ENERGY

ENERGY MANAGEMENT FOR THE FEED INDUSTRY

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AFIA
American Feed Industry Association

AUGUST 2014

Acknowledgement

Much of the information provided in this workbook was taken from several workshops, seminars and publications attended or read by the original author, Allen C. Merritt. Most of the information, especially specific examples of Energy Conservation Opportunities, was excerpted directly from ENERGY CONSERVATION PROGRAM GUIDE FOR INDUSTRY AND COMMERICE [EPIC], NBS Handbook 115 [Sept. 1974] and Supplements. In addition, considerable contribution to this book came from the previous AFIA energy management workbook complied by the AFIA Energy Committee.

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INTRODUCTION

Energy, its utilization and conservation, may be the greatest challenge facing management in the feed industry today and in the years ahead. All forms of energy are increasing in cost and diminishing in supply; yet effective energy management, or conservation, can reduce the cost impact and make better use of available energy supplies.

As energy is used more effectively, product costs can be reduced and profits improved. This can be accomplished even in the face of sharply increasing energy costs. Since industrial energy consumption accounts for approximately one third of the total energy used in the U.S., significant contributions can be made in the national effort to reduce energy consumption with industrial participation.

There is ample opportunity to reduce energy use and lower electricity costs given the extensive use of electric energy at every manufacturing facility-form powering motors that drive pumps, fans compressors, hydraulic equipment, conveyors, etc. to lighting, HAVAC systems, office equipment and the water coolers. Although the efficiency of how electricity is used varies from application to application, there is room for improving energy use in all cases; these improvements are typically cost-effective and are achieved with a short payback period and many times even for free.

According to the U.S. Department of Energy, the average cost of electricity for the industrial users in the U.S. has increased by almost 35 percent in the last 10 years and is projected to remain high.

Why should you consider improving energy efficiency in your facility?

- Improve your bottom line;
- Increase productivity and market competitiveness;
- Lessen the impact and protect your business from fluctuations in energy prices; and
- Reduce carbon emissions and stay ahead of government regulations.

Those feed mills and companies that conserve energy now will help insure their future survival, reduce their manufacturing costs and enhance their profits.

On the following pages, an energy management plan is outlined as an ongoing effort on the part of the American Feed Industry Association to serve the energy needs of the feed industry.

CHAPTER 1: ENERGY, GOVERNMENT AND AFIA

The U.S. government has taken a very visible role in industry's energy management program. The amount of energy consumed, the energy source, the building design, the methods of sales and production and distribution, are all affected by government regulations concerning energy.

It is impossible to list and explain all energy regulations that affect the feed industry; however, previous regulations, which influence energy management decisions and future policies, are briefly discussed.

The Federal Energy Administration Act of 1974 requires all persons owning or operating a major energy consuming facility to make available to the DOE information regarding energy efficiency improvement.

The **energy policy of the U.S.** is determined by federal, state and local entities in the U.S., which address issues of energy production, distribution and consumption, such as building codes and gas mileage standards. Energy policy may include legislation, international treaties, subsidies and incentives to investment, guidelines for energy conservation, taxation and other public policy techniques.

The **Energy Policy and Conservation Act** of 1975 (EPCA) is a United States Act of Congress that responded to the 1973 oil crisis by creating a comprehensive approach to federal energy policy. The primary goals of EPCA are to increase energy production and supply, reduce energy demand, provide energy efficiency and give the executive branch additional powers to respond to disruptions in energy supply.[

The feed industry is recognized under the National American Industry Classification Standards NAICS code 311119.

The U.S. industry covers establishments primarily engaged in manufacturing animal food (the cat and dog industry is recognized under the National American Industry Classification Standards NAICS code 311119) from ingredients, such as grains, oilseed mill products and meat products.

Table 1. Heating Values Conversion Factors for Various Energy Sources

Energy Source	Conversion Factor (BTUS/energy unit)
Electricity	3,412/kwh
Natural Gas	1,020/cu. Ft.
Bituminous Coal	22,565,000/short ton
Propane LPG	91,620/gal.
LPG	95,500/gal.
Distillate Fuel oil (Including Diesel)	138,690/gal.
Residual Fuel Oil	149,690/gal.

To calculate energy efficiency, the British Thermal Units consumed are divided by the units of production (tons, ft., lbs., etc.). The current energy efficiency is compared to the base year to determine energy efficiency improvement.

The EPCA allows corporations to report their energy efficiency improvement through a reporting sponsor, thereby maintaining their anonymity. DOE requests all corporations (those under one trillion BTUs) to voluntarily report their energy efficiency improvement through a reporting sponsor.

AFIA is a reporting sponsor and does report to DOE for many companies, both identified and voluntary.

Future energy regulations will continue to have a strong influence over the feed industry. All feed manufacturers should remain aware of current energy policies that may affect business operations.

CHAPTER 2: ORGANIZING AN ENERGY MANAGEMENT PROGRAM

All forms of energy are increasing in cost. Reports on the availability of energy resources indicate most supplies are decreasing. As a result, a major new stress in business management has surfaced; however, energy is one item in the world of business problems, which is very susceptible to management techniques.

The task of energy management can be subdivided into five elements: planning, organizing, staffing, directing and controlling. These elements are as applicable and important in small businesses as they are in large corporations. The energy planning function is comprised of defining the conservation objectives, establishing energy policies and standards, and developing the plans needed to insure accomplishment of the objectives. Organizing consists of providing a structure capable of achieving the established energy objectives. The staffing element defines the manpower requirements of the program, selection of individuals to carry out the program, and training and developing these individuals to perform their duties effectively and in accordance with the program objectives. It also includes the allocation of sufficient time to perform energy conservation tasks. Directing encompasses the influencing of all employees to achieve their cooperation in the accomplishment of the established objectives. The controlling element encompasses the setting of energy use standards, monitoring progress toward the achievement of the energy program's objectives, and taking corrective action where and when necessary.

Energy conservation, as a management tool, can reduce both energy use and cost. If the feed mill management demonstrates a distinct and enthusiastic commitment to energy conservation, the employees at all levels of the organization will work toward such a commitment. Thus, those feed manufacturers who conserve energy will help to insure their future by reducing their costs and improving their profits. In addition, if by conservation, production can be maintained in spite of fuel curtailment, the sales and profit advantage over competition is made obvious.

Management Commitment

The most important item in an energy program is top management commitment; however, a meaningful energy program may require changes in capital investment criteria, changes in production methods, changes in formulation, improved maintenance practices and much more. The recognition, acceptance and initiation of these changes must begin with top management, who must also understand that the rewards of the energy program will be proportional to the effort put into it. Top management must recognize that energy conservation is compatible with other business objectives and is a necessary element of sound business planning.

Energy planning is initiated with the establishment of a conservation goal. Such a goal is essential since it is a measure of top management's commitment to energy efficiency. The goal should be carefully considered, practically attainable and revised from time to time as the conservation program matures. AFIA believes a 15 percent reduction in energy consumption per unit of production over a feed mill's base year data is readily attainable. Once top management has committed to energy conservation, this commitment must be communicated to all employees, as employee cooperation is required for a successful energy program. This communication must take place through words as well as actions. The feed Mill Manager should inform all employees of his commitment, the direction of the company toward energy conservation, and that his representative, the Energy Coordinator, is due all consideration and cooperation. A sample memorandum, which serves as a sample of one way to communicate these points to employees, is illustrated on page 5.

Management Organization

A basic principle of management is that to meet an objective, someone needs to be clearly responsible. Thus, to achieve the energy objectives, an Energy Coordinator must be appointed. His role will be to develop conservation plans, recommend energy use improvements and establish communication channels between departments, employees and himself, to disseminate energy information, and to tabulate and evaluate energy conservation results. A new slot on the organization chart will not necessarily be required; the coordinator may be selected from the existing staff. In the selection process, it should be remembered that conservation goals and plans must be carried out through line management personnel with the assistance of staff. Therefore, in many feed mills, the coordinator may well be the Mill Manager, but in multi-plant companies, a new position may be required. In any event, the commitment to energy conservation by the coordinator will require that sufficient time be spent to accomplish the program objectives and impact overall energy use at the mill.

The Energy Coordinator will require engineering and other technical skills or assistance to determine the feasibility of energy saving opportunities. Plus, financial analysis to determine the cost effectiveness of specific projects will be needed. Small mills may be forced to retain outside consultants to assist the coordinator. In time, the Energy Coordinator will recommend operation, maintenance, process changes and expenditures to meet the conservation objectives.

These recommendations must be carried out by line management personnel. As a result, contributions from many people will be required for the success of the energy program. In most cases, capital will also be required, and the Mill Manager must recognize that these resources must be committed to meet the goal.

To assist the Energy Coordinator, the Mill Manager may appoint a plant energy committee comprised of people representing various functions within the mill, i.e., engineering, maintenance, traffic, production, accounting, etc. This group should meet on a predetermined schedule to review the status of the energy program and establish ways to improve it, to promote employee energy awareness, to monitor energy use, to evaluate energy conservation opportunities and to determine corrective actions when deviations from established standards, or the overall energy program, are detected.

Employee Involvement

Motivation and communication are the key elements to employee involvement in the energy management program. Such involvement is essential to the success of the program. The Energy Coordinator should prepare a program to inform and involve each employee. This program may extend to employee's in-home activities, since a BTU saved at home should be used to keep a mill in operation. The employee program should encompass awareness of the need for energy conservation, cooperation in the mill's energy program, mill management's commitment to the program, a suggestion program for energy improvements, the need for employee cooperation relative to the success of the mill's energy program and encouragement of energy saving ideas. Information for such programs can be obtained from the DOE, U.S. Department of Commerce or the local utility company.

Energy Use Controls

All personnel involved in the energy management program must be involved in controlling energy use. The process used to accomplish control involves the establishment of performance standards, measurement of performance against the standards, identification of deviations from the standards and implementation of corrective action.

An effective control system will insure that the plans forming the system basis are complete and understood by all energy management team personnel. In addition, the system must clearly delineate responsibility for executing the energy plans and control processes.

The purpose of the control process is to ensure that the energy management program progresses as planned. A number of control techniques can be employed. Examples of individual techniques include:

- Personal monitoring of facilities and equipment;
- Energy budgeting;
- Total energy use accounting;
- Energy ratio monitoring;
- Standard cost accounting;
- Energy conservation activity reports; or
- Capital budget allocation for energy projects.

Contingency Planning

Since energy emergencies are no longer a novelty and have been occurring with increasing frequency, contingency planning should be an integral part of the energy management program. The objective of such planning is to cope with such an energy emergency while maintaining production at the highest practical level and to guard against the economic impact of the emergency.

Contingency plans should be developed for each energy type used by the mill and should recognize the inter-relationship of these energy types, i.e., alternate fuels. The plans should detail the steps to be taken during an energy emergency and should include provisions for coordination with the energy supplier to produce timely energy availability forecasts. The plans should be well publicized among management and supervisory personnel to insure familiarity with required actions, and should specify responsibility for the plan's implementation and execution.

March 4, 2013

From:
To: All Employees
SUBJE Energy Management Program

Television, radio and newspapers are filled with reports on the energy shortages. This problem has implications far beyond the inconvenience we experience at our local gasoline service stations. This energy problem has a potentially serious impact on American industry, including the ECONERGY Feed Company.

Not only are the costs of purchasing electricity and fuels soaring but the availability of our vital raw materials is declining as a result of the energy shortages. To avoid production disruptions which may result from these shortages, we are initiating an Energy Management Program (EMP) to identify and eliminate inefficient, unnecessary or wasteful uses of energy throughout the mill.

To accomplish this task, I have appointed Mr. J. C. Feed, Production Department, to head the Energy Conservation Committee. This committee will formulate a program which will enable us to reduce our energy consumption without disruption to our production. The support and active participation of every employee is essential if we are to achieve our goal of 15 percent savings in energy use this year.

