3 EVALUATION OF ENERGY AND WASTE COSTS

3.1. FINANCIAL ANALYSIS

Financial analysis of proposed energy projects essentially "sell" the ideas to the client. In today's competitive environment, industry can ill afford starting a project with fiscal uncertainties. This section covers the basics of pre-investment financial breakdowns and performance considerations.

3.1.1. Definitions

Block: A division of billing based on usage. The total block amount of use is divided into blocks of different price per unit of use.

Btu: British thermal unit. It is the amount of energy to raise or lower one pound of water one degree Fahrenheit.

CCF: One hundred cubic feet of gas. (Typically 1 Therm = 1.02 CCF)

Celsius: A metric unit for temperature measurement.

Collector: Panels for collecting and transforming the sun's radiation

Constant: Multiplier used in computing electric meter reading.

Degree Day: The sum of the average outdoor temperature over a short time frame (day). Usually subtracted from 65 used as the heat balance temperature.

Demand: Highest amount of electricity used in a month, measured in Kilowatts (kw). Usually approximated by integrating the consumption over the highest 15-30 minute period during any one month. Power companies must have the generating capacity to meet the demands of their customers during these peak period.

Duty Cycle: Controlled interruption of a piece of equipment that is within its operating band. It is designed to reduce demand, usage and the equipment's life.

Enthalpy: A measure of the energy content of a substance, reflecting both moisture content and temperature.

Fossil Fuel:	Fuel (natural gas, coal, oil etc.) coming from the earth that was formed as a result of decomposition of vegetation or animal matter.
Humidity:	The ratio of water vapor within a given space to the amount of water the air can hold at that temperature and pressure (saturation).
HVAC:	Heating, ventilation and air conditioning.
HVLP:	High Volume Low Pressure. A type of paint gun that uses less paint.
Infiltration:	Air flowing inward through a wall, window, door or a crack., associated with an equal amount of air leaving a structure (exfiltration).
Insulation:	A material having a relatively high resistance to heat flow, principally used to retard the flow of heat. This ability is measured as “R” factor. The higher the factor the higher the ability to insulate.
Interruptible Service:	Large users of electricity or gas who are able to turn off a portion of their use during peak periods are rewarded by lower rates.
Kilowatt:	1000 Watts, unit of power.
Kilowatt Hour:	Unit of electrical power consumption. It is one kilowatt used for one hour.
LP Gas:	Liquid petroleum gas. This fuel is distributed in pressurized cylinders in liquid state and by releasing it is converted into a combustible gas.
Load Scheduling:	A clock programmed by the user to start and stop electric loads on selected days at particular times.
Load Shedding:	A scheduled shutdown of equipment to conserve energy and reduce demand.
Lumen:	A unit for quantitative measure of light.
Make-Up Air:	Air forced into the area equal to the air lost through exhaust vents.
MEK	Methyl Ethyl Ketone, a highly volatile solvent.
Optimum Start:	The load scheduling program, when applied to heating or cooling loads, is modified to follow temperature changes outside the building.
Power Factor:	Ratio between usable power supplied (kW) and reactive power (kVAR) used in inductive loads.

Ratchet:	A utility rate charged to customers based on the peak yearly demand of a facility. The rate is designed to represent the cost to the utility of constructing and maintaining enough capacity to meet that demand.
Service Charge	A fixed fee for providing service from a utility company.
Therm	A unit of heat, equivalent to 100,000 Btu.

3.1.2. Sample Calculation of Savings

Examples of calculations or approaches to a variety of problems are the best tools for learning. This methodology continues here with sample recommendations and calculations.

Energy Conservation

Energy consumption at your plant for the twelve month period from October 1993 through September 1994, consisted of:

4,303,202kWh of electricity (14,684 x 10^6 BTUs)

423,830 Therms of natural gas (42,383 x 10^6 BTUs)

This is equivalent to 57,067 million BTUs of energy. The energy costs for the period were $366,580 with unit energy costs averaging $0.059 per kW for electricity and $0.267 per Therm for natural gas.

The eight assessment recommendations related to energy described in this report, considered independently, could provide a net savings of about $167,868 each year, or about 46% of your total energy usage. However, due to the law of diminishing returns, your actual savings would be less. Our estimated costs for implementing the recommended energy conservation measures translates into an average payback of less than 3.2 years.

#	Energy Assessment Recommendation	Fuel Conserved	Energy Savings BTU x 106	Annual Cost Savings	Payback (Years)
1	Insulate Steam Lines	Natural Gas	385.6	$1,041	1.3
2	Use Synthetic Lubricants	Electricity	264.4	$4,572	-
3	Install Personnel Access Door	Natural Gas	173.4	$463	1.5
4	Replace Compressors with a Gas Unit and Utilize Heat Recovery	Electricity and Natural Gas	505 334	$8,732 $890	1.2
5	Install Piggy Back Motors on Cooling Towers	Electricity	30	$513	1.7
6	Install Air Curtains	Electricity and Natural Gas	125.3 153.1	$2,166 $409	0.36
7	Install Packaged Cogeneration	None	None	$144,532	3.4
8	Install Desuperheater	Natural Gas	1,685	$4,550	2.1

Table 3.1: Energy Assessment Recommendations

Waste Minimization

The one assessment recommendation related to waste described below can save $21,760 with varying paybacks depending upon the type of implementation.

#	**Recommended Measures**	**Waste Stream Components**	**Projected Annual Reduction (gal/yr)**	**Net Cost Savings ($/yr)**	**Payback (Years)**
1	Install Water Treatment Station	Waste Water	None	$21,760	4.2-10.6*

* Depends on the manufacturer price of and features of different systems

Table 3.2: Waste Assessment Recommendation

Example of Incorporation of Waste Information in Process Description

Manufacturing Process Overview

The principal products produced in this plant are shift levers, shift fingers, remote control housings, shift towers, shift rods, clutch relief yokes, and bearing caps. Raw materials for production include several grades of steel, iron and aluminum castings, 5/8" and 2" diameter steel rods and steel tubing.

