determined in part by the maximum demand drawn by a facility, measures to reduce the maximum demand often become apparent and contribute significantly to a lowering of your energy bill.

As well, the demand profile can reveal loads that are operating when they don't need to be, and systems that are sized inappropriately. Taking corrective action in these instances can lead to both energy consumption and cost reductions.

Depending on the size of the facility and the resources at your disposal, it may be desirable and possible to install metering—even temporarily—at various locations to generate a profile of electrical demand. Alternatively, the electrical utility may be able to provide you with that information or assist you to obtain it by measurement.

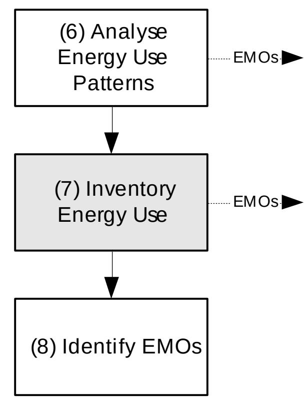
While the demand profile is a measurement of electrical energy, it also provides information about the consumption of other forms of energy. The demand profile provides an operational fingerprint or energy signature of a facility—as such it is a key part of any energy audit. Other methods of profiling or data logging are also discussed in Section 5.5.

3.4.6.1 What is a Demand Profile?

The demand profile for a facility, building, service entrance or any user of electricity is simply a record of the power demand (rate of energy use) over time. Its purpose is to provide detailed information about how the facility, as a whole, uses energy. It is, in essence, the "electrical fingerprint" of the facility. To the auditor, the demand profile is an extremely useful tool for tracking energy use.

Details on the forms that demand information can take, the methods of collecting the data, and the intelligence that can be derived from analysing it are discussed in Module 5, Section 5.3.

3.4.7 Step 7: Inventory energy loads



Two of the essential tools for the energy auditor to fully assess a facility are the demand profile—to characterize the electrical loads with regard to time of use and size—and the load inventory. These two tools are complementary to the extent that they describe in quantitative detail the systems that consume energy in the facility.

The energy auditor needs to know where energy is being consumed, how much is consumed by each system, and how all the systems add up as an aggregate load. It is helpful to know how the total energy load is distributed among the various systems.

The load inventory is a systematic way of collecting and organizing this kind of information. It is a useful tool for doing “what if” assessments—estimating the impact of retrofits or other technological or operational change—of proposed measures.

3.4.7.1 The Electrical Load Inventory

Making a list or inventory of all loads in a facility answers two important questions:

- **Where** is the electricity used?
- **How much** and **how fast** electricity is used in each category?

Often the process of identifying categories of use allows waste to be easily identified, and this often leads to low-cost savings opportunities. Identifying the high-consumption loads lets you consider the best savings opportunities first. Because the inventory also quantifies the demand (or the “how fast”) associated with each load or group of loads, it is invaluable in further interpretation of the demand profile.

Details on the collection of electrical load inventory data and the analysis of those data are discussed in Module 5, Section 5.4.

3.4.7.2 The Thermal Energy-Use Inventory – Identification of Energy Flows

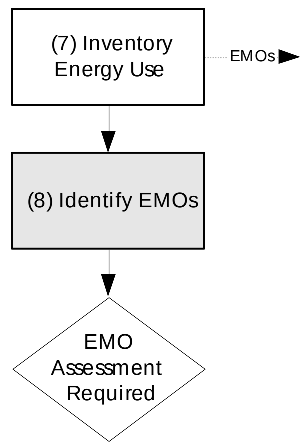
Identification of the thermal energy flows associated with each energy use in a facility is made simple with the use of an energy flow diagram. A useful energy flow diagram will show all energy flows into the facility, all outgoing energy flows from facility to environment, and all important energy flows within the facility.

We saw a sample energy flow diagram in Figure 3.2. Because the purpose of such a diagram is to illustrate energy flows, not to describe a process in detail, the diagram will not generally show the specific devices and equipment that are found in its various subsystem “blocks”. The flows are the important thing here.

