2 ENERGY AND WASTE ASSESSMENT

2.1. ASSESSMENT METHODOLOGY

There is no single approach toward performing industrial assessments. Each assessing individual will develop personalized techniques to identify potential opportunities and establish the close relationships necessary while determining the needs of the client. Upon agreement of the client's wishes, the assessment team member may then apply the professional techniques in the assessment arsenal to identify dollar saving, energy conserving, and waste minimization opportunities. The assessment does not end with the detailed calculations of the benefits of adapting these strategies, the assessment team member next pitches the ideas to the client using the written report as the gun but clear, concise logic as the ammunition. The selected material presented here outlines some basic rudimentary knowledge which every assessment team member should possess.

2.1.1. Client Selection Based on Industry Type

In the process of getting potential clients, acquisition of preliminary data and an understanding of the industrial process involved in these companies help the industrial assessment team member to get a "foot in the door". Presentations to the client may start with background data already prepared but the data primarily aids in getting the client interested. The selection of a potential client should start with looking at a compiled list of industries which traditionally use a lot of energy or historically are known to be inefficient. Some industrial processes inherently generate a substantial amount of waste and represent good assessment opportunities. Almost all companies provide supporting activities that are essential for the business that are inherently wasteful, as in the necessary evil of product packaging.

Using SIC (Standard Industrial Classification ") code enables us to group industries into certain categories and today we can present lists of potential energy or waste intensive industries.

Assessments in this publication are classified as energy assessments (EA) or industrial assessments (IA). Industrial assessments address both energy and waste issues. It would be rather unusual to provide only a waste assessment but this is not technically impossible.

1. Generally good industrial assessment candidates (waste intensive)
   SIC
   26 - Paper and allied products (with chemical processing)
   27 - Printing and publishing (with ink printing)
   28 - Chemical and allied products
   29 - Petroleum refining and related industries
   34 - Fabricated metal industries (with cleaning, surface finishing)

35 - Industrial machinery (with cleaning, surface finishing)
37 - Transportation equipment (with cleaning, surface finishing)

2. Usually sufficient waste for a successful industrial assessment
   SIC
   20 - Food and kindred products
   22 - Textile mill products (if dyeing is done)
   25 - Furniture (if finishing is done)
   30 - Rubber and miscellaneous plastic products
   31 - Leather and leather products (if tanning is done)
   36 - Electronic and electric equipment (other than assembly)

3. Energy Intensive with Frequently Doubtful Waste Profile
   SIC
   21 - Tobacco products
   23 - Apparel and other textile products
   24 - Lumber and wood products
   32 - Stone, clay, glass, and concrete products
   33 - Primary metal industries
   38 - Instruments and related products
   39 - Miscellaneous manufacturing industries (unless significant solvent use)

Waste Minimization Opportunities " Commonly Applicable to Many Plants

In this section we make an attempt to provide a list of practices which will improve or entirely convert wasteful methods of material handling. Generally speaking, not all the introduced improvements reduce the waste itself, in some cases, the financial aspect prevails.

1. Solid Landfill (Non-Hazardous) Waste:
   ◊ Segregate (paper, cardboard, metals) and recycle
   ◊ Compact for volume reduction disposal cost savings
   ◊ Market wood scrap as fireplace fuel

2. Wastewater
   ◊ Treat (filtration, precipitation, pH neutralization) and reuse in-plant processes for clean-up

3. Contaminated Liquid Cleaning Systems
   ◊ Purify (filtration, distillation) and reuse in plant

4. Evaporative Losses of Water or Solvents
   ◊ Modify equipment or procedures to reduce evaporative losses

5. Compressed Air Oily-Water Condensate
   ◊ Install oil/water separator to reduce disposal costs

2.1.2. Techniques for Use of Information Obtained from Plant Survey

It is beneficial to prepare for the assessment of the plant before the actual visit; this homework really pays off. Most of the work that is outlined below can be conducted over the phone, by fax, and by acquiring copies of pertinent information. Some guidelines for the plant inspection are also included.

1. Conduct an interview prior to the physical inspection; use a questionnaire

2. Follow flow of materials through plant processes

3. Control pace of plant walk-through inspection

4. Prepare material flow diagrams

5. Record questions raised while physically inspecting equipment or processes

6. Initiate discussions with equipment or process operators.

2.1.3. Types of Assessments

It is not unusual to divide all assessments into three basic categories. Energy, waste including pollution prevention (P2) and industrial (both energy and waste). Furthermore waste assessments could be performed for just regular waste or hazardous waste (obviously also for both). Industrial assessments in this text are not compliance audits . It is absolutely essential to make sure that the client understands this, otherwise cooperation dissipates along with the assessment's value.

Start-up Resources - Good Places for Data

EPA website for publications www.epa.gov/epahome/index.html

Pollution Prevention Assessment.
EPA, Facility Pollution Prevention Guide, EPA/600/R-92/088, 1992.

Industry- Specific Guides (Example)
EPA, Guides to Pollution Prevention: The Fabricated Metal Products Industry, EPA/625/7-90/006, 1990.

Process-Specific Guides (Example)

EPA, Guides to Cleaner Technologies Organic Coating Removal, EPA/625/R93/015, 1994.
For industrial and waste *auditing* the regulations are basically the driving force.
In the case of Industrial Assessments, other considerations might be:

- Priorities-Ozone depleting chemicals
- Cost
- Data
- Targeting

2.1.4. Benefits of Industrial Assessments

Assessment team members must realize that the major driving force is money to be saved for the company and not compliance with regulations or perceived salutary benefits. That's not to say that the assessmentor should not try to combine these two aspects; and in practice it works that way.