You will soon be seeing posters that say "savEnergy." This is more than a catchy slogan; it is a reminder that energy will always be available at home and at work if we are careful in the ways we use it.

Sample Memorandum

ECONERGY FEED COMPANY EMPLOYEE BULLETIN

CHAPTER 3: HOW TO CALCULATE ENERGY REQUIREMENTS BY SYSTEM

Cost Centers

For many years the cost center concept has been used in feed manufacturing plants for cost analysis. It is also a convenient method for identifying energy usage and costs by function, system or cost center.

Receiving Cost Center

The receiving cost center begins with ingredients (raw materials) and supplies on the mill rail siding or in trucks in the plant yard. The cost center ends as the raw materials and supplies are at their first place of rest in storage bins, tanks (liquids) or in the receiving warehouse.

Work in this cost center includes the receiving, handling and storing of all incoming raw materials and supplies. In the receiving cost center, the likely energy uses would include the following:

<u>Electricity</u>

- Electric motors - conveyors, elevators, cleaners (scalpers), dust collectors, distributors, car pullers, front end loaders, etc.
- Lighting - exterior lighting in receiving area(s) and interior lighting
- Battery operated forklift trucks

<u>Boiler Fuels (natural gas, fuel oil, coal, etc.)</u>

- Steam, or hot water, heating of liquid tanks and for heating tank railcars or trucks

<u>Vehicle Fuels (diesel fuel, gasoline, propane, gasohol, etc.)</u>

- Front end loaders (Bobcats), forklift trucks, company operated railcar movers (track mobiles)

Processing Cost Center

The processing cost center begins with grain or other ingredients to be processed, in primary storage. The cost center ends as the processed ingredients are in place, either in mixer bins or in processed ingredient storage bins.

Work in this cost center includes grinding, rolling (or crimping), cracking, re-cleaning and the movement of grain and other ingredients to and from the processing equipment. In the processing cost center, the energy usages would likely include:

<u>Electricity</u>

- Electric motors – conveyors, elevators, distributors, feeders, grain cleaners, grinders, roller mills, etc.
- Lighting in processing areas

<u>Boiler Fuels</u>

- Steam for steam rolling, flaking or crimping
- Space heating in the processing area

Mixing Cost Center

The mixing cost center begins at the point of storage in bins, tanks or warehouses of the materials to be used in feed mixing. The cost center ends after mixed feeds are placed in holding bins ahead of the next cost center—pelleting or blocking, packaging or bulk feed load out.

Work in this cost center includes the movement of all raw materials into the cost center, the weighing or metering of macro and micro ingredients, opening and dumping bagged ingredients, premixing and the actual mixing of feeds.

In the mixing center, the energy usages would include the following:

<u>Electricity</u>

- Electric motors – conveyors, elevators, distributors, feeders, liquid pumps, mixers, blenders, etc.
- Lighting in the mixing areas
- Electro wrap tracing of liquids lines
- Electric (battery charged) forklift trucks

<u>Boiler Fuels</u>

- Steam, or hot water, tracing of liquids lines and/or heating of liquids work tanks
- Space heating in the mixing areas

<u>Vehicle Fuels</u>

- Forklift trucks and, possibly, front end loaders if used to charge mixers

Pelleting (Blocking or Extruding) Cost Center

This cost center begins with mixed feed in holding bins ahead of the pellet mill(s), blocker or extruder. The cost center ends as pellets, crumbles or extruded (expanded) products are deposited in holding bins at the packing station, in bulk load out bins or in mixer bins for those products, which include these products as an ingredient, i.e., textured feeds. In the case of blocking, the cost center ends as blocks are delivered to the wrapping and/or palletizing station.

Work in this cost center includes the operation of all pelleting, blocking or extruding system equipment.

In this cost center, the energy usages include the following:

<u>Electricity</u>

- Electric motors – conveyors, elevators, distributors, feeders, pellet mills, blockers, extruders, coolers or dryers, crumble rolls, shakers, fat addition devices, liquids pumps, etc.
- Lighting in the pelleting, blocking, extruding areas
- Electro wrap tracing of liquids lines

<u>Boiler Fuels</u>

- Steam conditioning of mash for pelleting or extruding.
- Dryers for extruded (expanded) products
- Steam, or hot water, tracing of liquids lines and/or heating of liquids work tanks

(Note: For energy usage and cost analysis, the pelleting, blocking and extruding systems should be handled as separate entities, or cost centers.)

Packaging Cost Center

The packaging cost center begins with the feed (meal, pellets, etc.) in the packing bins or in the holding bins over the molasses mixer for textured feeds. For blocks, it begins with the block at the wrapping or palletizing station. The cost center ends after filled bags (or wrapped blocks) have been placed in the finished product warehouse.

Work in this cost center includes weighing, packaging and closing of finished packaged feeds. It also includes transportation of packaging supplies (bags, twine, etc.) from storage to the packaging station and transportation of finished products to the warehouse.

In the packaging cost center, the energy usages include the following:

<u>Electricity</u>

- Electric motors – feeders, packers, bag conveyors, closing equipment, molasses blender, liquid pumps, turntables, palletizers, etc.
- Lighting in the packaging and palletizing areas
- Electric forklift trucks

<u>Boiler Fuel</u>

- Space heating in the packaging areas
- Steam or hot water, tracing of liquid lines and/or heating of liquid work tanks

<u>Vehicle Fuel</u>

- Forklift trucks

Warehousing and Loading (Finished, Packaged Products) Cost Center

The warehousing and loading cost center begins with finished, packaged feed at the first place of rest in the warehouse. The cost center ends as the railcars or trucks are loaded and ready for departure from the mill.

Work in this cost center includes all movement of finished, packaged products (including non-manufactured products) within the warehouse and the loading of rail cars and trucks. Any re-sacking of materials from broken bags is also included.

In the warehousing cost center, the energy uses would be:

<u>Electricity</u>

- Lighting in the warehouse and loading areas
- Electric forklift trucks

- Electric motors- rebagging equipment
- Stretch or shrink wrap equipment, if used

Boiler Fuels
- Space heating in the warehouse

Vehicle Fuels
- Forklift trucks

Bulk Load Out Cost Center

The bulk load out cost center begins with finished, bulk feed in bins ahead of the bulk railcar or bulk truck loading operation. The cost center ends as the railcars or trucks are loaded and ready for departure from the mill.

Work in this cost center includes the loading and weighing of feed into the transport vehicle.

In the bulk load out cost center, the energy usages are:

Electricity
- Lighting in the bulk load out area
- Electric motors- conveyors and elevators, shakers, liquid application equipment (blenders and liquid pumps), etc.
- Electro wrap tracing of liquids lines

Boiler Fuel
- Space (office) heating
- Steam, or hot water, tracing of liquids lines and/or heating of work tanks

Vehicle Fuel
- Yard tractor for moving bulk feed trailers

Plant Services

This is not, specifically, a cost center in the usual sense of the term; but energy is used to provide services to the various cost centers. These potential energy uses include the following:

Maintenance Shop and Compressor
- Electricity
  - Power tools, welders and fabrication equipment
  - Lighting in the maintenance areas
  - Air compressor motor
  - Electrical portable hoists, etc.
- Boiler Fuel
  - Space heating in the maintenance areas

Office and Laboratory
- Electricity
  - Lighting in the offices and laboratory
  - Office and laboratory equipment
  - Air conditioning
  - Boiler Fuel
  - Space heating in the offices and laboratory

Electricity

Having identified the costs centers, or systems, of the feed mill, the next step in calculating energy requirements is to determine the amount of electricity used in each. This may be done by adding the horsepower of the individual electric motors of the systems to determine total connected horsepower.

For example, a pelleting cost center might include the electric motors listed in Table 3.

Assuming an average throughput of ten (1) tons per hour for this system, there are several calculations that can be made. These calculations are shown on the following page.

Table 2: Example of Connected Motor Horsepower in a Pelleting System

Driven Unit	Motor Horsepower
Feeder Conveyor	1.0
Mash Conditioner	7.5
Pellet Mill	200.0
Centri-Feeder	3.0
Cooler (Horizontal)	1.0
Cooler Fan	50.0
Airlock	0.75
Crumble Rolls	20.0
Bucket Elevator	5.0
Shaker	3.0
Distributor	0.25
Pellet Coater w/ Pump	5.75
Conveyor	2.0
Distributor	0.25
Total Connected Motor Horsepower	299.5

Energy Calculations

1. Kilowatt hours (kwh) per operating hour or per ton

$$\frac{\text{Connected HP x 0.7455*}}{\text{tons/hr}} = \frac{\text{kwh/hr.}}{\text{tons/hr.}} = \text{kwh/ton}$$

$$\frac{299.5 \text{ x } 0.7455}{10} = \frac{223.28}{10} = 22.328 \text{ kwh/ton}$$

* 1 horsepower hour = 0.7455 kwh

2. Cost of electricity per hour or per ton

$$\frac{\text{kwh x cost/kwh}}{\text{tons/hr.}} = \frac{\text{cost per hour}}{\text{tons/hr.}} = \text{cost/ton}$$

$$\frac{223.28 \text{ x } 0.07 = \$15.63/\text{ton}}{10 \qquad\qquad 10} = \$1.56/\text{ton}$$

3. BTU usage per hour or per ton

$$\frac{\text{kwh/hr. x 3412**}}{\text{tons/hr}} = \frac{\text{BTUs/hr.}}{\text{tons/hr}} = \text{BTUs/ton}$$

$$\frac{223.28 \text{ x } 3412}{10} = \frac{761,831}{10} = 76,183 \text{ BTUs/ton}$$

** 1 kwh = 3412 BTU

These examples provide information regarding the usage and cost of electricity in a specific cost center; however, they do not include lighting or a pro rata share of electricity used in the service departments.

Briggs[3] states that "Feed mills use… 1 kwh per ton (or finished product) for lighting, etc." Using this rule of thumb, a pro rata share of 1 kwh (or 3412 BTU) per ton should be assigned to each cost center.

The distribution of this cost, or usage, becomes subjective but should be allocated to the cost centers to determine the total cost of usage or electricity within each cost center or system.

Boiler Fuel

Calculating the boiler fuel requirements by cost center, or system, is the next step in determining total energy requirements. Except for space heating, the cost centers likely to require steam are listed in Table 4.

The amount of steam required in a feed mill will vary according to several factors: the product mix, general climatic conditions, and the condition of the steam generator and steam distribution system.

Table 3: Steam Requirements by Cost Center

Cost Center	Probable Use of Steam
Receiving	Liquids tank heating, tank car heating
Processing	Steam rolling, flaking, crimping
Mixing	Liquids lines tracing, work tank heating
Pelleting	Mash conditioning, liquid lines tracing, work tank heating
Packaging	Liquids lines tracing, work tank heating
Bulk Load Out	Liquids lines tracing, work tank heating

For live steam applications, such as pellet mash conditioning and grain conditioning prior to steam rolling, the boiler horsepower required can be determined by knowing the percent moisture added to the product by steam and the pounds per hour throughput.

4. Boiler Horsepower $= \dfrac{F \text{ x } M}{0.83 \text{ x } 34.5}$

F = Pounds of feed per hour
M = Percent of moisture to be added by steam

In our example of a pelleting system with an average throughput of 10 tons per hour, assuming a 5 percent moisture addition to the mash, the required boiler horsepower would be:

$$\text{Boiler HP} = \frac{20,000 \text{ x } .05}{0.83 \text{ x } 34.5} = 34.9 \text{ HP}$$

Thus, at least 35 boiler horsepower will be required for the process of pelleting. A boiler of this size will evaporate 1,207.5 pounds of water per hour and will use approximately 10.5 gallons of #2 fuel oil per hour or 1.470 BTU of natural gas*.