The sum of the energy outflows must equal the purchased energy inflows. When we have the complete picture of the important internal energy flows as well as those from and to the surroundings, it is often possible to see opportunities for energy reduction and recovery.

A method for developing an energy flow diagram and finding EMOs is discussed in Section 5.4.

3.4.8 Step 8: Identify energy management opportunities

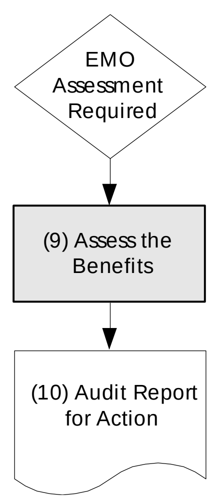


Examination of the audit process flow chart indicates that EMOs are identified at several points:

- At the **walk-through stage**, obvious needs for repair or operational changes that require no further assessment come to light.
- When the facility **Demand Profile** is examined, other opportunities having cost or consumption reduction potential are identified; for example, load shifting opportunities that lower peak demand, or loads that are on when the building is unoccupied, may become apparent.
- The **Load Inventory** quantifies the distribution of energy consumption among building systems, and provides a basis for reconciliation of load with billings; variances in the reconciliation and insight into load distribution can lead to yet more EMOs.

EMOs arising from the walk-through and Demand Profile are addressed elsewhere in this Guidebook. However, much remains to be done in the identification of EMOs, and it is this step in the process that is explored in this section. The intent is to identify potential EMOs and to assess their feasibility and/or cost-effectiveness. The approach described is logical and systematic.

3.4.9 Step 9: Assess the costs and benefits



Having identified a “basket” of EMOs, the auditor needs to provide guidance on the feasibility of measures and recommendations for implementation. To a large extent, the assessment of proposed measures focuses on their cost-benefit.

While detailed economic analysis may go beyond the parameters of the audit, nevertheless the auditor should know:

- What benefits should be taken into account;
- What costs should be included in the analysis;
- What economic indicators provide a realistic projection of the financial viability of a proposed measure over time.

3.4.9.1 A Comprehensive Assessment

A comprehensive assessment of the benefits and cost associated with an energy savings opportunity extends well beyond the cost of the energy involved and in many cases may involve:

Benefits:

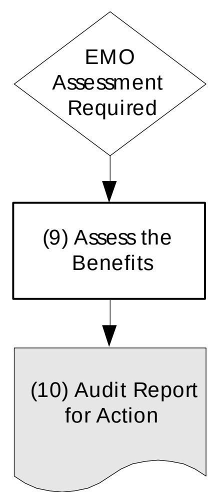
- direct energy savings
- indirect energy savings
- comfort/productivity increases
- operating and maintenance cost reductions
- environmental impact reduction

Costs:

- direct implementation costs
- direct energy costs
- indirect energy costs
- O&M cost increase

These key issues are explored in detail in Section 5.7.

3.4.10 Step 10: Report for action



Regardless of how thoroughly and carefully you conduct the energy audit, and regardless of how beneficial the proposed EMOs are, nothing will be achieved unless action is taken. The link between the audit and action is the audit report.

Too often, audit reports gather dust on someone's shelf. The goal of the Audit Report should be:

- To provide a clear account of the facts upon which your recommendations are made;
- To interest those who read the report in acting upon those recommendations.

There may be a "sales job" to be done on the audit findings, and the report is your vehicle for making the sale.

There are principles of good technical report writing that should be followed, and some of these are included in the guidelines provided in this section. Nevertheless, the auditor should review as necessary his or her technical writing skills, at least to ensure that the use of language is effective, concise and accurate, and that the style of writing is appropriate for the target audience.

Module 8 provides a template for good audit reports, and some suggestions about how to ensure that they lead to action on the audit recommendations.