1. Economic Incentives
   Lowering energy bills (electricity, gas, oil, coal)
   Streamlining the process
   Finding newer and less expensive ways to manufacture

Cost savings due to lowering volume and/or toxicity of wastes can be found in the following areas:

- Disposal fees
- Generator fees/taxes
- Transportation costs
- On-site waste storage and handling
- Pre-disposal treatment
- Permitting, reporting and record keeping
- Emergency preparedness and site clean-up following accidents
- Pollution liability insurance
- Raw supply materials
- Operating and maintenance costs

2. Liabilities
   Cradle-to-grave, meaning that the polluter is forever responsible
   Waste minimization required in the 1984 Hazardous and Solid Wastes Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA)
   At present three formal statutory requirements were enacted as part of the 1984 HSWA amendments: section 3002(a)/6, section 3002(b) and section 3005(h)

3. EPCRA - Community Right-to-Know
   Emergency Reporting
   Toxic Release Inventory (TRI)

Reporting of releases
Reporting of pollution prevention

4. Waste Reduction Laws
   30 States
   Different State Requirements
      Mandatory planning - voluntary
      Implementation
      Mandatory toxins use reduction

5. Develop Benchmarks
   Energy [Btu/Ft2]
   Demand [kW/mo]
   Cost [$/Ft2]

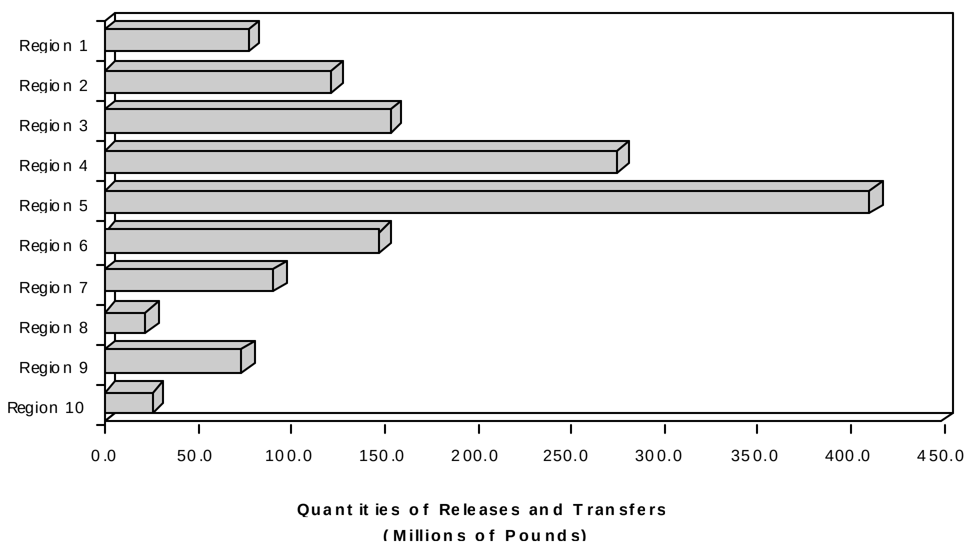

Figure 2.1: Typical Waste Release per Year in EPA Classified Regions

The picture above gives some idea of waste quantities involved in the various regions of the US. The regions were grouped by EPA.

6. Train Facility Staff
   New staff
   Overcome myths
   Introduce new technologies
   "Another set of eyes" (mental blocks)

7. Education On Billing Algorithms

8. Identify Need For Sub-Metering / Data Collection

9. Collect Input For Building Simulation

10. Improve System For Monitoring Performance

11. Confirm Proper Operation Of Equipment & Controls
    As designed
    Review as a complete system
    Confirm suspicions

12. Identify New Potential Conservation & Low Maintenance Options
    Repair
    Upgrades
    New alternatives & ideas

The US DOE's Industrial Assessment Centers, formerly Energy Analysis and Diagnostic Centers, provide technical assistance to manufacturers in reducing energy consumption and minimizing waste. The following summary shows quite clearly that the benefit of an assessment to the customer is undeniable. The numbers were compiled using the program database from the Office of Industrial Productivity and Energy Assessment at Rutgers University. The IAC database tracks energy and waste assessments performed by the major US universities under the Department of Energy (DOE) umbrella.

Summary of Energy, Cost and Environmental Savings
From Industrial Energy Conservation Assessments

Mfrs. Served	5,058
Number of Recommendations	33,980 ECOs
Total Recommended Cost Savings	$210,827,619
Implementation Rate	44%
Avg. Payback Period	1.36 years

Energy Type	Recommended Energy Savings, MMBtu/yr	Recommended Cost Savings, $/yr
Electricity	639,017	11,184,344
Natural Gas	865,927	3,750,278
Other	260,333	1,282,887
Totals	**1,765,277**	**16,217,509**

Energy Type	CO2 Emission Reductions,	CO Emission Reductions,	NOx Emission Reductions,	SO2 Emission Reductions,

	Billion lbs/yr	lbs/yr	lbs/yr	lbs/yr
Electricity	326	51,100	1,044,000	1,077,000
Natural Gas	249	72,600	290,000	1,250
Totals	575	123,700	1,334,000	1,078,250

Note: Air pollutant emission factors provided by the U.S. EPA, Office of Air and Radiation

Waste minimization / pollution prevention aspects of the industrial assessment provide implementation-worthy technical assistance to manufacturers.