The castings arrive in cardboard boxes, approximately 75% of which are lined with plastic. Most boxes are banded with either plastic or metal bands. Plastic banding and used cardboard boxes are discarded in the municipal refuse.

To produce the assorted products, the castings are removed from the boxes and are transported by small push carts to the appropriate milling, drilling, tapping and grinding machines. The metal waste from the metalworking operations and metal banding are deposited in a designated trash container and shipped off-site for recycling. Most of the metalworking machines utilize a "wet process" with circulating coolant. Coolant in individual machines is replaced using a "Yellow Bellied Sump Sucker" when the operator of the machine concludes that the coolant is no longer effective. Oil skimmed off coolant reservoirs, along with contaminated hydraulic oil, is pumped into a waste oil containment system, and is hauled off-site in bulk on a monthly basis.

After the castings are machined to specification they are categorized into one of three groups. The first group of parts is washed in a single immersion tank and washer, then removed, allowed to air dry and placed in cardboard boxes. This parts group is subcontracted out for off-site heat treatment, then returned and put in storage or transported to the assembly area. The second group of components is washed in the same manner as the first group, allowed to air dry, then heat treated on-site using a 25kW induction heat-treater, and finally transferred to storage or an assembly areas.

Used transmissions to be remanufactured are usually received in a relatively oily and debris-contaminated condition. Therefore, complete used transmissions are initially placed in a "Storm Vulcan" washer. This high temperature, high-pressure washer thoroughly cleans the transmission exteriors before disassembly. The cleaning solution is changed twice a year, with the entire volume of cleaning solution placed in drums and disposed of as a hazardous waste. This washer produces a waste water stream on the magnitude of eight drums per year. Once the transmissions are disassembled using hand-held air tools, they are remanufactured using new gaskets, original parts in good condition, and new parts produced in the plant to replace broken or worn out parts. Some assembled transmissions are painted and then tested on one of two test stands for normal operation before crating for shipment to customers.

Breakdown of Handling Labor and Record Keeping Costs

Total estimated handling labor costs associated with all waste streams:
($6/hr)(2 workers)(8 hr/day)(5 day/wk)(52 wk/yr) ≅ $25,000/yr
Total estimated handling labor costs associated with all waste streams:
($25/hr)(1 employee)(1 hr/2 wks)(52 week/year) ≅ $ 700/yr

Total estimated handling and record keeping costs: ≅ $25,700/yr

Waste Stream	Quantity Generated Annually (lbs)	Raw Material Replacement Cost	Estimated Handling Labor and Record Keeping Costs*	Off-Site Removal Cost	Total Annual Cost
Waste wood	36,200,000	$0	$269,750	$1,128	$270,878
Toner and Washcoat Overspray	21,364	$22,880	$3,250	$0	$26,130
Toner and Washcoat VOC Evaporation	152,886	$163,730	$3,250	$0	$166,980
Lacquer Overspray	21,346	$14,300	$3,250	$0	$17,550
Lacquer VOC Evaporation	152,866	$102,300	$3,250	$0	$105,550

*Handling labor and record keeping costs have been estimated from experience with other plants

Table 3.3: Total Cost Associated with Waste Streams

Quality Technical Tools for P2

- Pareto Chart: Bar graph to Prioritize data
- Ishikawa Diagram: Cause and Effect of "Fishbone"
- Histogram: Frequency Distribution of Data
- Scatter Diagram: Groupings, Bimodality
- Check Sheet: Tabulation of Results
- Shewhart Control Chart: Analysis of Variation; Control limits
- Stratification of Data

Status	Waste Stream	% of Total Handling Labor and Record Keeping Costs*	Estimated Annual Costs
Landfilled	Waste Wooden pallets	24%	$6,168
	Waste dry glue	1%	$257
	Waste wood (pieces)	6%	$1,542
	Waste cardboard	10%	$2,570
	Paint Overspray	2%	$514
	General landfill trash	6%	$1,542
Recycled	Waste metal banding	1%	$257
Shipped off-site at no cost	Waste wood (sawdust)	50%	$12,850
	Total =	**100% =**	**$25,700**

*Percentages based on estimations by plant personnel and staff experience with other plants.

Table 3.4: Handling Labor and Record Keeping Costs Breakdown

3.1.3. Electric Bills and Rates

The structure of electric bills differ from region to region. Traditionally, utility companies have been regulated by the Public Utility Commission or Public Utility Board of a particular state of operation. Approval was needed for any rate change and was subject to reviews confirming the necessity of such change. The rates reflected the requirement to maintain a sound financial condition of a utility company and also to pay a "reasonable return" to the shareholders. De-regulation of the industry is likely to change these structures forever.

The Electric Bill Components

1. Components Of Your Electric Bill

- Customer Charge
- Demand Charge
- Energy Charge
- Reactive Demand Charge
- Sales Tax

2. What Is Included In The Customer Charge

- Fixed monthly amount
  Designed to recover:
  - Service drop - wires from transformer to connection on building.
  - Meter.
  - Billing, credit and collection and related costs.
  - Customer service - costs to encourage safe, efficient and economical use of electricity.

3. What Is Included In The Demand Charge

   - Generally based on highest 15-minute integrated kW consumption. Sometimes "ratcheted" to represent highest yearly demand.

     Designed to recover:
     - Investments in generating plants.
     - Investments in transmission system - 345,000, 115,000 & 34,500 volt lines and substations.
     - Investments in distribution system - all voltages below 34,500 volts, including distribution transformer.