*1 gallon of # fuel oil = 138,690 BTU
1 cu. ft. of natural gas = 1,035 BTU

The calculations for the cost of boiler fuel for pelleting are shown below.

#2 Fuel Oil:

$$\frac{\text{Gallons/hr. x cost/gal}}{\text{tons/hr.}} = \text{cost/ton}$$

$$\frac{10.5 \text{ x } \$3.50}{10} = \$3.67\text{/ton}$$

Natural Gas:

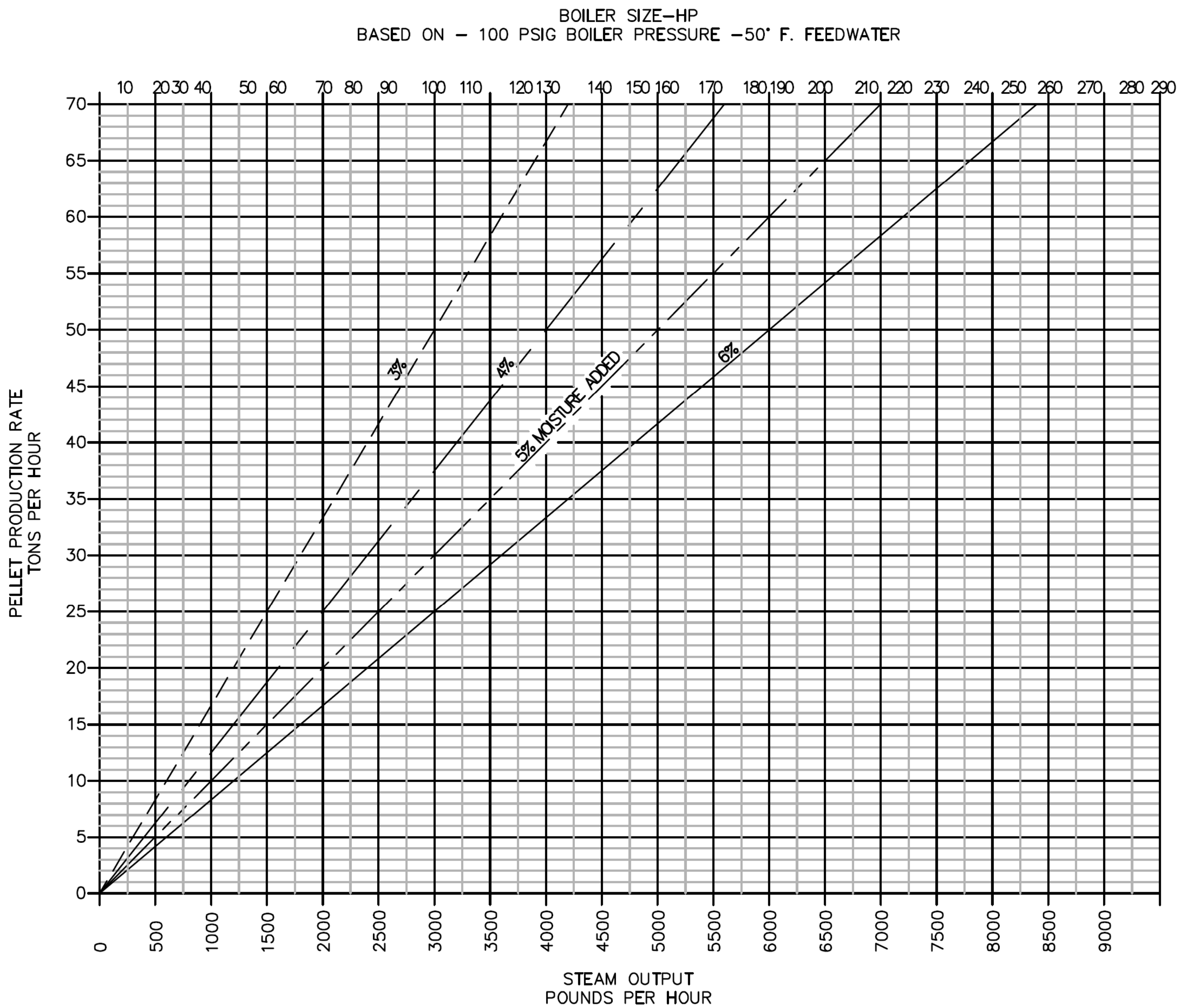
$$\frac{\text{Million BTU (MBTU) x Cost/MBTU}}{10} = \text{Cost/ton}$$

$$\frac{1.470 \text{ x } \$3.00}{10} = \$0.44\text{/ton}$$

To determine the BTU requirement, or usage, divide the BTUs/hr by the tons/hr.

$$\frac{1{,}470{,}000}{10} = 147{,}000 \text{ BTU/ton}$$

Figure 1: Boiler Size and Pellet Production



Boiler Requirements Based on Pellet Production and Moisture Addition

For closed system applications, such as liquids tank heating, the boiler horsepower, fuel costs and usage, or BTUs, are not so easily calculated. There are so many variables that each application must be calculated based on specific conditions. Some of the more obvious variables include: the temperature of the liquid as received (which in itself will vary from load-to-load); ambient temperatures; the quality of tank insulation; how heat is to be applied (exterior or interior coils); etc. For example, a Minnesota feed manufacturer may assume that it will require 15 boiler horsepower to heat a 20,000 gallon tallow tank and keep it heated to 110°F; while a feed manufacturer in Florida may use very little or no steam to heat its fat tank.

There is no well-defined standard for determining the boiler horsepower required for tank heating, space heating and other miscellaneous uses of steam in a feed mill; however, an accepted rule-of-thumb would be to oversize the boiler by 25 percent to 30 percent after such identifiable steam requirements as pelleting and steam rolling are adequately covered. As an example, a feed mill with a 200 HP pellet mill and a 36" steam roller mill may require a boiler sized as follows in Table 5.

Table 4: Boiler Sizing

Steam Use	HP	Approx. BTU/hr.
Pelleting @ 10t/hr.	35	1,470,000
Steam Rolling @ 8t/hr.	30	1,260,000
Tank, space heating, etc.	25	1,050,000
Total	90	3,780,000

If the total finished feed output of this mill averages 30 tons per hour, the expected BTU/ton and cost of boiler fuel (natural gas) would be:

$\frac{3,780,000}{30}$ = 126,000 BTU/ton or \$0.38/ton @ \$3.00/MBTU

In actual practice, the determination of boiler fuel usage, costs and BTUs would be based on actual fuel usage and actual tonnage manufactured on a monthly or periodic basis.

Vehicle Fuels

This amount of energy is easier to determine than either electricity or boiler fuels. It's a simple matter to measure and record the amount of fuel consumed by each forklift, Bobcat or any other vehicle used in the manufacturing process.

Table 5: Energy in Vehicle Fuels

Fuel	BTUs/Gallon *
Gasoline	124,950
Diesel Fuel	138,690
LPG	95,500
Gasohol (10% Ethyl Alcohol)	121,157

*Note: These are conversion rates. You should check with your suppliers, and if their products differ from the average, use their conversion rates. LPG, for example, is particularly variable.

As nearly as possible, the use of vehicle fuels should be assigned to the cost center in which the vehicle is used. Some vehicles are dedicated to a specific system or cost center, and should cause no allocation problem. Other vehicles, such as a forklift truck used in several cost centers, should have its fuel usage prorated based on approximate hours used in each cost center.

Total Energy Requirements

Accurate knowledge of energy usage and costs in the various processes, systems or cost centers, as well as in the total feed mill, is a usual management tool and essential to an effective energy management program.

Table 7 shows a simulated analysis of monthly energy usage and costs in a full line feed mill producing 10,000 tons per month. Such an analysis is not suggested on a monthly basis, but should be performed periodically to identify energy usage and costs in order to take such actions as are necessary to conserve energy.

Table 6: Analysis of Monthly Energy Cost and Usage- Typical Full Line Feed Mill (Simulated)

		Electricity (a)			Boiler Fuels (c)			Vehicle Fuels (d)			Total Energy		
Cost Center	Tons	KWH (b)	Cost @ 0.07/ kwh$	BTU (000)	Cubic Ft. (Nat. Gas)	Cost @ 3.00/ MBTU $	BTU (000)	Gallon s	Cost @ 4.20/ gal. $	BTU (000)	Cost $	BTU (000)	% of Total Energy
I Receiving:													
Per Month	1000	15750	$1103	53739	122000	$379	126000	117	$491	16244	$1973	195983	7.39
Per Ton		1.6	.11	5.4	12.2	.38	12.6	.01	.49	1.6	1.97	19.6	
II Processing:													
Grinding													
Per Month	2000	43000	3010	146160	-	-	-	-	-	-	3010	146160	5.51
Per Ton		21.5	1.51	73.4	-	-	-	-	-	-	1.51	73.4	
Cracking													
Per Month	500	2530	177	8632	-	-	-	-	-	-	177	8632	0.33
Per Ton		5.1	.35	17.3	-	-	-	-	-	-	.35	17.3	
Steam Rolling													
Per Month	2000	35800	2506	122150	487000	1512	504000	-	-	-	4018	626150	23.61
Per Ton		17.9	1.25	61.1	243.5	.76	252	-	-	-	2.01	313.1	
Total Processing													
Per Month	4500	81330	5693	277498	487000	1512	504000	-	-	-	7205	780942	29.45
Per Ton		18.1	1.27	61.7	108.2	.34	112	-	-	-	1.60	173.5	
III Mixing:													
Batch Mixing													
Per Month	8000	25000	1750	85300	31956	99	33075	158	662	21867	2511	140242	5.29
Per Ton		3.1	.22	10.7	4.0	.01	4.1	.02	.08	2.7	.31	17.5	
Cont (dairy) Mixing													
Per Month	4000	4228	296	14426	31956	99	33075	-	-	-	395	47501	1.79
Per Ton		1.1	.07	3.6	8.0	.02	8.3	-	-	-	.10	11.9	
Total Mixing													
Per Month	12000	29228	2046	99726	63912	198	66150	158	662	21867	2906	187743	7.08
Per Ton		2.4	.17	8.3	5.3	.02	5.5	.013	.05	1.3	.24	15.6	
IV Pelleting:													
Per Month	6000	134968	9448	460511	730435	2268	756000	-	-	-	11716	1216511	45.87
Per Ton		22.5	1.57	76.8	121.7	.38	126	-	-	-	1.95	202.8	
V Packaging:													
Per Month	3000	9328	653	31827	63913	198	66150	158	662	21867	1513	119844	4.52
Per Ton		3.1	.22	10.6	21.3	.07	22.1	.05	.22	7.3	.50	39.9	
VI Warehousing & Loading:													
Per Month	3000	3500	245	11942	31956	99	33075	315	1324	43733	1668	88750	3.35
Per Ton		1.2	.08	4.0	10.7	.03	11.0	.105	.44	14.6	.56	29.6	
VII Bulk Loadout:													
Per Month	7000	8577	600	29265	31956	99	33075	-	-	-	699	62340	2.34
Per Ton		1.2	.09	4.2	4.5	.01	4.7	-	-	-	.10	8.9	
III Total Plant:													
Per Month	10000	282681	$19788	964508	1531737	$4756	1584450	746	$3135	103531	$27680	2652113	100.00
Per Ton		28.27	$1.98	96.45	153.17	$0.48	158.45	.07	$0.32	10.37	$2.77	265.21	

(a) Lighting and plant services electrical usage (1 kwh/t) prorated as follows:

Cost Center-System		Kilowatt hours/month
1. Receiving		750
2. Processing		
a. Grinding	400	
b. Cracking	200	
c. Steam Rolling	400	
d. Total Processing		1000
3. Mixing		
a. Batch Mixing	1000	
b. Continuous Mixing	500	
c. Total Mixing		1500
4. Pelleting		1500
5. Packing		1000
6. Warehouse & Load Out		3500
7. Bulk Load Out		750
8. Total @ 1 KWH/ton manufactured		10,000 KWH

(b) Connected motor horsepower by system, or cost center, is estimated as follows:

Cost Center – System		Connected Motor Horsepower
1. Receiving		60
2. Processing:		
a. Grinding	160	
b. Cracking	25	
c. Steam Rolling	190	
d. Total Processing		375
3. Mixing:		
a. Batch Mixing	120	
b. Continuous Mixing	50	
c. Total Mixing		170
4. Pelleting		170
5. Packaging		299
6. Warehouse/Load Out		0
7. Bulk Load Out		30
8. Total Plant Connected Motor HP		1,104

(c) The boiler is sized 25 HP beyond the known steam requirements (steam rolling and pelleting) to provide tank heating, space hating, etc. Allocation of these boiler horsepower are as follows:

Cost Center-System		Boiler HP
1. Receiving		10
2. Mixing		
a. Batch	2.5	
b. Continuous	2.5	
c. Total Mixing		5
3. Packaging		5
4. Warehouse/Loading		2.5
5. Bulk Load Out		2.5
6. Total		25

(d) For simplicity, the assumption is made that all forklift trucks and frontend loaders are fueled with gasoline. Vehicle hours chargeable to the cost centers are estimated at:

Cost Center	Vehicle Hours/Month
Receiving	65*
Mixing	175
Packaging	175
Warehouse/Load Out	350

*20% (200 T.)Received using Bobcat @ 30T/hr.