Summary of Pollution Prevention and Cost Savings
From Industrial Pollution Prevention Assessments

Manufacturers Served	61
Number of Recommendations	175 WMOs
Total Recommended Cost Savings	$4,134,097
Implementation Rate	58.0%
Avg. Payback Period	1.08 years

Waste Type	Recommended Liquid Waste Reduction	Recommended Solid Waste Reduction
Hazardous Waste	931,998 gals/yr	2,016,905 lbs/yr
Nonhazardous Waste	384,774 gals/yr	31,878,822 lbs/yr
Total	1,316,772 gals/yr	33,895,727 lbs/yr

2.1.5. Assessment Structure

Each industrial different assessment's keeps the assessment team member fresh as it remains impossible to have "seen it all". However, certain tasks repeat and can be planned ahead and development of standard assessment performance methodologies remains good practice. In this section, the individual steps in the process developed from decades of experience are recalled for use as a starting point for a novice assessmentor as well as reference for the old hands.

Major Assessment Tasks

1. Introductory Meeting with Clients
   - Be flexible, solicit cooperation
   - Be friendly but firm - keep interview moving
   - Explain the program/assessment:
     Give background (be brief but thorough)
     Point out cost vs. benefits
     Brief the client on the day's activities
   - Identify any items requested but not obtained prior to the assessment
   - Ask about client's concerns
     Problem areas
     Measurements
     Needs, ideas

2. Plant Tour
   - Follow process flow
   - Ask numerous questions until acquiring full understanding
   - Take notes - if it is not written down, it did not happen
   - Make sure to ask what areas can be accessed and what is off-limits
   - Keep the assessment crew and client together
   - Try to get the tour leader to introduce you to floor supervisors, etc.
   - Afterwards, reiterate your needs and set a time to meet with the management before leaving
   - Inquire if the assessment team needs to be escorted

3. Assessment Recommendation " (AR) Idea Generation
   - Following the tour compile a list of potential ARs
   - Assign the assessment recommendations to the various team members for measurements

4. "The Rest of the Day"
   - Take measurements, collect data, and look for additional ARs. Talk with the plant personnel. Teams should compare notes for internal consistencies among the recommendations.
   - About 30 minutes prior to the scheduled meeting time, attempt to organize plans for the wrap-up meeting.
   - Have wrap-up meeting with the management. Discuss your potential ARs and answer any questions or concerns. Be sure to follow up on the manager's questions or ideas. Inquire about obtaining follow-up data. Discuss reporting requirements.
   - Sort out plans and ideas before leaving site.

2.1.6. Techniques and Tools

Since there is not a recognized unified assessment technique or universally accepted approach to the assessment, it is up to the individual assessmentor to develop his or her own. As a guideline, an example of a typical industrial assessment is provided. This section focuses on tasks which, in our view, are more difficult for an inexperienced assessmentor. Generally, waste related techniques are more difficult to develop and therefore are introduced in more detail. At the same time common sense indicates that there are a lot of commonalties between energy and waste, especially in areas which describe dealing with the client.

Case Study Task Outline

- Preassessment information
- Plant Visit: Waste-related objectives
- Plant visit slide presentation
- Process flow diagram
- Waste stream data
- Brainstorming
- Analysis
- Summary

Preassessment Information

Here is an example of the type of information that should be obtained prior to an industrial assessment.

Type of Products Manufactured:	Telescopic sights, mounts
Types of Wastes Generated:	Coolants, Rinse water, Metal chips
Relevant Data:	Water, Sewer, Sewer/Waste Hauling Bills; Hazardous waste; Manifests

Plant Visit: Waste-Related Objectives

When conducting the waste portion of an industrial assessment it is a good idea to make a checklist of tasks to be performed.

Identify Process Wastes
Identify Current Waste Management Practices
Look for waste-reduction opportunities
Identify key personnel for follow-up interviews

WASTE-RELATED ISSUES

Ask:

- Does this process generate waste? What is it?
- How much is generated? (weekly, yearly) Who has the data?
- How is the waste currently managed?
- What are the waste management costs? Who has the data?
- What waste reduction measures have been tried?

See:

- Raw materials and production areas
- Waste generation and accumulation areas
- Waste treatment and disposal areas

Waste Stream Data

After the waste streams have been determined, specific information is gathered for each.

- Cutting Fluid from Machining

Amount of waste formed:	3,020 gal/yr
Composition:	98% water, 2% concentrate
Disposal:	TSDF blends into cement
Disposal Cost:	$1,360/yr

- Rinse Water from Polishing, Salt Blackening

Amount of waste formed:	90,400 gal/yr
Composition:	Water pH> 7.0
Disposal:	Neutralize with H_2SO_4, sewer
Disposal Cost:	$100/yr

- Metal Chips from Machining

Amount of waste formed:	unknown
Composition:	Aluminum, steel
Disposal:	Drained, collected by metal reclaimer credit
Disposal Cost	Credit

- Acetone from assembly operations
- Amount of waste — 700 gal/yr
- Composition — Acetone Vapor
- Disposal — Evaporates to Atmosphere
- Raw Material Cost — $1,890/yr

Brainstorming: Waste Reduction

After collecting all the relevant data, these waste minimization opportunities were suggested:

- Reduce volume of waste
  - Treat with acid to induce phase separation
  - Dewater by heat addition
  - Implement more aggressive coolant recycling
- Replace flood cooling with spray
- Reduce volume of waste water
  - Treat and recycle rinse water
- Replace acetone with less hazardous cleaner
  - (note: this is Pollution Prevention, not waste reduction)
  - Use Aqueous cleaner
  - Use less hazardous organic solvent

Brainstorming: Other Potential Recommendations

As with any industrial assessment, an energy analysis was also conducted. It resulted in the following Energy Conservation Opportunities.

- Compressed Air
  - Repair eight leaks
  - Reduce tank pressure
  - Use outside air: Door kept open
- Insulate heated caustic and salt blackening tanks
- Replace 81 kW electric annealing oven with gas oven
- Implement PM (Preventive Maintenance) program to reduce oil on shop floor
- Replace TCA vapor degreaser: Done January 1993

Analysis: Acid Treat Waste Cutting Fluid

Add sulfuric acid to induce separation of organic and aqueous phases. Tests indicate that pH 5.5 is optimal. Sewer aqueous phase. Dispose of organic phase in non hazardous waste oil.