4. What Is Demand)?

   A. Assume: Fifty (50) - 100 watt light bulbs.
      All 50 bulbs are on at the same time.
      50 bulbs x 100 watts each = 5000 watts
   B. Total Demand (Load) on System:
      5000 watts/1000 = 5 kilowatts (5 kW)

5. What Is Included In The Energy Bill

   - Price per kWh designed to recover:

     - Variable costs to generate electricity
     - Oil costs
     - Nuclear fuel costs

     Varies with voltage levels due to losses

(See Electricity section for an example of a typical electric bill.)

Load Factor is a useful method of determining if the manufacturer is utilizing their energy consuming equipment on a levelized basis, or using the equipment for a short duration, thereby paying a demand penalty. The following figures show examples of different loads, and load factor calculations.

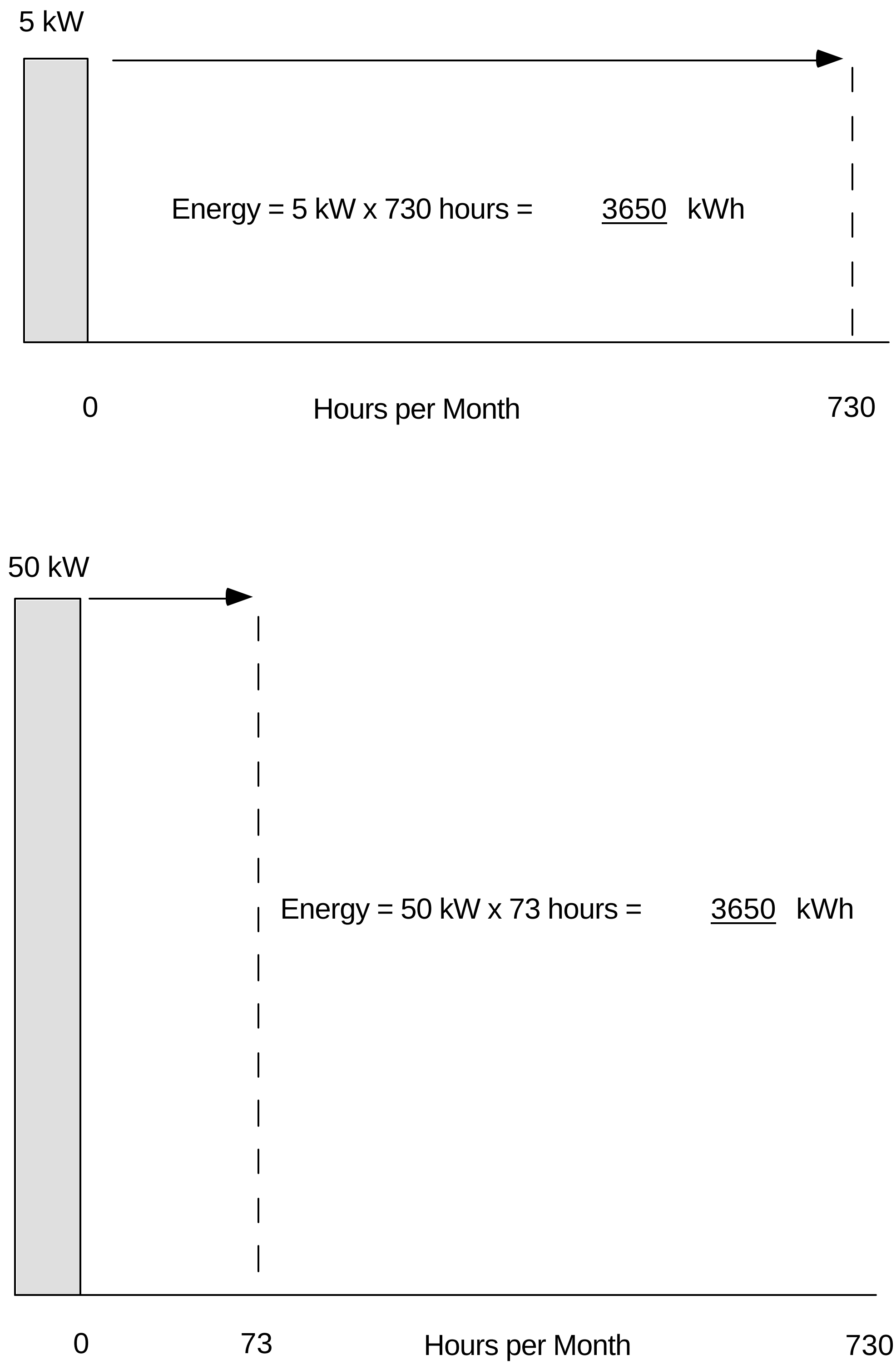


Figure 3.1: Relation of Demand (kW) to Energy (kWh)