CHAPTER 4: AFIA FEED INDUSTRY ENERGY AUDIT

The AFIA has developed an energy audit for the feed industry. The audit is to be used as a tool in the total energy management program. The audit is designed to assist management in determining what specific areas or processes consume the most energy and which ones offer the most potential saving in energy consumption.

The Feed Industry Energy Audit must be conducted by qualified personnel. A plant manager along with a maintenance supervisor or a production or process engineer or any other qualified personnel must conduct the audit. The person or people conducting the audit must be familiar with all the processes in the feed plant and must be objective and honest in their answers.

The audit should be completed at least once every year for each feed mill. Any changes made as a result of the audit should be monitored to insure that optimum efficiency is being obtained.

The following form, starting on page 17 and instructions below, is used to conduct the Feed Industry Energy Audit. With the information obtained by the audit, one can use the energy calculation examples in this guidance document to determine actual cost and/or consumption savings for a specific mill.

Audit Instructions

The numbers correspond to the numbers on the Feed Industry Energy Audit Form on page 17.

1. From invoice – make sure to convert to 1000 ft^3 (McF) – invoices may be in 100 ft^3 (Ccf), cubic ft. or therms.
2. From invoice.
3. From invoice.
4. From invoice
5. Simple calculation using information from invoices.
6. The idea here is to determine if there are any leaks in the system between the meter and the equipment.
7. A test of your oil tank should be made annually for leaks. This test is similar to an automobile radiator check. Using a small amount of pressure and measuring the rate of loss—was there a pressure drop? There is no way to estimate this cost. The tank should be near full for best results.
8. Stack temperatures can be used to determine change in your boilers' condition and are also necessary pieces of information used to determine actual efficiency of boilers. It is an excellent gauge of dirty tubes or a burnt-out baffle condition. As a rough rule of thumb, your boiler should be within 100^0 of the steam temperature. Steam temperature can be determined by adding 14.7 psi to your boiler and looking up the ^{0}F of steam on Chart B page 17 in appendix. This should be checked at high and low fire.
9. Usually this would be the ambient or outside air temperature.
10. See boiler efficiency problems on page 21. Most people have a boiler expert come in and do reading.
11. Calculations from charts.
12. Recent year's average monthly fuel cost—add together the year's invoices and divide by 12.
13. If boiler is uninsulated or poorly insulated, answer no.
14. Actual plant audit. Do not include return lines. It is not practical to insulate return lines because of problems with the condensate returning to steam after the trap where lines are insulated.
15. Actual plant audit.
16. Actual plant audit.
17. Actual audit—if insulation is poor, answer no.
18. Actual audit—if insulation is poor, answer no.
19. Count all lines including the exceptions noted above that do not return to the boiler but emit BTU's to air or sewers.
20. Actual audit.
21. There are different rate structures for different types and quantity of users available from most utility companies. Some utilities will help users stay on the least expensive rates while some will not. **Users must take the initiative** in most cases. When pressured, even the most reluctant utility company will help make a study.
22. Although it happens infrequently, a utility company may not be billing a user on the schedule they have signed for, or the commerce commission may not approve the schedule. All rates are regulated and must be approved.
23. If a user is billed off of two or more meters, a feasibility study should be made on the use of one meter and the savings of doing so. Savings

come from getting more usage on the low end of a sliding scale.

24. The power company can help do a meter study.
25. At five different times, survey your plant for motors running, but not being used. Estimate HP hours not used per day. For example: crumble roll runs eight hours, gets used two hours. Motor is 10.0 HP. HP hours not used would be 60/day.
26. Again, a check should be made at five different times. Amperage should be checked against full load on the motor to see what unused motor capacity there is. Also, a pellet mill or other permanently installed amp meter should be checked to see that reading is accurate and that the maximum mark on amp meter is the full load of the motor. Note: A 100 HP hammer mill runs at 125 amp full load. The amp meter could be off 10 percent or the operator may be running 10 percent under the full load. Either way there are 12.5 amps not used. If the hammer mill runs 10 hours a day this would be 125 amp hours. If voltage is 440, then the survey would be answered 440 x 125 or 55,000 volt amp hours.
27. Low or poor power factor is the result of power that is produced for you but isn't used because of a number of variables. It can be corrected by capacitors. The utility company or a good electrical company can advise you on this at no cost.
28. Demand is a charge for the maximum short period use of power a user "demands" from a utility company. This period is usually 15 minutes or 30 minutes. Demands are charged because the power company must invest in equipment to generate your demand usage. If your usage is always the same, you couldn't save anything. If there are periods when your usage shoots up above your average usage, and the periods are few, then an electrical firm can put a demand controller in your operation to automatically control your demand usage by shutting off equipment not vitally needed if your demand is starting to move beyond the preset point.

    Note: A hammer mill could be shut off for 4 to 15 minutes, five or six times a day without affecting most operations. This, at average demand costs today, could save $1,000-$1,200 per year – about the cost of a simple demand controller.
29. From utility company schedule.
30. Survey plant and multiply total wattage of lamps times hours presently used but not needed.
31. Fluorescent is cheaper than incandescent—were incandescent are used in offices or in areas where they are on continuously, fluorescents should be considered. Survey for this.
32. Metal-halide is cheaper than fluorescent or incandescent to operate. Outside lighting lends itself well to sodium vapor. Survey for these possibilities.
33. Actual air compressor operating pressure.
34. Air compressor horsepower.
35. Estimated air compressor hours running per year.
36. Survey for number of air leaks.
37. Air intake survey reference calculations.
38. How many degrees are heated areas set over or under ^{0}F.

Feed Mill Energy Audit Form

1. Natural gas cost per 1000 cubic ft.–or propane cost per gallon? NG_______ Propane_____________
2. Fuel oil #2 cost per gallon? ___________________________
3. Fuel oil #6 cost per gallon? ___________________________
4. Average monthly power bill? ___________________________
5. Monthly cost/kwh power bill ÷ monthly kilowatt hour usage = cost/kwh ? ___________________________
6. Cubic foot reading of gas usage from the meter for 30 minutes with all gas burning equipment off? Start: ________ | End: ________
7. Fuel oil loss per year – pressurize tank to 5 psi and determine if pressure drops over 8 hour period. Was there a pressure drop? Yes_______ No________
8. Stack temperature of boiler ^{0} F? High Fire: ________ | Low Fire: ________
9. Temperature of air into boiler burner ^{0} F? ___________________________
10. 0_2 or CO_2 reading of stack gas? ___________________________
11. Boiler in efficiency using 8, 9, 10 above and Charts B, C, D, or E, depending on fuel used? ___________________________
12. Average monthly fuel bill? ___________________________
13. Is the boiler well insulated? Yes________ No__________
14. The length of uninsulated steam pipe (not including return line)? ___________________________
    14.a. Uninsulated pipe diameter. ___________________________
15. Number of steam leaks in plant observed? ___________________________
16. Number of traps stuck open? ___________________________
17. Is fat tank insulated? Yes________ No________
18. Is molasses tank insulated? Yes________ No________
19. Number of space heaters in service but not required? ___________________________
20. Obtain comparison from power company showing past 12 months cost of other available schedules. The annual potential savings would be:___________________________
21. Check your schedule with State Commerce Commission and your invoice against your schedule. ___________________________
22. Number of power meters billed from? ___________________________
23. If more than one billing meter, ask power company for potential annual savings if only one meter was used. ___________________________
24. Make five spot checks of the plant and estimate the number of horsepower hours running per day but not being used. ___________________________
25. Make five spot checks of the plant and estimate volt-amperage hours not being used. ___________________________
26. Power factor cost savings for 12 months? ___________________________
27. Peak demand less average demand in kilowatts? ___________________________
28. Demand cost/kilowatt from utility supplier schedule? ___________________________
29. Watt-hours of lights used but not needed per day? ___________________________
30. Total watt-hours of incandescent lights that could be fluorescent per day? ___________________

32-33. Total watt-hours of fluorescent lights that could be sodium vapor, Mercury vapor or metal-halide per day? ________________________

34. Air compressor pressure? ________________________

35. Air compressor horsepower? ________________________

36. Air compressor **annual** running hours? ________________________

37. Number of air leaks? ________________________

38. Is the air compressor intake drawing inside or outside air? ________________________

39. Heated areas temperature setting? ________________________

Electrical Energy Audit Form

1. Monthly cost per kW/hr. from power bill monthly kW/hr. usage = ____________cost per kW.
2. Number of power meters ____________ .
3. If more than 1 meter, cost savings to eliminate additional meters __________savings.
4. Complete power factor tested under normal load conditions__________________.
5. Calculated power factor savings if less than 90 percent _________ savings
6. Peak demand less average demand in kW.

   Peak _________ - Average_______ = Demand Opportunity ________________
7. Demand cost/Kw from supplier.

Demand Opportunity ______ x Cost/Kw ________ = Potential Savings__________

8. Air compressor leak test. Record pressure at compressor with no air users operating.

15 min_____ 30 min_____ 45 min_____ 60 min_____

9. If more than a 10 lb drop in 1 hour, identify all air leaks. Number __________
10. Does air compressor draw air from outside? Yes___________ No__________
11. Record watts of lights used, but not necessary.

    Watts per hr./day_______ / 1000 = kW/hr.________
12. List equipment systems and number of HP hours running day, but not being used.

HP. Running

System	Not Used	Hr./Day

Steam Generation

1. Percentage of steam lines insulated ____________ %.
2. Percentage of condensate lines insulated _________ %.
3. Does Condensate return to the feedwater tank? Yes __________ No ______
4. Complete an inspection of steam traps and note any that are leaking.
   Traps leaking_____ / total traps = ______percent leaking
5. List liquid tanks and heating source.