Volume of spent cutting fluid = 3,020 gal/yr
Composition: 98% (v/v) water, 2% organic concentrate
Reduction in waste requiring hauling to TSDF:
Waste reduction = (3,020 gal/yr)(1.00-0.02) = 2960 gal/yr
Annual cost savings, S = ($0.45/gal)(2,960 gal/yr)
Annual Cost - [(3,020 gal/yr(1hr/bch)($25/hr)] / (200 gal/bch)
S = $955/yr

Equipment required for implementation: 200 gallon tank
Mixer
pH meter

Implementation cost:	$1,000
Payback period:	($1,000)/($955/yr) = 1.0 yr
Alternative approach:	Dewater with evaporator
Advantage:	Reduce expenditures for labor
Disadvantages:	Three - year payback period
	Possible air pollution problem
	Requires electricity

1 Summary of Assessment Recommendations

Assessment Recommendation	Annual Savings	Implementation Cost	Payback Period
1. Repair Air Leaks	**$7,730/yr**	**$800**	**0.1 yr**
2. Gas Annealing Oven	**$8,330/yr**	**$53,000**	**6.5 yr**
3. Acid Treat Spent Cutting fluid	**$955/yr**	**$1,000**	**1.0 yr**

Additional Measures Considered

It is useful to introduce all ideas, including those which might present just a relatively weak opportunity for an implementation at present time. The economic climate might change and the customer will have the basic information needed.

Replace flood cooling with spray cooling.

- Advantage: Eliminate spent cutting coolant waste stream
- Disadvantage: Higher implementation and operating costs

Replace acetone with less hazardous cleaner

- Advantage: Eliminate a source of solvent air emissions
- Disadvantage: Prolonged drying time for aqueous cleaners

2.1.7. Identification, Selection, Analysis and Write-up of ARs

1. AR Identification
   - Focus attention on the largest and most costly waste streams
   - For each waste stream generate one or more possible AR ideas;
     Use the following ideas sources:

     Consider common-sense approaches to waste reduction (e.g. simple procedural changes)

Review available waste reduction literature
Survey databases
Other sources detailed below

2. AR Selection
    - Include all simple concepts (assured technical feasibility), short payback ARs for relatively significant waste streams
    - Be cautious in selecting measures with highly doubtful technical feasibility
    - In general, select measures with paybacks less than 5 years

3. AR Analysis (See 2.1.8.4 "AR Analysis")

4. AR Write-up

(All items below should be included; the more clear the text the better)

- State current practices and observations
- Recommended action has to be clear, write in plain language
- Estimation of reduction in amount of waste
- Estimation of associated net waste management (and if relevant, energy) cost savings
- Implementation considerations

    Equipment requirements and costs
    Procedural changes
    Payback calculation
    Cautions, if any

5. Example

Develop Record Keeping Systems

- Waste Profiles
- Disposal Plans
- Manifests
- Generation and Disposal Reports
- Training Records
- Inspection Records
- Contingency Plans
- Correspondence
- Assessment Summaries

AR calculation references

General

Thumann, Albert, Handbook of Energy Assessments, Association of Energy Engineers, Atlanta, GA (several editions).

Industrial Market and Energy Management Guide, American Consulting Engineering Council, Research and Management Foundation, 1987.

Energy Conservation Program Guide for Industry and Commerce, NBS Handbook 115 and Supplement, U.S. Department of Commerce and Federal Administration, U.S. Government Printing Office, 1975.
Mark's Handbook of Mechanical Engineering, Baumeister (Ed.), McGraw-Hill, Eight Edition, 1978.

ASHRAE Handbooks, Fundamentals, Systems, Equipment, Application, HVAC and Refrigeration Volumes, American Society of Heating, Refrigeration and Air Conditioning Engineers.

Directory of Software for Energy Managers and Engineering, Association of Energy Engineers, Atlanta GA, 1990.

Boilers

Dyer, David and Glennon Maples, Boiler Efficiency Improvement, Boiler Efficiency Institute, Auburn, Alabama, 1981.

Steam Efficiency Improvement, Boiler Efficiency Institute

Air Compressors

Compressed Air and Gas Data, Ingersoll-Rand Company, 1982

Compressed Air Systems, A Guidebook on Energy and Cost Savings, Varigas Research, Inc., Timonium, MD 1984.

Compressed Air and Gas Handbook, Compressed Air and Gas Institute, New York, New York, Third Edition, 1961.

Sources for Implementation Cost Data

<u>Installation and Labor Costs</u>

Installation and labor costs are of great importance whenever one faces the responsibility of estimating pecuniary aspects of an engineering proposal. It is an indisputable fact that different companies have different overhead costs, therefore similar jobs may not necessarily cost the same. However, it is possible to estimate expenditures for standard tasks typically required in order to accomplish specific projects.

Some typical jobs, such as concrete work, masonry, thermal and moisture insulation, carpentry, plumbing, and variety of electrical installations can be estimated using cost data books. As an example see “Means Building and Construction Data” and “Dodge Unit Cost Data”. These provide standard costs for a great variety of tasks commonly encountered. Prices contained in these books are those that would be incurred by a general contractor. The general contractor’s overhead and markup are not included in any of the prices in these references. Caution must be exercised since no two projects are identical and conditions of work may differ considerably. Special project conditions must be reflected in the simplicity or complexity of work items. The size and scope of work have a significant impact on cost. Economies of scale can reduce costs for larger projects and unit costs can often run higher for small projects.