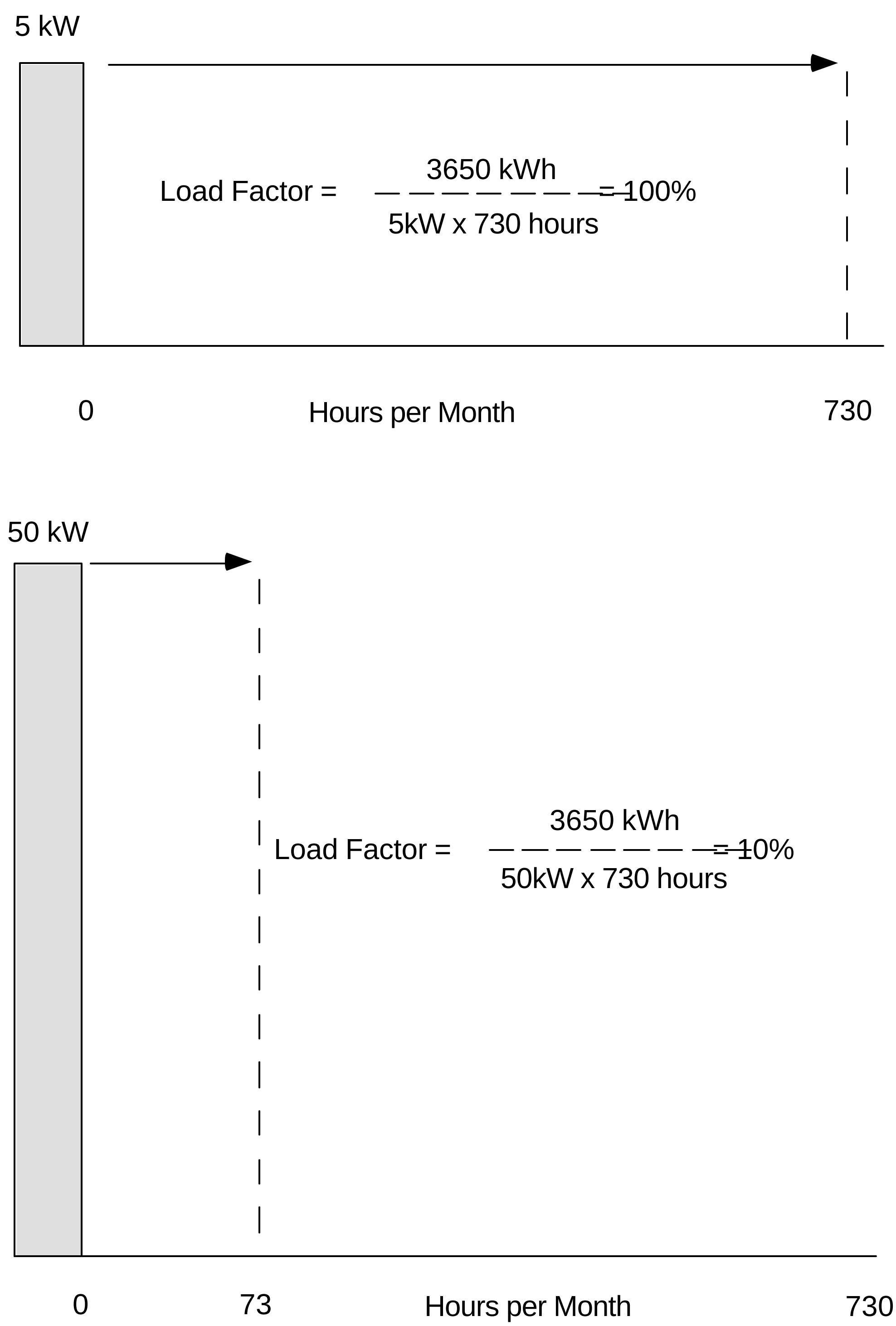
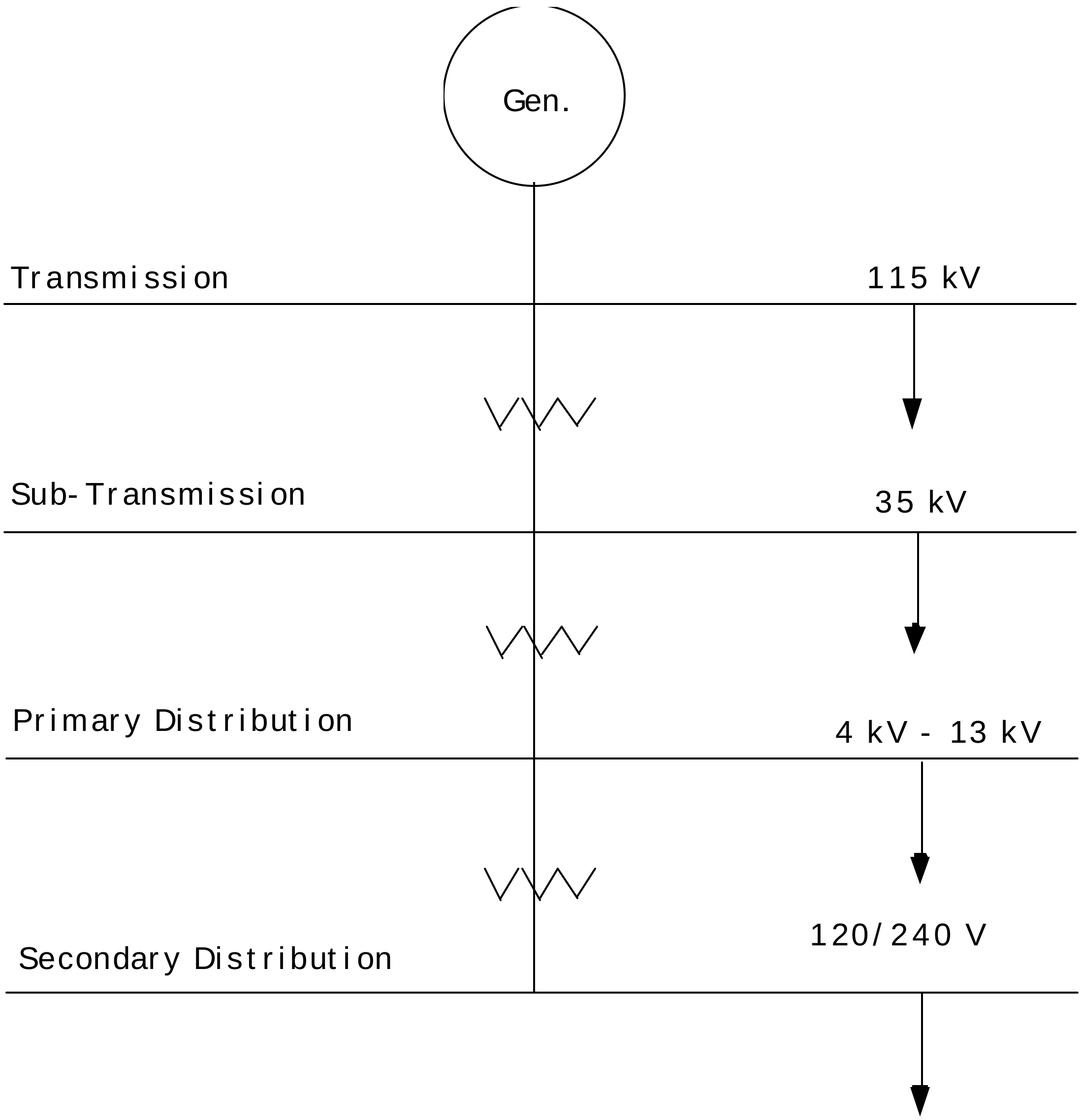


Figure 3.2: Load Factor

Load Factor = kWh used in period / (max kW x hours in period)

Elements of a Utility System



Costs vary with the voltage level.