Is Tank Insulated?	Product Stored?	Heating Method?	Temperature Control Range	Product Temperature

6. Natural gas/propane meter reading with all gas uses off.

Reading	Time
________	30 min
________	60 min

____

7. Are the boiler insulation and shell in good condition? Yes_______No_______
8. Identify any steam openings into sewer or into the atmosphere.
   Number of openings ________
9. Number of space heaters in service and not required. _______________
10. Test boiler efficiency. ______________ (Should be above 82 percent).
11. Measure average thickness of scale on boiler tubes (1/32 in = 7% fuel waste.
    1/16 in. = 13% fuel waste).
12. Natural gas cost/1000 cu ft on propane cost/gal
    NG__________ Propane_______

Compressed Air System Evaluation

Date: ____________________ Completed by:________________________

1. Evaluate all equipment using air and determine the highest air pressure required in plant. Set compressor air to that pressure.
2. Shut down entire plant so that every area is quiet.
3. Run air compressor so the lines are at maximum pressure.
4. Shut off compressor.
5. Walk through plant and mark all leaks with caution tape or anything to make it visible.
6. Write general location of leaks below.
7. Record time that it takes until pressure has decreased to 40psi.

Example:

If maximum required pressure is 100psi and it takes 20 minutes until pressure is 40psi.

100psi - 40psi = 60psi lost in 20 minutes.

60psi/20min = 5psi/min

Recording Time and Pressure Drop

End time_____________- Start time_______________=Total time

Bagging pressure________________psi - 40psi. = __________psi pressure drop

Pressure drop_____________psi/__________min (total time) =__________min

Repeat after leaks are fixed and record improvement.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____
11. ____

CHAPTER 5: SPECIFIC ENERGY CALCULATIONS, AND SPECIFIC ENERGY CONSERVATION OPPORTUNITIES

BOILER EFFICIENCY

The most common reasons for boiler inefficiency are scaled tubes (water side), or sooted tubes (fire side), and improper burner settings. In addition, operating the boiler at operating pressure when not needed and the condition of fuel oil, such as fuel oil temperature, are factors to consider when looking at boiler efficiency.

1. Thermometer to Measure Boiler Performance - One way to detect if there are boiler inefficiencies is to use a thermometer installed in the boiler stack or flue. A rough rule of thumb says that if the stack temperature is over 100^0F of the steam temperature, there is a problem. By using the Properties of Saturated Steam (temperature) Chart shown in the appendix a boiler steam temperature can be determined.

Example – For a boiler operating at 60 psi:

Boiler psi = 60
psi + 14.7 = psi
Boiler psi = 74.7

Steam temperature at 60 psi is then read from the Properties of Saturated Steam (temperature) Chart shown in the appendix. At 74.7 psi, the steam temperature would be between 300^0F and 310^0F, or more accurately, 308^0F.

Max Stack Temp =
Boiler Steam temp. + 100^0F =
308^0F + 100^0F = 408^0F

2. Flue Gas Analysis - A more quantitative way to determine if there are boiler inefficiencies is to analyze the stack or flue gases. There are several inexpensive analyzers on the market and for larger boilers there are more expensive continuous measuring devices. Using an analyzer, either the oxygen level or the carbon dioxide level can be determined depending on the type of analyzer.

Example – Using a boiler flue analyzer and a thermometer, the following facts are obtained:

Boiler burns Natural Gas

Air Temperature	65°F
Stack Temperature	605°F
O_2 Reading	8.77%
CO_2 Reading	7.0 %

Using this information and Chart B in the appendix, the heat loss up the stack is found to be 26.8 percent:

O_2 Reading Is	8.77%
Excess Air (From Chart)	65.5%
CO_2 Reading Is	7.0%
Heat Loss (From Chart)	26.8%
Heat Used (100° - 26.8°)	73.2%
Room Temperature	65°F
Stack Temperature	605°F
Temperature Difference	540°F

As most boilers can operate between 82 percent to 86 percent efficiency, an adjustment of the burner or cleaning of the tubes is called for. In this example, after cleaning the tubes and adjusting the boiler, the following were the readings:

Air Temperature	65°F
Stack Temperature	485 °F
O_2 Reading	4.43 %

Using this information and the same Chart B, the heat loss is found to be 19.9 percent.

Adjustment of the boiler to lower O_2 to get a better fuel to air ratio yields:

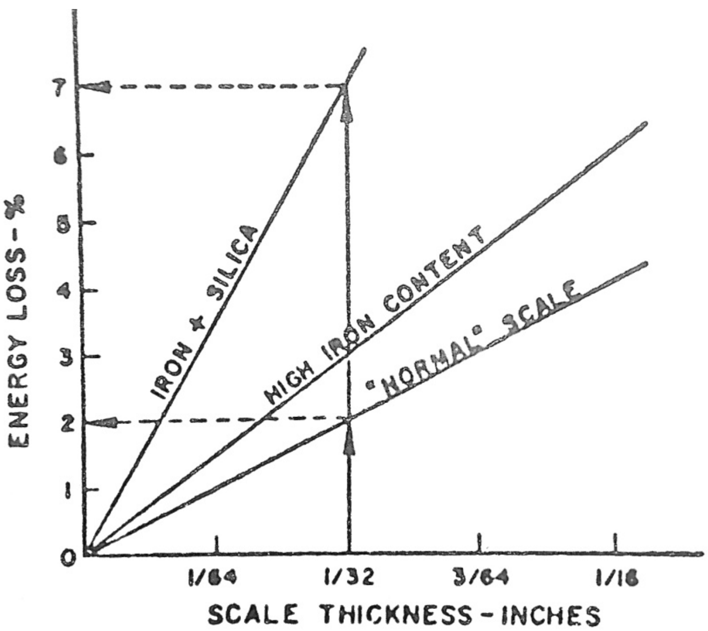
$$\text{Gain in fuel} = \frac{\text{heat used after adjustment} - \text{heat used before adjustment}}{\text{heat used after adjustment}} \times 100$$

or
$$\frac{80.1\ \% - 73.2\ \%}{80.1\%} \times 100 = 8.6\%$$

At an average monthly fuel bill of $4,000, this adjustment from 605^{0}F stack temperature to 485^{0}F would be:

= 0.086 x $4,000/month
= $ 344/month
= $ 4,128/year

Figure 2. Percent Energy Loss from Thickness of Scale Deposits



Energy Loss from Scale Deposits

3. Water Side Boiler Tubes

The prevention of scale formation, even in a 100 HP boiler, can produce energy savings up to $7,000 per year. For an individual case the potential saving depends on the scale thickness and on its chemical composition.

Example – Consider a 100 HP boiler in use at its 100 percent rating of 3.35 MBTU/h into steam, or approximately 3,350 lb steam/h. At its rated 80 percent efficiency, and operating 4,000 h/yr. :

Annual Energy Input =

$$\frac{3.35 \text{ MBTU x } 4{,}000 \text{ h/yr.}}{.80} = 16{,}750 \text{ MBTU}$$

O_2 Reading Is	4.43%
Excess Air	24.3%
CO_2 Reading Is	9.5%
Stack Temperature	485°F
Room Temperature	65°F
Temperature Difference	420°F
Heat Loss	19.9%
Heat Used	80.1%

Condition A: If scale 1/32" thick is allowed to form on the tubes, and the scale is of "normal" composition (salts of Ca and Mg), reference indicates an energy loss of 2 percent. Under These conditions:

Annual Energy Loss =
16,750 MBTU x 0.02 = 335 MBTU /yr.

If the scale is cleaned out and prevented from reforming, and assuming the fuel oil used has a heating value of 144,000 BTU/gal and costs .90 per gal., there will be an

Annual Cost Saving =

$$\frac{335 \text{ MBTU x } 0.90\text{/gal}}{0.144 \text{ MBTU.gal}} = \$2{,}093 \text{ /yr.}$$

Condition B: If scale of the same thickness forms, but of a composition high in iron and silica, Figure 2 indicates an energy loss of 7 percent.

Annual Energy Loss =
16,750 MBTU x 0.07 = 1,173 MBTU /yr.

Removing the scale and preventing its reforming with the same assumptions as to fuel oil:

Annual Cost Savings =

$$\frac{1173 \text{ MBTU x } 0.90\text{/gal}}{0.144 \text{ MBTU/gal}} = \$7{,}331 \text{ /yr.}$$

Suggested Action – Check boiler tubes visually for scale while the boiler is shut down for maintenance. Operating symptoms, which may be due to scale, include reduced steam output, excessive fuel use and increased stack temperature.

If the scale is present, consider modifying the feed water treatment and/or the schedule of chemical additives. The cost of modification can vary widely, depending on such factors as the type of treatment facilities already available and the chemical problems present if any. The advice of a consultant or of a vendor of water treatment chemicals can be helpful.

4. Fire Side Boiler Tubes

An actual example of the effect of sooty tubes in a 400 HP. boiler follows:

An opportunity to save $8,350 per year by utilizing an automatic tube cleaner was identified by a can manufacturing company. The accumulation of soot on the surface boiler tubes acts as a thermal insulator, which reduces the overall boiler efficiency. The normal procedure is to periodically (weekly or biweekly) shut down the boiler and manually clean each tube. With the installation of the automatic tube cleaning system, each tube is cleaned at least every 30 minutes by adjustable, timed blasts of compressed air. A catalyst is also automatically injected into the tube area to reduce soot and smoke emissions to the atmosphere.

This plant installed automatic tube cleaners on two fire boilers in September, 1967. One boiler was rated at 400 HP (13.4 MBTU/h) and the other was rated at 500 HP (16.7 MBTU/h). The following table shows the actual fuel oil consumption and the number of degree days for the year preceding the installation of the automatic tube cleaner and for two heating seasons following the installation.

Season	**No. 6 Fuel Oil Consumption, Gal**	**Degree-Day**	**Gal/Degree-Day**
1966-67	373,062	4147	89.96
Automatic tube cleaner installed September 1967			
1967-68	349,773	4196	83.36
1968-69	327,712	3942	83.13

For the 1967-68 and 1968-69 heating seasons, the

Avg. gal/degree-day =

$$\frac{83.36 + 83.12}{2} = 83.25 \text{ gal/degree-day}$$

Average percent savings in fuel with the automatic tube cleaner installed is

$$\text{Percent Savings} = \frac{89.96 - 83.25}{89.96} \times 100 = 7.46\%$$

Annual Fuel Savings =
373,062 gal/yr. x .0746 = 27,830 gal/yr.

Assuming the No. 6 fuel oil has a heating value of 149,690 BTU/gal

Annual Energy Savings =
149,690 BTU/gal x 27,830 gal/yr.= 4,166 MBTU/per yr.

Based on a fuel oil cost of $0.85/ gal
Annual Savings =
27,830 gal/yr. x 0.85 $/gal. = $23,655 /yr.

In addition to the fuel cost savings of $23, 655 per year resulting from cleaner tubes, a substantial savings in labor required to hand clean the tubes on a periodic basis (the 400 HP unit has 273 tubes and the 500 HP unit has 293 tubes) was realized. This plant has recently changed to No. 2 fuel oil for environmental reasons.

Suggested Action – Consider installing automatic tube cleaners in both fire tube and water tube boilers as a means of saving fuel and labor. A fast check on the efficiency of the boiler can be made by installing a thermometer in the stack gas as close as possible to the last set of tubes. If this temperature exceeds the steam/water temperature by more than 100^0 F, fuel savings can be realized.

5. Fuel Oil Condition

Fuel savings of $14,400 per year were found to be achievable by heating fuel oil to the proper temperature. This savings potential was in a Midwestern meat packing plant where three oil burning boilers had a combined rating of 200,000 pounds per hour of process steam. The fuel/air ratio was manually adjusted by the operator to maintain clear stacks. This practice resulted in approximately 15 percent excess air with the No. 6 fuel oil used at the specific oil supply temperature of 190^0F.

After a change of fuel oil suppliers and the purchase of fuel oil with a different specification, it was necessary to readjust combustion air flow to maintain clear stacks. After some months, a flue gas analysis was run and the excess air was found to be between 25 percent and 30 percent. The burner manufacturer's representative was called in to determine why excess air could not be reduced without smoke.