Since each project is an complex engineering undertaking hiring a consultant experienced in the field is encouraged before any work is to begin. The fees for such services vary from $1500 to $2000/day based on level of expertise and difficulty of the task.

1. MEANS Cost References:
   - Electrical
   - Mechanical
   - Construction
   - Man-hour Standards
   - System Costs

2. Local Wholesale / Retail Supplier Catalogs:
   - Grainger
   - McMaster-Carr
   - Ryall Electric
   - Poudre Valley Air

3. Manufacturer's Representatives (Equipment Costs):
   - Bell and Gossett
   - ITT
   - Conservawatt
   - Kewanee
   - Cleaver Brooks
   - Marley

4. Contractors
   - Sheet Metal
   - HVAC / Mechanical
   - Plumbing

5. Industrial Assessment Database (past assessments)

6. Manufacturer's Data / Cost Catalogs

7. Common Sense In-house Estimates

Software

1. Basic tools:

   Weather Data / Data Extraction
   - Your local Climate Center
   - In-house Energy Billing information
   - In-house Extraction Codes
   - ASHRAE Bin Data

   Billing Data
   - FASER
   - In-house Spreadsheet Program

   Simple Measure Evaluation
   - Spreadsheets / Code
   - Hand Calculations

   Building Simulation
   - Simple Buildings - Modified Bin Program
   - Complex Buildings - Consultant

   Daylighting
   - Simple - SuperLite or Equivalent
   - Complex - Consultant
2. Other assessmenting software:

   Daylighting
   - DOE-2 (LBL)
   - Controlite (LBL)
   - SuperLite (LBL)
   - Daylite (Claude Robbins)

   Billing Data Tracking
   - FASER
   - ENACT
   - Spreadsheet (Lotus, Quatro Pro, Excel, etc.)

Weather Data Manipulation
- Your Local Climate Center
- TMY Data Tapes
- Extraction Code

Database
- FoxPro
- Paradox
- DBase IV
- RBase

2.1.8. Tasks and Data for Energy and Waste Assessments

Elements of an Industrial Assessment

1. Pre-plant visit data collection and review
2. Plant visit
3. Follow-up process information and data request(s), if needed
4. Report preparation

Pre-plant Visit Data Collection and Review

1. Desirability of advance data collection
   - To prepare assessment team to efficiently address plant-specific processes and associated waste streams and energy usage
   - To "get a jump" on waste and energy consumption data collection which is often time-consuming and difficult to complete in plant.

2. Data desired
   - General description of major energy consuming and waste-generating processes
   - Identification of all major types of waste stream releases:
     a) Solid or liquid (other than water) containerized waste streams:
        Hazardous waste: type of waste, lbs (or containers)/yr shipped off site, cost of shipments.
        Non-hazardous solid (landfill) waste: principal components, lbs (or containers) shipped/yr, cost of shipments.

     b) Waste water: process yielding waste water, lbs (or gal)/yr released, sewering costs.

c) Air releases:
   Permitted: nature of release(s), lbs/yr released, cost of replacement chemicals.
   Non-regulated (e.g. water evaporation): lbs/yr, purchase cost of water.

3. Caution
   - Extensive data requests (especially regulated discharges) in advance of plant visit may threaten or otherwise discourage client from continuing with assessment!

Plant Visit Activities

1. Staff Interview
   - Make sure you understand energy usage in the plant and billing schedules involved
   - Ask questions to gain a basic understanding of plant processes yielding waste and to identify point sources of waste generated in plant
   - Obtain approximate quantitative data for major waste streams (amounts and associated costs)
   - Request and review available waste data records (and energy bills if necessary)

2. Inspection of Plant Manufacturing and Support Operations
   - Clarify process details
   - Confirm point sources of waste
   - Clarify causes of waste production and energy consumption
   - Characterize waste handling/processing procedures
   - Generate preliminary AR ideas
   - List areas/processes for which additional quantitative data is needed for later analysis

3. Exit Interview
   - Present list of lacking essential data for follow-up transmittal to you
   - Clarify process details limiting feasibility of brainstormed ARs
   - Present and discuss proposed ARs

Waste Content of Client Energy/Waste Assessment Reports

Following the assessment, a report should be generated for presentation to the client. This assessment report should at least contain the following categories.

1. Disclaimer
   Information presented and recommendations made do not address or guarantee plant compliance with any environmental laws.

2. Executive Summary
   Listing of energy and waste reduction measures recommended

3. Sections Addressing Energy Consuming and Waste Generating Processes
   Energy and waste discussion in process description
   Include process flowsheets indicating point sources of waste streams

4. Section Presenting Summary of Waste Production Rates and Associated Costs

5. Listing of Measures Undertaken Previously by Plant to Manage Waste or Lower Energy Usage (Best Practices)

6. Assessment Recommendations (ARs)

AR Analysis

1. Clearly identify energy-consuming equipment and waste stream(s) associated with recommended measure (e.g. motors, raw waste water or waste water treatment system sludge)

2. Specify current energy usage or waste production rates for considered stream(s); Obtain data from:
   - Energy bills
   - Waste release records
   - Mass balancing
   - Plant personnel estimates
   - Assessment team estimates (e.g. cardboard fraction in landfill waste)

3. Estimate costs associated with waste streams of concern
   - Raw materials replacement costs
   - Estimates of administrative and handling labor costs, if any
   - Release permitting costs, if any
   - Estimates of shipping costs, if any

4. Specify reduction amount for waste stream(s) minimized; obtain reduction amounts from:
   - Case study experience (literature information)
   - Equipment vendor data
   - Estimates of assessment