Figure 3.3: Power Transmission

SOURCES (kWh)	1997	1973
Coal	50 %	45 %
Nuclear	18 %	5 %
Hydro	9 %	14 %
Oil	2 %	17 %
Natural Gas	8 %	18 %
Non-Utility Generators	12 %	n/a
Other	< 1 %	< 1 %
Total	100%	100%

source: Monthly Energy Report

What Is The Reactive Demand Charge?

- An amount per kVAR of reactive demand in excess of 50% of monthly demand (for example, LGS is 50% of first 1,000 kW of monthly on-peak kW demand and 25% of all additional monthly on-peak demand).
- No kVAR billing unless power factor below 90% (higher for customers with demands in excess of 1,000 kW).
- Designed to recover the difference of the cost between real power produced and apparent power consumed.

Sales Tax

- If electricity is used in a manufacturing process, customer can get an exemption for majority of sales taxes. It is advantageous for the community to have the tax incentives in order to preserve or help manufacturing in the area.

3.1.4. Examples of Gas Bills and Gas Rates

Unlike electric charges (discussed in detail in Electricity section), gas utility bills are very simple to read. In the following section a typical example of a monthly gas utility bill is introduced.

Terminology and the Bill

1. The service period on a monthly basis.

2. The rate schedule and terms used.
   Gas company rate are based on the following priority schedule:

- GN-1 is for residential and small industrial users consuming less than 100,00 cubic feet of gas per day.
- GN-2 is for industrial users consuming over 100,000 cubic feet per day and who have standby fuel capability.

3. The actual month's consumption in cubic feet of gas.
   - The billing factor is the actual heat content of the gas (can vary depending on location).
   - The final column is the amount of therms used for the month.
   - Meter units are 100 cu. ft. (i.e., example equals 3,806,000 cu. ft.).

1

Service Period	
06-18-79	07-18-79

Service Address: ____________________

2

Rates	Therms	
GN-1		
GN-2	17,667	
GN-3	22,486	
Total	40,153	$9,760.09

3

Meter Number	Meter Readings Previous	Meter Readings Present	Difference	Billing Factor	Therms
2345678	917920	955980	38060	1,055	40,153

Our hypothetical bill is interpreted as follows:

1.	Gas consumption @ GN-2 rate	= 17,667 therms
2.	Gas consumption @ GN-3 rate	= <u>22,486</u> therms
3.	Total gas consumption	= 40,153 therms
4.	Difference in meter readings	= 3,806,000 cu. ft.
5.	Btu content of gas	= 1,055 Btu/cu. ft.
6.	Amount of therms used per month = (3,806,000 x 1,055) / 1000,000	= <u>40,153</u> therms

1 therm = 100,000 Btu

Actual BTUs consumed = 40,153 x 10^5 Btu

In-Plant Metering

The monthly gas bills show how many Btu's have been expended to produce a product, heat a building, etc. However, the bill does not indicate where the Btu's were used in a particular gas consuming process.

As the nation's energy requirements grow, industry can expect to pay even more for gas in future years. Plants that will remain dependent upon gas for their production processes will be placing even greater emphasis on in-house conservation efforts in order to achieve maximum production efficiency from this increasingly expensive fuel. Cost allocations within departments and fuel surcharges to customers will become commonplace. Close monitoring of allocated supplies will become a necessity in energy management.

The basic and most important tool in energy management is an energy monitoring system. Before energy can be saved, an accurate metering system must be established in the plant to determine exactly how and in what quantities energy is being used; considerable savings can be realized almost immediately from the data derived from an energy audit using in-plant metering. Gas consumption monitoring can also be advantageously used to control oven or furnace temperatures and prevent over-temperature damage.

Measuring fuel consumption alerts maintenance crews to a variety of potential problems such as:

- Leaking fuel lines.
- Faulty temperature measuring devices.
- Faulty relief valves.
- Excessive burner cycling.
- Warped furnace doors.
- Deteriorating furnace insulation.

A relatively low cost monitoring device is the "Annubar". This device is a primary flow sensor designed to produce a differential pressure that is proportional to the flow. The flo-tap annubar can be inserted and removed from operation without system shut down. It can be interfaced with secondary devices, a standard flow meter is available for rate of flow indication. It can also be used as a portable meter or permanently mounted one. Annubar connected to a differential pressure transmitter (electric or pneumatic) is used with a variety of standard secondary equipment for totaling, recording, or controlling complex systems.

3.1.5. Fuel Oil Rates

Fuel oil is supplied by a private contractor. The price is negotiated before the season or period of interest to both parties. The supplier is obligated to provide the oil to the customer for an agreed upon period (typically a year). The price is fixed for an estimated amount of consumption and provides for an adjustment if supplier's costs change during the period. The supplying company might require a minimum purchase, called "allotment", in order to maintain the required service as well as the price. It is noteworthy to point out that some customers may decide to burn more fuel than necessary for the operations just to preserve their pricing.

The normal way of calculating the average cost of oil is simply the total money spent divided by volume purchased.