The representative determined that the fuel oil supply temperature of 190^0 specified for the original No. 6 fuel oil supply was inadequate for the new fuel supply. He advised that the temperature should be increased to 220^0 F so the viscosity of the oil supplied to the burners would be the same as the original viscosity specification.

Figure 3. Liquid Petroleum fuel Savings by Reducing Excess Air to 10%

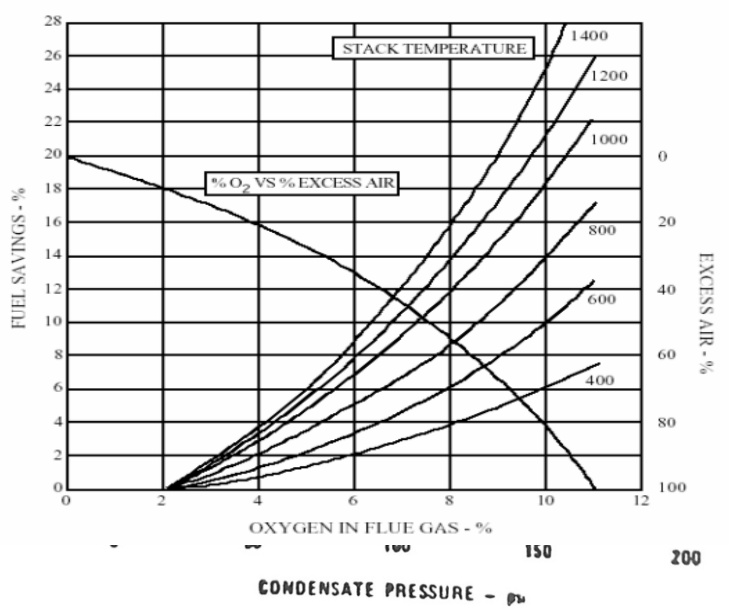
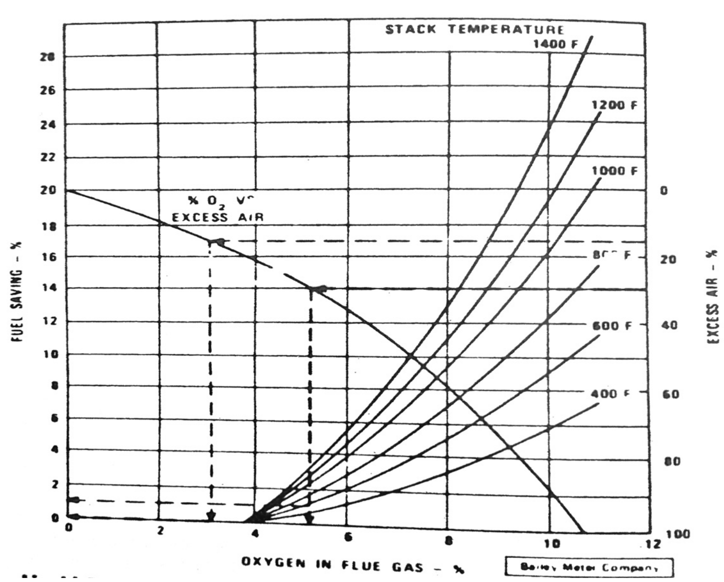


Figure 4. Liquid Petroleum Fuel Savings by Reducing Excess Air to 20%



From the table shown, the estimated fuel savings for reducing excess air to 15 percent from 30 percent is 1 percent (note: this estimate is conservative due to the limit on the table which neglects fuel savings below 20 percent excess air and assumes stack temperatures between 400^0F and 600^0F).

With the boilers operating 7200 hours per year at 80 percent efficiency and requiring 1000 BTU input per pound of steam:

Annual energy Requirements =

$$\frac{200{,}000 \text{ lb. steam/h} \times 1000 \text{ BTU/lb. steam} \times 7200 \text{ h/yr.}}{.80} = 1{,}800{,}000 \text{ MBTU/yr.}$$

If the estimated fuel saving is 1 percent

Annual Fuel Saving =

$$\frac{1{,}800{,}000 \text{ MBTU/yr.}}{100} = 18{,}000 \text{ MBTU/ yr.}$$

If the fuel cost is $7.20 MBTU

Annual Cost Saving =

18,000 MBTU/yr. x $7.20/MBTU = $129,600

Suggested Action – Check fuel oil supply temperature and compare with burner manufacturer's recommendation for the fuel preheaters specification used.

Savings determined by these curves reflect the following approximation: the improvement in efficiency of radiant and combustion radiant and convection heaters or boilers without air preheaters that can be realized by reducing excess air is 1.5 times the apparent efficiency improvement from air reduction alone due to the accompanying decrease in flue gas temperature.

STEAM TRANSMISSION

For feed mill operations, the most common steam transmission losses in energy occur because of improper pipe insulation, not returning condensate to the boiler, steam leaks and malfunctioning steam traps.

1. Pipe Insulation Losses

A survey of a plant steam system found 120 feet of bare half of an inch steam line and 70 feet of bare 1 inch steam line operating at 150 psi and 230 feet of bare 2 inch steam line operating at 30 psi. The value of the steam was $2.40 per MBTU (from natural gas as boiler fuel). The amount of heat loss per year was determined from the following figure. The heat loss as determined from chart is:

½ inch line = $\frac{120 \times 300}{100}$ = 360 MBTU/ yr.

1 inch line = $\frac{70 \times 430}{100}$ = 301 MBTU/ yr.

2 inch line = $\frac{230 \times 370}{100}$ = 851 MBTU/ yr.

Total Heat Loss = 1512 MBTU/ yr.

The amount of heat saved by insulating bare steam lines depends on the type of insulation and other variables. If its assumed that a 95 percent efficiency—a value reasonably achieved in insulation installations—is obtained, then:

The cost saving = 1512 MBTU/ yr. x .95 x $2.40/MBTU= $3,447 /yr.

For superheated steam, the losses are about the same as for saturated steam. The higher temperatures are about offset by lower heat transfer coefficients from the steam through the pipe.

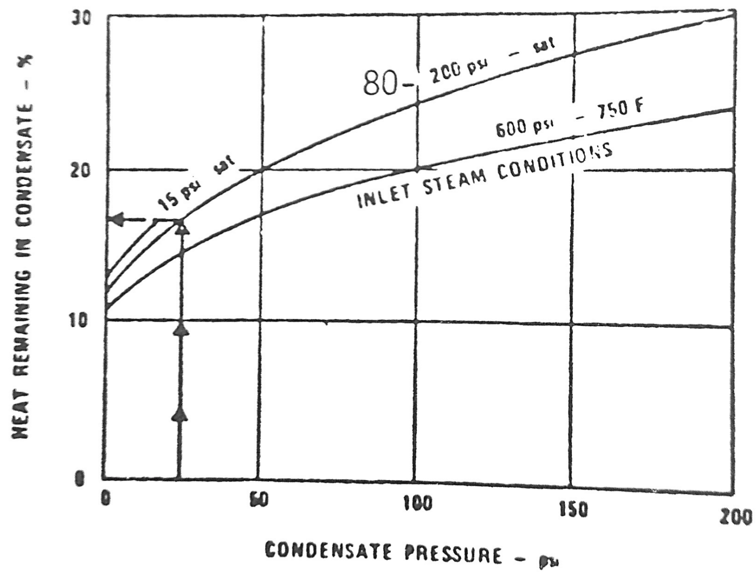
Suggested Action:
1. Have plant maintenance install proper insulation; or
2. Contact insulation contractor.

2. Return Steam Condensate

The amount of fuel used for steam generation can be reduced 10 percent to 30 percent by returning steam condensate to the boiler plant for use as feed water.

Example – In a plant where the value of steam is $2.40/MBTU, saturated steam was delivered to one building at a pressure of 80 psi, at an average rate of 320 lb/h. and for an average of 8,000 h/yr. The steam was reduced through control valves and condensed in heating coils at an average pressure of 25 psi. The condensate was returned to the boiler plant and used as feed

Figure 5. Heat in Steam Condensate



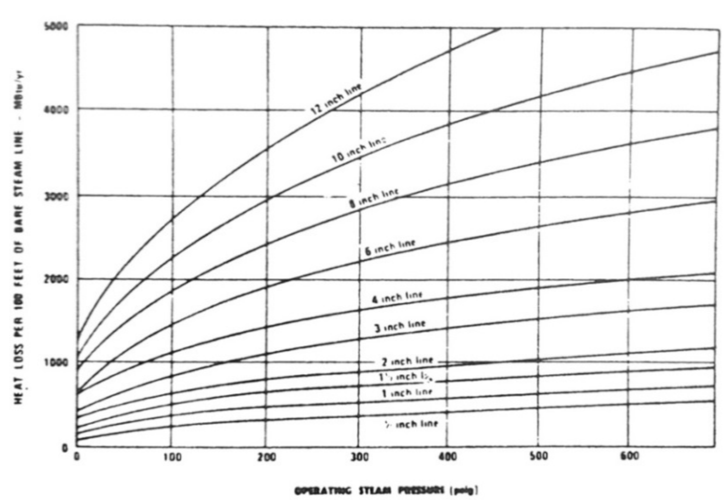
water. The amount and value of the heat recovered is calculated below.

From Figure 5 above, it is determined that 17 percent of the heat remains in the 25 psi condensate from the 80 psi saturated steam.

The heat recovered in condensate
17 x 1145 x 320 x 8000 = 498 MBTU /yr.

The value of the heat recovered =
498 MBTU/yr. x $2.40/MBTU = $1,195/yr.
This is the estimated savings for one 15,000 gal fat tank that is insulated and trapped but condensate is set to the sewer.

Figure 6. Heat Loss from Steam Leaks



It should be noted that these values represent heat saving potential since no heat loss has been considered for returning the condensate to the boiler plant. The heat loss is dependent on factors such as the length of return lines and the amount of insulation.

In addition to saving heat, the return of condensate to the boiler plant will:

1. Save treated makeup boiler feed water.
2. Save energy and chemicals used in the water treating operation.
3. Reduce water pollution.
4. Reduce (but not eliminate) the cost of losses due to steam trap leakage.

Suggested Action – Estimate cost of a condensate return system and install, if justified. The return of condensate to the boiler plant requires precautions to avoid contamination with oil or chemicals.

From the steam Chart B in the Appendix, the heat value

- for 80 psi saturated steam = 1,183 BTU/lb.
- for 70^0F (assumed ambient temp.) of makeup water if condensate is not returned to boiler = 38 BTU/lb.
- Net Heat Value = 1145 BTU/lb.

3. Steam Leaks

In a plant where the value of steam is $2.40/MBTU, a leak estimated to be one-eighth inch in diameter was found in a steam tracing line operating at 100 psi. From the figure shown, the steam loss was at an annual rate of 540 MBTU.