5. Calculate net cost savings associated with waste reduction amounts; Consider:
   - Recurring costs associated with new waste streams produced, if any
   - New labor costs
   - Operational costs of new equipment

6. Estimate AR implementation cost (one-time capital expenses)
7. Calculate simple payback

§ *Mass Balancing Example*

Spray Painting of Automotive Sideview Mirror Housings

Basic material mass balances (on a unit time basis):

1. Paint:
   Quantity purchased - Quantity stored = Quantity used
   Quantity used = Quantity deposited on parts +
   Quantity disposed as liquid waste +
   Quantity disposed as solid waste
2. Reducer:
   Quantity purchased - Quantity stored = Quantity used
   Quantity used = Quantity evaporated in paint mixing area +
   Quantity evaporated in paint booths +
   Quantity evaporated in paint curing oven +
   Quantity evaporated in clean-up operations +
   Quantity disposed as waste (contaminated) liquid

Waste Management Component Costs

1. Hazardous Waste (solid and liquid)
   a) Raw materials replacement
   b) Administration and record keeping
   c) Materials handling
   d) Pre-treatment on-site, if any
      Chemicals (e.g. acid neutralization)
      Energy (e.g. heating, materials transfer)

2. Air Emissions (vapors and particulates)
   a) Raw materials replacement
   b) Release permitting
   c) Pre-treatment on-site if any
      Materials (e.g. baghouse filters)
      Energy (e.g. incineration)

3. Wastewater
   a) Make-up (replacement) water
   b) Release permitting

c) Pre-treatment on-site, if any
    System components (e.g. filters)
    Chemicals (e.g. pH adjustment)
    Energy (e.g. pumping)
d) Periodic effluent sampling and testing

4. Landfill Waste (Solid)
    a) Raw materials replacement (e.g. paper)
    b) Administration and record keeping
    c) Materials handling
    d) Equipment rental (e.g. dumpsters, compactors)
    e) Hauling

§ *Waste Minimization Example in Minimizing Waste of Tap Water*

<u>Current Practice and Observations</u>

It was noted that tap water was being used to cool the 60 horsepower air compressor by letting it flow freely through the compressor cooling coils. The temperature rise of the cooling water at inlet was 65°F and the exit water temperature was 85°F. The unrestricted flow results in significant waste water. The compressor oil temperature was also found to be 90°F.

<u>Recommended Action</u>

Reduce flow of cooling tap water by installing a gate valve and/or recirculate water through a small cooling tower.

The air compressor specifications indicate that the operating temperature of the oil should be maintained at approximately 150 °F. The free flow of tap water through the cooling passages is wasting water and overcooling the compressor oil.

- *A gate valve (with a hole drilled in the gate of the correct cross section to limit the flow to rate to the minimum acceptable to the manufacturer of the compressor) should be installed.*
- *The hole will guarantee that the cooling water will not be accidentally shut off*
- *The use of a valve rather than a flow restrictor will permit adjustment of the flow rate in the event of line fouling and permit periodic flushing of the line to eliminate scale.*

Additional water savings would be possible by installing a small cooling tower to reject heat from the compressor cooling water and then recirculate it through the compressor cooling lines.

<u>Anticipated Savings</u>

At full load (60 HP) approximately 20% of the energy delivered to the compressor is removed by the cooling water. The flow rate in gallons per hour for a 20°F temperature rise is given by:

$$GPH = \frac{f * HP * CF * GPP}{CP * \Delta T}$$

where:

GPH	=	Gallons of water per hour through the compressor.
HP	=	full load horsepower of the compressor
f	=	the fraction of compressor power lost to cooling water (0.2)
CF	=	the conversion factor (2,545 BTU/HP-hr)
GPP	=	Gallons of water per pound mass (0.12 gallons/lbm)
CP	=	specific heat of water (1 BTU/lbm°F)
ΔT	=	Temperature rise of water through the compressor (20°F)

$$GPH = \frac{0.2 * 60HP * 2545 Btu / hr * 0.12 gal / lbm}{1 Btu / lbm^{0}F * 20^{0}F}$$

It is assumed that allowing the exit water temperature to rise to 145°F will maintain the compressor oil at 150°F. The flow rate can be reduced by (85°F - 65°F) / (145°F -65°F) yielding the flow rate as:

(85°F - 65°F) / (145°F- 65°F)) x 183 GPH = 46 GPH

and the cost savings as:

$$CS = L * HR * CF$$

CS	=	Cost Savings in $/yr
L	=	total water flow reduction rate (183 GPH - 46 GPH = 137 GPH)
HR	=	yearly operating time of the compressed air system (8 hours/day) x (5 days/ week) x (52 weeks/yr) = 2,080 hours/yr
CF	=	Cost of tap water consumption ($18/1000 gallons)

Thus with gate valve flow restrictor:
CS = (137 gal/hr) x (2,080 hrs/yr) x ($0.018/gallon) = $5,129/yr

Cooling tower makeup water is estimated to be no more than 10 gallons per hour for this size unit, thus the cost savings with an installed cooling tower would be:

CS = (183 GPH - 10 GPH x (2,080 hrs/yr) x ($0.018/gallon) = $6,477/yr

Total Annual Savings = $6,477

Implementation

It is estimated the cost of a flow good gate valve will be approximately $20 and it can be installed and drilled by maintenance personnel. Based on the implementation cost and reduction in cost of wasted tap water, the simple payback period for this recommendation is:

($20 implementation cost) / ($5,129/yr savings) = 1.4 days

The implementation cost with a cooling tower is considerably greater. It is estimated to be $7,500 for a five ton packaged unit which would be adequate for this application. Based on this implementation cost and reduction in cost of wasted tap water, the simple payback period for this recommendation is:

($7,500 implementation cost) / ($6,477/yr savings) = 1.2 years.