In the United States three types of fuel are available. The most expensive oil is No. 2, 138 000 Btu/gallon. A little cheaper option is No. 4, 142 000 to 145 000 Btu/gallon and the cheapest is No 6, 149 690 Btu/gallon. It is important to keep in mind that the fuels are not interchangeable because the combustion equipment is designed for only one type of fuel. Different fuels also have to be handled differently, for example No. 6 fuel requires heating to flow. A very detailed information about equipment, characteristics of fuel oils and exact Btu content is available from individual suppliers.

The Fuel-Adjustment Charge

The fuel-adjustment change permits the utility companies to adjust the total cost for producing electricity due to increased fuel costs, without making a request for a rate increase.

3.2. METHODS FOR ENERGY AND WASTE

Energy or waste costs savings can be calculated in many different ways. Which is the most appropriate model sometimes depends on the level of detail desired, tax structure of the state or service charge structures of utility or waste removal company. The proper model has to be carefully selected and an assessment team member must know why a particular method was employed. If simplifications are made, they have to be justifiable.

3.2.1. Estimates of Project Costs

Cost estimates for energy or waste reduction projects do not differ much from any other cost estimates for engineering projects. The regular cost estimating procedures will prove adequate. The usual way of employing standard engineering data, using available catalogues or books (Means Construction Cost Data or Dodge Unit Cost Data for example), obtaining estimates from contractors and manufacturers or recommended consulting firms are all legitimate means for getting the information necessary to make a qualified decision about an energy or waste savings measure.

A detailed flowchart of activities involved and bill of materials required is the best starting point. The more detail provided before beginning the work the better chance for success for the whole enterprise. If the project is not well defined, flexibility must be allowed for contingencies and unexpected complications. Also, contractors can be much more specific thus more realistic with their proposals. Not negligible is the fact that the cost can by also better tracked by the customer.

One of the most important factors during the proposal process clearly lies in the ability to demonstrate the benefit of proposed changes. Characteristically, the most important revelation lies in an attractive rate of return, return on investment or simple payback period. Fiscal data gathered and presented must represent reasonable forecasts of the cause and effect relationship from implementing energy, waste or production recommendations. Accurate forecasts, however, are not easy to come by but may be reasonably defended if the typical data calculations include ratios, percentages and logically estimated values as in the case of price projections. The assessor is urged to exercise extreme caution when prognosticating fluctuations in inflation, material and labor costs while calculating implementation values. While difficult for persons new to on site industrial assessments, experience provides valuable educational lessons as confidence grows during these excursions by the engineer into the financial world.

3.2.2. Payback Periods

As with most company decisions, an energy project's feasibility will be evaluated in conjunction with its financial impact. Payback period calculation provides a quick feasibility analysis and for that reason occupies status known as "common practice". More sophisticated analysis should be employed if either greater detail requirements indicate or the assessor believes simple payback to be inadequate for decision making under particular circumstances.

Waste Minimization AR Write-Up Example for Cardboard Recycling

<u>Current Practice and Observations</u>

A substantial amount of corrugated cardboard is generated by packaging of incoming raw-materials, supplies, and other parts used in the manufacturing process. Cardboard waste is not currently being segregated and recycled. It is disposed with other solid waste and hauled to the municipal landfill. The estimated amount of cardboard generated at this facility is 15% of the total solid trash volume. This estimate is based on observation of the dumpsters. The annual volume of trash hauled to the landfill is about 4,000 cubic yards per year as determined from the trash bills. The bills also indicate a unit disposal cost of $2 per cubic yard.

<u>Recommended Action</u>

A recycling program for corrugated cardboard should be implemented. Segregate the cardboard into a separate dumpster and deliver it to a recycling center.

<u>Anticipated Savings</u>

The annual solid waste volume reduction and the estimated annual solid waste savings are calculated as follows:

$$SWRV = PC \times CTV$$
$$SWS = SWRV \times UCD$$

where:

SWS	=	Solid waste savings, \$/yr
PC	=	percent of solid waste which is cardboard, 15% (estimated)
CTV	=	Current annual solid waste volume, 4,000 yd3/yr
UCD	=	Unit cost of solid waste disposal, 2 \$/yd^3.
SWRV	=	Solid Waste Volume Reduction, yd^3/yr

$$SWRV = 0.15 \times 4{,}000 \text{ yd}^3/\text{yr} = 600 \text{ yd}^3/\text{yr}$$
$$SWS = 600 \text{ yd}^3/\text{yr} \times 2 \text{ \$/yd}^3 = \$1{,}200/\text{yr}$$

<u>Implementation</u>

The cost of recycling the cardboard is based on discussions with a waste management company. The cost to haul one 30 cubic yard dumpster to a recycling center, dump it, and return the dumpster is estimated as $165 per trip. The recycling center pays about $55 per ton of cardboard and a 30 cubic yard dumpster holds about 3 tons of cardboard if the boxes are broken down flat. The cost of hauling is thus equal to the recycle credit. The only other requirement is that plant personnel responsible for solid waste removal to the dumpster must be trained to separate out the cardboard and break down the boxes.

There is no associated implementation cost and the payback is immediate.

<u>Simple Payback = immediate</u>

3.2.3. Methods for Financing Conservation Projects

Energy conservation and pollution prevention projects, as with all projects proposed, indicate analysis requirements pertaining to cost and financial implications. Company management as a matter of course determine a set of parameters or benchmarks which have to be met for project approval. Upon passing the initial hurdle (perhaps by achieving the simple payback goals), projects move to the next tier and subjection to further scrutiny along with other plans up for adoption for ranking in order of greatest financial potential.

Capital Budget

Probably the most common form of financing conservation, minimization or prevention projects requires a charge to the company's capital budget. These projects compete equally with other pending projects for available funds. Project acceptance occurs when the defined set of financial indicators (typically financial ratios) falls in line with corporate policy. Financial return examination requires a most advantageous outlook but, if found acceptable, project funding through capital budgeting risks little more than the original principal. The best possible cash flow continues as there is no repayment of loans and no future obligation of capital. If the project fails to achieve the expected goals, the company may suffer slightly in profit/loss accounting but only for the year of the cash outlay. Subsequent years' profits remain unaffected.