By repairing the leak,

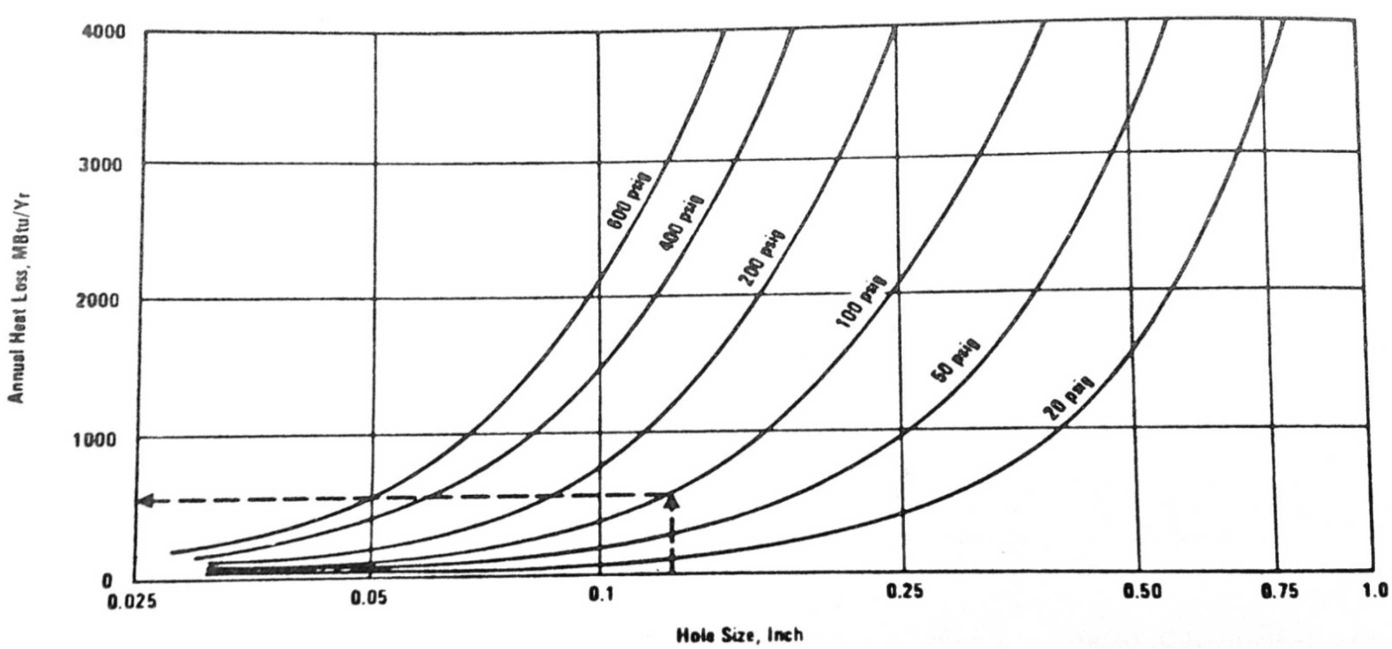
Annual Savings =

540 MBTU/yr. x $2.40/MBTU = $1,296/yr.

Suggested Actions –

1. Survey the steam lines for leaks using appropriate acoustic and temperature probes. Many important steam leaks are hidden, such as:
   a. Leaking or stuck traps or bypass valves discharging to sewer or condensate system.
   b. Leaking valves leading to idle equipment.
   c. Leaks in heater or other equipment connected to the steam system.
2. Establish a program for regular inspections to detect hidden leaks.
3. Shut off steam to equipment whenever it is taken out of service.
4. Reroute piping, where practical, so that leaks are visible rather than hidden.
5. Repair steam leaks promptly.

Figure 7: Heat Loss Due to Leak Size



4. Steam Traps

Efficient operation of any steam system requires well designed trapping that is periodically inspected and properly maintained. It is only in this way that condensate and air will be removed automatically as fast as they accumulate without wasting steam.

Initial inspections commonly reveal that as high as 7 percent of the traps in a system are leaking. It has been demonstrated that by careful maintenance and frequent inspection this can be reduced to 1 percent.

> **Example** - In a plant where the value of steam is \$2.40/MBTU an inspection program revealed that a trap on a 100 psi steam line was stuck open. The orifice in the trap was ¼ inch. From Figure 7, steam loss was indicated to be at the rate of 2,100 MBTU/year. By repairing the trap,

Annual Savings = 2,100 MBTU/yr. x \$2.40/MBTU = \$5,040 /yr.

Suggested Action

1. Establish a program of regular systematic inspection, testing and repairing of steam traps.
2. Inspection and testing, on a suggested frequency of about once a week, should provide answers to the following questions:
    a. Is the trap removing all of the condensate?
    b. Does it shut off tight after operation?
    c. Is bypass, or separate discharge, closed and free of leaks?
    d. Is frequency of discharge in an acceptable range? Too frequent discharge indicates possible under capacity; too infrequent discharge indicates possible overcapacity and inefficiency.

GAS AND OIL LEAKS

1. Oil leaks

There are no reliable means to calculate the cost of an oil leak.

2. Natural Gas or Propane Leaks

Loss of combustible gases, natural gas, methane, butane, propane, hydrogen, etc., through pipeline leaks is a direct waste of valuable energy.

The figures in Tables 8 and 9 reflect annual energy in Mcf or 1,000 cu.ft.

Table 7 was calculated from a formula that takes into consideration that the leak is confined in the earth and some back pressure is present.

Table 7: Annual Natural Gas Loss from Leaks in Underground Pipelines (Mcf)

Line Pressure (psi)							
Corrosion Hole diameter (In.)	0.25	5	25	60	100	300	500
1/64	1	4	10	20	30	80	140
1/32	2	6	20	35	60	160	250
1/16	10	40	100	200	320	900	1,500
1/8	50	200	600	1,200	1,800	5,000	8,200
1/4	250	1,200	3,300	6,500	10,300	28,300	46,500
1/2	1,400	6,600	18,800	37,300	58,000	156,500	263,000

Leak flows in Table 8 were calculated with an equation and procedure for square edged orifices discharging compressible fluids to atmosphere.

Table 8: Annual Natural Gas Loss from Leaks in Above Ground Pipelines

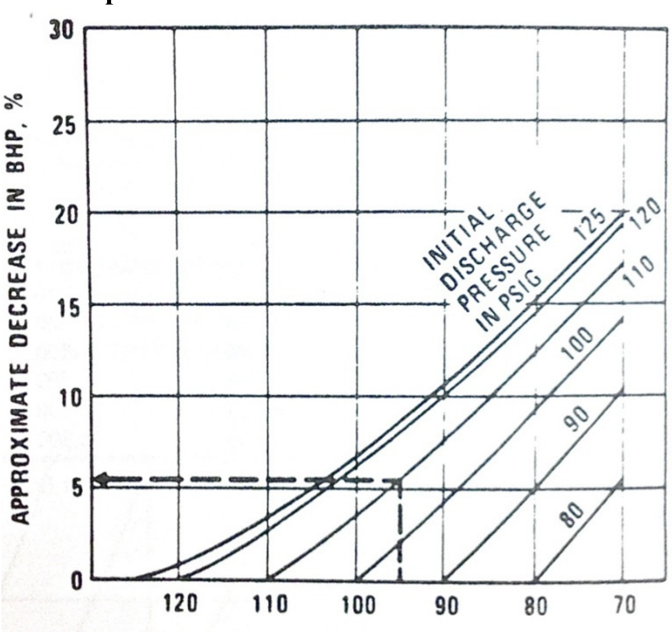
Line Pressure (psi)							
Corrosion Hole diameter (In.)	0.25	5	25	60	100	300	500
1/64	5	26	69	136	212	581	953
1/32	21	102	277	544	846	2,330	3,810
1/16	85	409	1,110	2,180	3,390	9,300	15,300
1/8	341	1,640	4,430	8,700	13,500	37,200	61,000
1/4	1,360	6,540	17,700	34,800	54,200	149,000	244,000
1/2	5,540	26,200	70,900	139,000	595,000	595,000	977,000

Example – One hundred psi natural gas leaking through a one-eighth inch diameter hole in an underground pipeline results in annual loss of 1,800 thousand cu. ft. (Mcf), at $2.40 MBTU, and 1,000 BTU/cu. ft. of gas. The loss = $4,320.

At the same pressure, gas leaking from the same size hole in an above ground pipe could amount to an annual loss of 13,500 Mcf. at $2.40 MBTU and 1,000 BTU/cu. ft. of gas. The loss = $32,400.

Suggested Action – Eliminate leaks in combustible gas lines to avoid loss of valuable energy and to prevent the hazard of fire or explosion. A continuing program of periodic leak detection surveys and prompt repairs is essential.

Figure 8. Single Stage Reciprocating and Screw Compressors



Lowered Discharge Pressure, PSIG

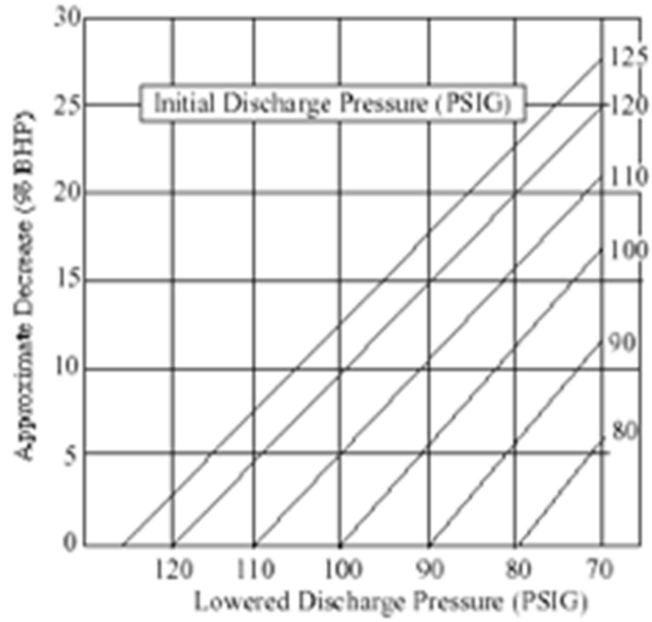
COMPRESSED AIR

The most common losses of energy in this area for feed mills are excessive pressures, air leaks and position of air intake.

1. Pressure Drop

Example – If pressure is reduced from 120 psi to 100 psi in a 25 HP single stage compressor, Figure 9 shows a 10 percent savings in horsepower.

Figure 9. Two Stage Reciprocating and Centrifugal Compressors



2. Air Leaks

The cost of leaking compressed air is often considered insignificant. The following example illustrates that appreciable energy savings can be realized by repairing leaky lines.

For a compressor operating 4,000 hours a year, the kwh savings is:

$$\frac{10 \text{ x } 25 \text{ HP x } .746 \text{ kw x } 4{,}000 \text{ hr.}}{100} = 7{,}460 \text{ kwh/yr.}$$

At $0.055 per kwh, the savings would be: 7,460 kwh/yr. x $0.055 = $410/year

A complete inspection of a plant compressed air system was conducted at the start of a regular monthly leak detection program. Air compressor discharge pressure was 100 psi. At a power cost of $0.055 per kwh the cost of the leaks found in the compressed air system is illustrated in Table 10.

Table 9: Cost of Power, Fuel and Free Air Wasted As a Result of Air Leaks				
Number of Leaks	Estimated Diameter (In.)	Free Air Wasted, cu ft/yr.	Fuel Wasted, MBTU/ yr.	Cost of Power Wasted $/yr.
3	1/4	106,500,000	2,920	16,059
7	1/8	62,3000,000	1,700	9,338
12	1/16	26,600,000	727	3,996
15	1/32	8,300,000	227	1,230
37	1/64	203,600,000	5,574	$30,623

The energy and cost saving possible by fixing compressed air system leaks can be estimated below:

Table 10: Potential Energy and Cost Savings from Fixing Air System Leaks					
Hole Diameter, In.	**Free Air Wasted (a), cu ft per yr., by a Leak of Air at:**	**Fuel Wasted (b) MBTU/yr.**	**Cost of Power Wasted (c), $/ yr at Unit Power cost of**		
	100 psi		**$.050/kwh**	**$0.055/ kwh**	**$ 0.060/kwh**
3/8	79,900,000	2,190	10,950	1,202	13,110
1/4	35,500,000	972	4,860	5,353	5,820
1/8	8,880,000	240	1,215	1,334	1,458
1/16	2,220,000	60.6	303	333	363
1/32	553,003	15.1	75	82	91
1/64	**70 psi**		**$.050/kwh**	**$.055/kwh**	**$.060/kwh**
3/8	59,100,000	1,320	6,600	7,260	7,950
¼	26,200,000	587	2,935	3,230	3,510
1/8	6,560,000	147	735	806	882
1/16	1,640,000	36.6	183	201	220
1/32	410,000	9.2	46	51	55

Based on data from the reference:

a. Based on nozzle coefficient of 0.65.
b. Based on 10,000 BTU fuel/kwh.
c. Based on 22 brake horsepower per 100 cu. ft. free air per min for 100 psi air and 18 brake horsepower per 100 cu. ft. free air per minute for 70 psi air.