Simple Payback = 1.2 years

The relatively long payback and complexity involved with the cooling tower may make this approach undesirable. If some other requirement within the plant makes a cooling tower purchase likely this solution should be considered.

2.1.9. Load Calculations and Energy Analysis

For any system that is encountered in the field an assessmentor should perform load calculations to see energy requirements. Given the equipment and/or process demands one can draw a conclusion whether the plant is using too much energy and if that is the case, start analyzing different components for potential savings.

1. POTENTIALLY ACCURATE METHODS
   - Heat balance
   - Weighting factors

2. COMPARATIVE METHODS
   - CLTD and CLF methods
   - BIN methods
   - Modified degree day methods

3. Complicated methods
   - TETD methods
   - 65°F-based degree method

Energy Estimating Methods

<u>Heating</u>

1. Heating Degree Day, EHT

$$E_{HT} = \frac{UA * DD}{h}$$

where

E = heating energy, Btu
UA = design heat load, Btu/°F day
DD = degree days, °F day
η = furnace efficiency

2. Variable Based Degree Days (Vbdd)

   Same, except we use degree days to the base t_b, where

$$t_b = \frac{t_i - Q_{GAIN}}{UA}$$

3. Bin Method

$$E_{HT} = \sum_{BINS} E_i$$

where

E_i = BLC x (t - $t_{o,i}$)

4. Detailed Simulation Methods

<u>Cooling</u>

1. Cooling Degree Day

$$E_{CL} = \frac{24 * BLC * CDD}{COP}$$

where
COP = coefficient of performance
CDD = cooling degree days

2. Bin Method

3. Cltd/Clf Method

4. Tetd/Ta Method

5. Transfer Function Method
6. Heat Balance Method

Procedure for Building Simulation

1. GATHER DATA FROM BUILDING PLANS
   A. Determine appropriate zones
      - Perimeter vs. core
      - Wings
      - Different HVAC systems

   B. Identify wall sections, glazing types
      - i.e., Wood sheathing, 3 1/2” fiberglass insulation, 5/8” dry wall, etc.

   C. Define and size HVAC systems
      - From mechanical plans
      - Flow rates, coil ratings, sometimes controls

2. EVALUATE UTILITY BILLS (ELEC., GAS, WATER)
   A. Break out hot water energy use
      - Iterate fraction of hot water

   B. Break out HVAC use
      - Look for seasonal variation in electricity and gas usage

   C. Evaluate load factor

- Monthly usage / (peak demand x # of hours of operation in a month)

3. INTERVIEW FACILITY STAFF
   A. Obtain schedules for people, equipment, lighting, HVAC equip. control / operation
      - Setpoints and setback times
      - Outside air control (economizer)
      - Supply and exhaust fan schedules
      - Manual override of the system (typically seasonal)

4. SITE VISIT DATA COLLECTION
   A. Note day, outside weather conditions
      - compare to the mode of the system operation.

   B. Use a separate page for each zone: saves time when creating simulation input.
   C. Count lights and equipment
      - Find rating, size, etc.
      - Note how many are operating and time of survey

   D. HVAC SYSTEM OPERATION
      - Fan and coil operation (ON/OFF or variable speed)
      - Outside air damper setting (fixed position, economizer setting)
      - Note placement and setting of thermostats (setback capability)

5. CREATE SIMULATION INPUT FILE
   A. Alter file from similar building
      - Saves time

   B. Write simple input file first
      - Easier to debug
      - Start with components of zone loads

   C. Then add more schedules and complexity

   D. Compare the magnitude of the loads and the load shape with the bills

2.2. ENERGY AND WASTE INSTRUMENTATION FOR ASSESSMENTS

It is important to be able to gather all the information necessary for competent evaluation of energy usage and waste generation. Hardware designed to help data collection is available and should be used. Since manufacturers of measuring equipment constantly strive for better products it is a good practice to keep up with the latest development in the field. Then one is able to make use of state-of-the-art technology to achieve better results in his or her own work.

2.2.1. Equipment List

___1. Thermo Anemometer - *Alnor Model 8255* (Digital)

___2. Velometer - *Alnor* (Analog)

___3. *Amprobe* Ampere Meter (Digital)

___4. *Amprobe* Ampere Meter (Analog)

___5. PWF Meter

___6. Rubber Gloves

___7. Infra Red-Temp Sensor - *Kane May 500*

___8. Temperature Probes/*Flukes* Meters

___9. *Sylvania* Light Meters

___10. Combustion Analyzer - *Kane May 9003* (Silver)

___11. *Enerac* Combustion Eff. Computer - *Model 943* (Blue) and Separate Probe

___12. *Polysonics* - Ultra Sonic Flow Meter

___13. Drill and Bit from ME shop

___14. Safety Glasses, Ear Plugs

___15. Dust Masks

___16. *Amprobe Chart Recorder*

___17. Record of Previous Recommendations

___18. Tool Box (include flashlight, wire brush, rags)

___19. Preassessment Data Sheet

Number of Cases taken to site ___.