Leveraged Purchase

Borrowing money = maximum risk incurred = paying later for current expenditures = corporate debt secured from banks or other financial institutions. Maximum risk because the loan security equals the financial credit of the borrower. Less than expected return requires the money be made up from corporate resources for the entire term of the debt. Indebtedness must be reported on financial statements and the company benefits from limited tax advantages as only the loan interest is tax-deductible.

Leasing

An energy or waste project can be leased instead of being purchased. The simplest way is just in the form of a rental. A lessee pays a lessor an agreed upon sum of money for the use of the project. The savings should, of course, exceed the rent and therefore the lessee experiences a positive cash flow. The leasing does not have full tax deduction.

Shared Savings

An energy service company supplies, installs and maintains the energy project for which it shares project's savings with the client. There is no cash investment on part of the buyer, no maintenance cost associated with the project and the positive cash flow is immediate. There is a tax advantage in this scenario.

3.2.4. Comprehensive Simulated Assessment

- Client Selection: Waste-Related Issues (if industrial assessment)
- Energy and Waste-Related Information and Data
- Process Flow Diagram
- Preparations for Plant Visit
- Brainstorming: Ideas, Data Needed
- Analysis

- Assessment Recommendations

Client Selection: Waste-Related Issues

Hazardous Waste:	How much is generated?
Generator Status:	What are the costs?
Current Waste	Storage
Activities:	Treatment
	Disposal
	Tracking and Reporting
In-House Expertise:	Most small plants have part-time hazardous waste part-time person
Potential for Successful	
Outcome:	Client's motivation regarding pollution prevention policy measures
	Already tried/implemented involvement with production
	Specific problems/concerns relationship with regulators, access to facilities, data
Educational:	Quality of learning experience

Energy and Waste Related Information and Data

Products:	Coated metal and plastic parts
Electrical and Gas Bills	app. $100,000/yr
Raw Materials:	Paints, Coating, Solvents, Reagents, Parts
Wastes:	610,000 gal/yr Waste Water
	660 gal/yr MEK (Haz)
	40 gal/yr Paint Wastes (Haz)
	1,290 lb/yr Solvent Air Emissions
	300 lb/yr Paint Booth Filters
Waste Costs:	Approximately $15,000/yr
Already Implemented:	One HVLP Paint Gun
	Flow Reducers Flowing Rinses

Preparations for Plant Visit

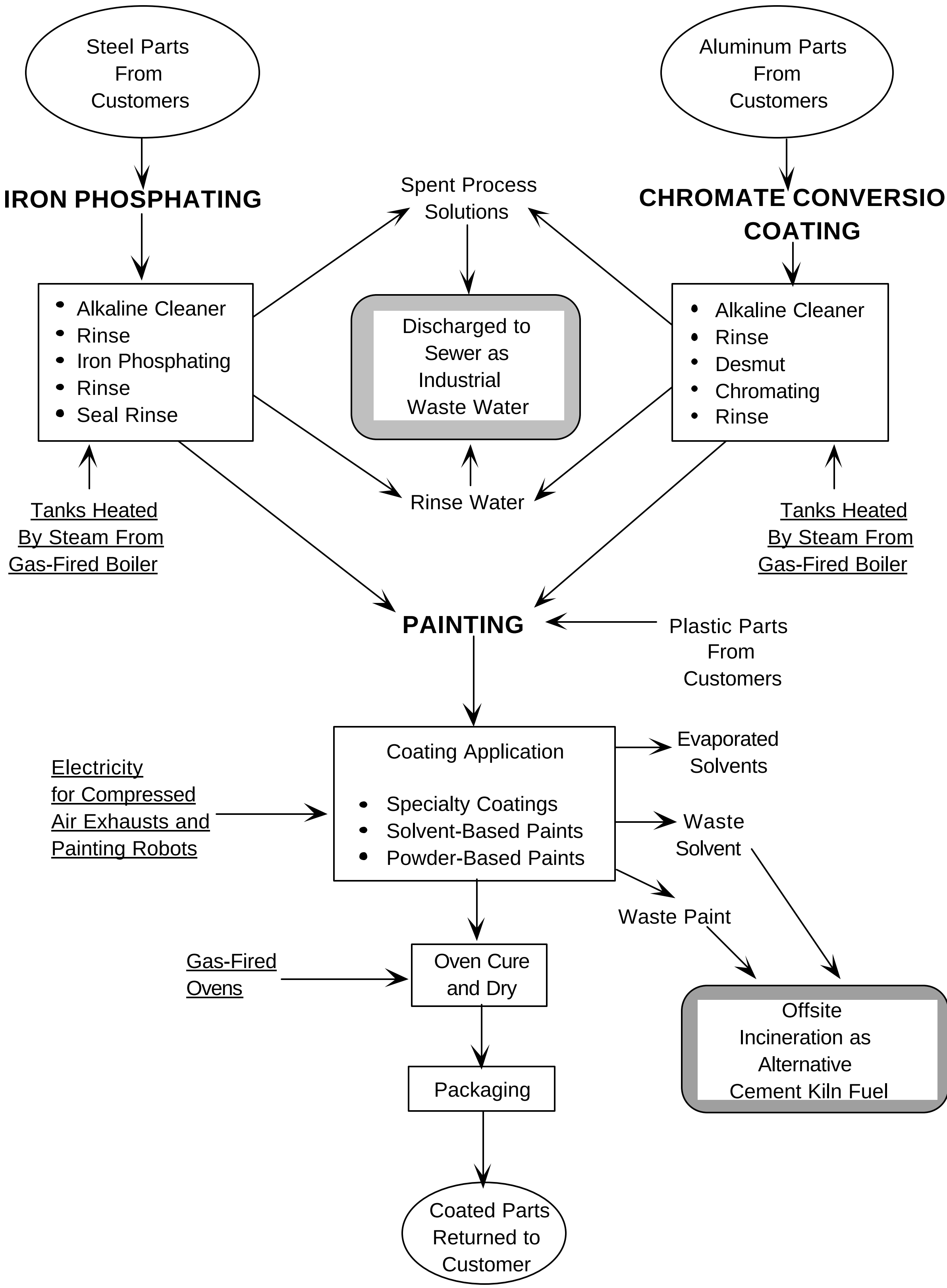
- Request: Electric bills, water and sewer bills, gas bills, hazardous waste manifests and invoices, paint and solvent purchase records POTW agreement.