2.2.2. Product and Supplier List

Combustion Analyzer

Energy Efficiency Systems 1300 Shames Drive Westbury, NY 11590 (800) 695-3637	Enerac 2000 - $3,000 Pocket 100 - $1,500
Universal Enterprises 5500 South West Arctic Drive Beaverton, OR 97005 (503) 644-9728	KM9003 - $2,000
Goodway Tools Corporation 404 W. Avenue Stanford, CT 06902 (203) 359-4708	ORSAT and EFF-1
Bacharach, Inc. 625 Alpha Drive Pittsburgh, PA 15238 (412) 963-2000	FYRITE II - $695 No CO or Combustibles
Dwyer Instruments, Inc. Highway 212 at 12 P.O. Box 373 Michigan City, IN 46360 (219) 872-9141	
Milton Ray Company Hays-Republic Division 742 East Eighth Street Michigan City, IN 46360	
Burrell Corporation 2223 5th Avenue Pittsburgh, PA 15219	

Amp Probe

Grainger	Analog Amprobe	Digital Amprobe
4885 Paris Street	#RS3 - $100	#3A360 - $350
Denver, CO		
(303) 371-2360		

Cogeneration:

Martin Cogeneration Systems (913) 266-5784
1637 SW 42nd St.
PO Box 1698
Topeka, KS 66601

Waukesha/Dresser
Waukesha Engine Division
Dresser Industries
1000 W St. Paul Ave.
Waukesha, WI 53188

Tecogen Inc.
45 1st Ave.
PO box 9046
Waltham, MA 02254-9046

Stewart and Stevenson, Inc. (713) 457-7519
Gas Turbine Product Division
16415 Jacintoport Blvd.
Houston, TX 77015

Boilers:

Kewanee Boiler Corporation (314) 532-7755
Suite 200
16100 Chesterfield Village Parkway
Chesterfield, MO 63017

Boiler Efficiency Institute
School of Engineering
Auburn University
PO Box 2255
Auburn, AL 36830

(Steam Traps)
Yarway Corporation (312) 668-4800
PO Box 1060
Wheaton, IL 60189

Weben-Jarco Inc.
PO Box 763460
Dallas, TX 75376-3460
Uniluc Manufacturing Company Inc. (416) 851-3981
140 Hanlan Rd.
Woodbridge (Toronto) Ontario, Canada L4L3P6

Waste Heat Recovery:

Beltran Associates, Inc. (516) 921-7900
200 Oak Dr.
Syoset, NY 11791

Therma Stak
1-800-521-6676
Des Champs Labs Inc. (201) 884-1460
Z Duct Energy Recovery Systems
PO Box 440
17 Farinella Dr.
East Hanover, NJ 07936

Pumps:

ITT Bell & Gossett (708) 966-3700
8200 N. Austin Ave.
Morton Grove, IL 60053

Ingersoll Rand

Taco, Inc. (401) 942-8000
1160 Cranston St.
Cranston, RI 02920

Lighting:

Valmont Electric (217) 446-4600
Hunt Electronics
1430 E. Fairchild St.
Danville, IL 61832

The Watt Stopper, Inc. (408) 988-5331
296 Brokaw Rd.
Santa Clara, CA 95050

MagneTek Universal Manufacturing (201) 967-7600
200 Robin Rd.
Paramus, NJ 07652

Philips Lighting Company (908) 563-3000
200 Franklin Square Dr.
PO Box 6800
Somerset, NJ 08875-6800

(Light Controls)
Powerline Communications, Inc. 1-800-262-7521
123 Industrial Ave.
Williston, VT 05495

Conservolite, Inc.
PO Box 215
Oakdale, PA 15071
(412) 787-8800

General Electric

Implementation Costs/Pricing:

RS Means Company Inc. 1-800-334-3509
100 Construction Plaza
PO Box 800
Kingston, MA 02364-0800

Grainger
(Regional Numbers)

General Information:

ASHRAE Handbook of Fundamentals

HVAC:

McQuay - Perfex Inc.
13600 Industrial Park Blvd.
PO Box 1551
Minneapolis, MN 55440

(Hot Water Systems)
Weben Jarco, Inc. 1-800-527-6449
4007 Platinum Way
Dallas, TX 75237

(Evaporative Cooling)
ECCI
PO Box 29734
Dallas, TX 75229
(214) 484-0381

(Chillers)
Carrier Corporation
Syracuse, NY 13221
Trane Company
Clarksville, TN 37040

(Cooling Towers)
The Marley Cooling Tower Company
5800 Foxridge Dr.
Mission, KS 66202 (913) 362-1818

(Radiant Heaters)
Roberts - Gordon Appliance Corporation (716) 852-4400
PO Box 44
1250 William St.
Buffalo, NY 14240

Air Compressors:

Ingersoll Rand Company
5510 77 Center Dr.
PO Box 241154
Charlotte, NC 28224

Gardner-Denver Company

Motors:

GE Company
Motor Business Group
1 River Rd.
Schenectady, NY 12345
Baldor

Variable Speed Drives:

York International (717) 771-7890
Applied Systems
PO Box 1592-361P
York, PA 17405-1592

ABB Industrial Systems, Inc.
Standard Drives Division
88 Marsh Hill Rd.
Orange, CT 06477

Allen Bradley
Drives Division
Ceadarburg, WI 53012-0005

Enercon Data Corporation
7464 W. 78th St.
Minneapolis, MN 55435
(612) 829-1900

Belts:

The Gates Rubber Company (303) 744-1911
990 S. Broadway
PO box 5887
Denver, CO 80217

REFERENCES

1. Thumann, Albert, Handbook of Energy Assessments, Association of Energy Engineers, Atlanta, GA (several editions).
2. Industrial Market and Energy Management Guide, American Consulting Engineering Council, Research and Management Foundation, 1987.
3. Energy Conservation Program Guide for Industry and Commerce, NBS Handbook 115 and Supplement, U.S. Department of Commerce and Federal Administration, U.S. Government Printing Office, 1975.
4. Mark's Handbook of Mechanical Engineering, Baumeister (Ed.), McGraw-Hill, Eight Edition, 1978.
5. ASHRAE Handbooks, Fundamentals, Systems, Equipment, Application, HVAC and Refrigeration Volumes, American Society of Heating, Refrigeration and Air Conditioning Engineers.