- Personnel:

	John A	Group Leader
John B	Group Leader Assistant	
	John C	Team Member
	John D	Team Member
	John E	Team Member

- Review: Paint application technology safe solvent product files iron phosphating process chromate conversion process enclosed paint gun washer file solvent recovery unit file.
- Discuss: Safety issues, equipment needs.

Process Flow Diagram



Brainstorming: Energy and Waste Reduction

IDEA	DATA
Use Energy Efficient Lights	Manufacturer's data
Insulate Steam Pipes	Calculations and manufacturer's data
Adjust Boiler Air/fuel Ratio	Measurements
HVLP Paint Guns	Paint consumption, costs
Solvent Recovery Unit	Spent solvent volume, Purchase and disposal costs
Replace MEK	Spent MEK volume, Purchase, Disposal, Replacement costs
Reduce Dragout	Observation of line operations, Estimates for dragout volumes Invoices for Reagent amounts and costs
Reduce Water Consumption	Water and sewer bills, determine locations for additional flow regulation, Interviews

Analysis of Waste Recommendations

HVLP Paint Guns

Replace five conventional paint guns with higher transfer efficiency HVLP paint guns. Paint transfer efficiency improves from 30% to 55%

PR = Reduction in paint consumed = 80 gal/yr
MR = Reduction in mixing materials consumed = 30 gal/yr
UPC = Average Paint Cost = $35.60/gal
UMC = Average Mixing Material Cost = $26.90/gal
PFS = Paint Booth Filter Savings = $1,450/yr

Savings = S = (PR)(UPC) + (MR)(UMC) + PFS

S = (80)(35.60) + (30)(16.90) + 1,450

S= $4,805/yr

Implementation Cost: $400/HVLP Paint Gun

IC = (5)(400) = $2,000 Payback = 2,000/4,805 = 0.42 yr

Solvent Recovery Unit

Distill and reuse parts cleaning solvent, MEK. The recovery factor for a commercial, 15 gal unit is 75%.

- Current waste generation and costs

  Volume spent MEK currently generated = 660 gal/yr
  PC = MEK purchase cost = $3.15/gal
  DC = Waste MEK disposal cost = $3.63 gal
  CAC = Current annual costs = (660)(3.15 + 3.63)
  CAC = $4,475

- Projected costs with solvent recovery unit

  NB = Number of batches = 660/15 = 44/yr
  CW = Cooling water required = 4,620 gal/yr
  WC = Water cost = $10/yr
  EC = Electrical cost = $40/yr
  LC = Labor cost = $550/yr
  LNC = Boiler liner cost = $132/yr
  SBDC = Still bottoms disposal cost increment = $2.91/gal
  EPC = Equipment purchase cost = $6,700
  EIC = Equipment installation cost
  WPC = Waste Profile cost

  OC = Annual operating cost = 10 + 40 + 550 + 132 +480
  OC = $1,212/yr
- Annual Savings

  S = (0.75)(4,475) - 1,212 = $2,144/yr

- Implementation Costs

IC = 6,700 + 200 + 300 = $7,200

- Simple Payback Period

P = IC/S = 7,200/2,144 = 3.4 yr

Replace MEK for Cleaning Parts

Replace MEK with a less hazardous parts cleaning solvent. The replacement is a hydrocarbon blend with lower vapor pressure and higher flash point. A dedicated parts cleaning appliance will be required. Periodic solvent addition and recharging will be needed.

- Current Waste Generation and Costs

Volume of spent MEK currently generated = 660 gal/yr
MEK purchase cost = $3.15/gal
Waste MEK disposal cost = $3.63/gal

- Projected Annual Costs

Dragout, evaporation, and annual 5 gal recharge:
(est. 0.25 gal/mo)(12 mo/yr) + 5 gal/yr = 8 gal/yr
(8 gal/yr)($19.60/yr) = $157/yr

- Raw Material Savings
RMS = (660)(3.15) - 157 = $1,922/yr

- Waste Disposal Savings
WDS = (660)(3.63) = $2,396/yr

- Total Savings

S = RMS +WDS = 1,922 + 2,396 = $4,318/yr

- Implementation

30 gal UNIT: $1,300 Freight: $150
Installation $1,200

IC = Implementation cost = 1,300 + 1,200 + 150 = $2,650
Simple Payback Period = 2,650/4,318 = 0.6 yr (7.3 mo)

Summary of Assessment Recommendations

ASSESSMENT RECOMMENDATION	**ANNUAL SAVINGS**	**IMPLEMENTATION COST**	**PAYBACK PERIOD**
1. Efficient lighting	$3,480/yr	$3,320	1.0 yr
2. Insulate steam pipes	$270	$270	1.0 yr
3. Adjust boiler a/f	$220/yr	$750	3.4 yr
ASSESSMENT RECOMMENDATION	ANNUAL SAVINGS	IMPLEMENTATION COST	PAYBACK PERIOD
4. HVLP paint guns	$4,805/yr	$2,000	0.4 yr
5. Solvent recovery unit	$2,144/yr	$7,200	3.4yr
6. Replace MEK	$4,318/yr	$1,450	0.3 yr

Additional Measure Considered

Install enclosed paint gun cleaning unit.

Advantage: Reduce solvent consumption
Disadvantage: 8.3 payback period

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