Air leaks can easily go unnoticed since they are odorless and invisible and their hissing sound can be hidden by other plant noise. Therefore, it is advisable to inspect pipelines, air hoses, valves and fittings at regular intervals to detect leaks. A common way of detecting leaks in air pipelines is by swabbing soapy water around the joints. Even very small leaks will make their presence known by blowing bubbles. Also there are instruments available that detect air leaks by sound.

Suggested Action – Leaks should be repaired as soon as practical. In some situations, there may be a need to wait for a scheduled plant shutdown. Temporary repair can often be made by placing a clamp over a leak.

3. Air Intake

Wherever feasible, the intake duct for an air compressor should be run to the outside of the building, preferably on the north or coolest side. Since the average outdoor temperature is usually well below that in the compressor room, it normally pays to take the cool air from outdoors. The energy savings potential in lowering the air intake temperature is illustrated in Table 12 on the following page.

Regardless of the outside temperature, the compressed air in a shop pipeline will closely approximate the temperature in the shop by the time it reaches the tools. Assume the indoor temperature to be 70⁰F. If the compressor takes in 1,000 cu. ft. of free air from the shop, it will deliver 1,000 cu. ft. of free air at the tools because the initial and final temperatures are the same.

Table 11: Energy Savings Potential in Lowering Air Intake Temperature

Temperature of Air Intake, °F	Intake Volume Required to Deliver 1,000 cu ft of Free Air at 70°F	% HP Saving or Increase Relative to 70°F
30	925	7.5 Saving
40	943	5.7 Saving
50	962	3.8 Saving
60	981	1.9 Saving
70	1,000	------
80	1,020	1.9 Increase
90	1,040	3.8 Increase
100	1,060	5.7 Increase
110	1,080	7.6 Increase
120	1,100	9.5 Increase

Suppose the outside air averages 50⁰F and the compressor is supplied with intake air from outdoors. Only 962 cu. ft. of free air will be required to deliver 1,000 cu. ft. of free air at the indoor temperature at 70⁰ F, a saving of 3.8 percent in the horsepower required.

Example – A compressor takes its inlet air directly from the compressor room where the average temperature is 80⁰F. The compressed air at 100 psi is delivered to a shop building where the temperature is maintained at 70⁰F. The compressor delivers 100 cu. ft. per min. of free air at 70⁰F for 2,000 hours per year. The 25 HP electric motor drive operates at full load. The average outside air temperature is 50⁰F. The energy savings to be realized by taking compressor inlet air from outdoors are calculated as follows:

From the intake table --

- For 80⁰F at the intake, volume to deliver 100 cu. ft. free air at 70⁰F = 1,020 cu ft.
- For 50⁰F air at the intake, volume to deliver 1,000 cu. ft. free air at 70⁰F = 962 cu ft.

The power savings from using the cooler intake,

- HP Saving = $\frac{(1020 - 962) \times 100}{1,020} = 5.69\%$

Annual Power Savings =
$\frac{5.69 \times 25 \text{ HP} \times 0.746 \text{ kw/HP} \times 2,000 \text{ h/yr.}}{100} = 2122$ kwh/yr.

If electric power cost is $0.055/kwh.

Annual Cost Savings =
2122 kwh/yr. x $0.055/kwh = $117/yr.

Suggested Action – Estimate the cost of running an intake duct from your air compressor to a cool location outdoors. Calculate your potential energy saving and evaluate whether the duct installation is justified.

SPACE HEATING, COOLING AND VENTILATION

The most common area for energy loss in this area of feed mills is office, mill, or warehouse space where heating that is not needed.

1. **Reduce Heat or Air Conditioning Needs**
   One degree turn down when heating, or up when cooling, results in approximately 7 percent energy savings.

   For an office with a $300 heating bill monthly, a drop in heating from 70⁰F to 68⁰F would result in a 14 percent savings or $42/month.

2. **Ventilation**

Energy savings may be realized by reducing forced ventilation in buildings to a lesser, but still adequate, amount required to provide safe conditions.

The air flow from a centrifugal fan varies directly with the rotational speed. Thus, the amount of ventilation can be reduced by decreasing fan speed.

Example – A new 150,000 cu ft warehouse was constructed with provision for five air changes per hour. This requires a 10 HP motor (with a fan load of 9.83 HP) driving a 24 inch centrifugal fan at 915 rpm to deliver air at the rate of 12,500 cfm. Later information showed that only four changes per hour would be adequate or 80 percent of the original design. Pulley changes were made, therefore, to reduce the fan speed to 915 x 0.80, or 732 rpm.

With the fan speed reduced to 80 percent of the full rating, the power required to drive it is only 50 percent of the full load. This is based on reduction in the static pressure required by the fan to move the lower volume of air. Assuming a motor efficiency of 80 percent at full load,

Power at Full Load =

$$\frac{9.83 \text{ HP} \times 0.746 \text{ kw/HP}}{.80} = 9.166 \text{ kw}$$

Assuming a drop in motor efficiency to 77 percent,
Power at 50 percent Load =

$$\frac{9.83 \text{ HP} \times 0.50 \times 0.746 \text{ hw/HP}}{.77} = 4.762 \text{ kw}$$

Elec. Power Saving =
(9.166 – 4.762) x 8760 = 38,580 kwh/yr.

If the utility consumes 10,000 BTU of fuel/kwh generated,

Annual Energy Savings =
38, 580 kwh/yr. x 10,000 BTU/kwh = 386 MBTU/yr.

Annual Cost Saving =
38, 580 kwh/yr. x $0.055/kwh = $2,122/yr.

Suggested Action – Determine whether the number of air changes provided by your ventilation system can be reduced and still maintain safe conditions.

Fan speed can be reduced, and energy saved, merely by changing pulleys. If the motor operates at less than 50 percent of its rated load, its efficiency may be very poor. In some cases a smaller motor rated for the job will produce greater savings. (Note: Reducing ventilation may also reduce the energy requirements for heating and cooling.)

3. Space Heating

If two 250,000 BTU/hour space heaters could be reduced from operating 24 hours a day during the colder months to operating 12 hours a day by using a thermostatically controlled valve the savings would be:

2 x 250,000 BTU/hr. x 12 hr./day x 31 days/month = 186 MBTU/month

At $2.40/MBTU the savings would be: $2.40 x 186 MBTU/month = $446/month

ELECTRICAL ENERGY SAVINGS

The most common losses of electrical energy in feed mills are nonessential lighting and motors, incorrect type of lighting, equipment not fully loaded, increased demand not needed, lack of capacitors and operation on the wrong electrical schedule.

1. Nonessential or Reduced Lighting

If a plant survey showed lights not needed of:
5 – 100 Watt x 8 hrs./day = 4000 kwh/day
10 –150 Watt x 12 hrs./day = 1800 kwh/day
4 – 500 Watt x 2 hrs./day = 4000 kwh/day
26000 kwh/day

Assuming 250 day/yr. and kwh cost of $0.055 the savings would be:

$$\frac{26000 \text{ kwh/day} \times 250 \text{ day/yr.} \times \$0.055}{1000} = \$360\text{/yr.}$$

2. Upgrading Lighting

The initial cost and annual operating cost comparison for the normal light sources are listed in Table 13 (numbers are for comparative purposes).

If a plant survey showed 20-150 watt incandescent lights burning 10 hr./day that could be replaced by metal-halide and 10-500 watt outside lights burning 8 hrs./day that could be replaced by high pressure-sodium, the operating savings for a 250 day/yr. and a cost of $0.055/kw is:

20 x 150 Watt x 10 hr./day = 30,000 wh/day
10 x 500 Watt x 8 hr./day = 40,000 kwh/day
70,000 kwh/day

$$\frac{30{,}000 \text{ kwh} \times 1.4}{3.6} + \frac{40{,}000 \text{ kwh} \times .9}{3.6} \times \frac{250 \times .055}{1000}$$

= $298/year or $10/year for each bulb

Table 12: Lighting Costs		
	Initial Cost	**Annual Cost**
Incandescent	1.0	3.6
Mercury	1.4	1.4
Metal-Halide	2.9	2.0
High Pressure – Sodium	2.9	0.9
Fluorescent	3.3	1.3

*Best for outside lighting where yellow cast is not a problem.

3. Equipment Not Fully Loaded

A 100 HP grinder has a rated full amps load of 124 amps. The grinder is found to be running at 111 amps regularly. The grinder capacity is 6 tons/hr. at 95 amps and 8 tons/hour at 111 amps. The grinder operates 250 days/year, at $0.055 kwh and 8 hours/day operation. The grinder produces 12,000 ton/yr.

At 95 amps, 12,000 ton/yr. 440 volts and $0.055 kwh, the savings is:

$$\frac{12{,}000 \text{ ton/yr.}}{6 \text{ ton/hr.}} = 2{,}000 \text{ hour}$$

$$\frac{12{,}000 \text{ ton/yr.}}{8 \text{ tons/hr.}} = 1{,}500 \text{ hour}$$

Hours saved = 500 Hours

Watts = Power Factor x Amps x Volts

Annual Savings is:

$$\frac{500 \text{ hrs. x } 95 \text{ amp x } 440 \text{ volts x } .90 \text{ power factor x } \$.055}{1{,}000} = \$\ 1{,}035\text{/yr.}$$

4. Power Factor

The penalty charge for a low electrical power factor can easily be saved by installing capacitors. The installation will normally pay for itself in one or two years.

Example – Consider the case of a plant with a maximum demand of 350 kw, and operating with a power factor of 0.65. Since the power contract has a penalty clause for power factors of less than 0.85, the monthly demand charge is:

Original Demand Cost –

$$\frac{350 \text{ kw x } 0.85 \text{ pf x } \$2.50\text{/kw}}{.65} = \$1{,}144 \text{ per month}$$

By installing capacitors rated at 0.55 kwa for each kilowatt of demand, the power factor could be improved to 0.85, assuming an installed cost of $30 per kvar.

Cost of Capacitors =
350 kw x 0.55 kvar/kw x $30/kw = $5,775

At the improved power factor of 0.85.

New Demand Cost =

$$\frac{350 \text{ kw x } 0.85\ 82.50 \text{ x } \$2.50\text{/kw}}{.85} = \$875 \text{ /mo.}$$

Annual Cost Saving =
($1,144 - $875 mo.) x 12 mo./yr. = $3,228 /yr.

Brief Explanation – Every inductive device (e.g. electric motors, transformers, magnetic vibrators, solenoids, etc.) has one or more magnetic coils through which flow two different components of electric power.

One component, measured in kilowatts, does the useful work and is the quantity recorded by a watt meter. It is approximately proportional to the amount of fuel burned by the electric utility.

The second component, reactive kilovolt-amperes (kvar), represents the current needed to produce the magnetic field for the operation of a motor, etc. This component does no useful work, is not registered on a watt meter, but does some heating of generators, transformers and transmission lines. Thus it constitutes an energy loss.

The relative amount of the kvar component in an electrical system is designated by the power factor (PF).

PF = Useful power/Total power = kvar

Figure 10 is a slide showing how the power factor is determined. It is a trigonometric function of a right triangle as shown below. The power factor is the cosine of the angle between true power and volt-amperes.

Figure 10. Determining Power Factor

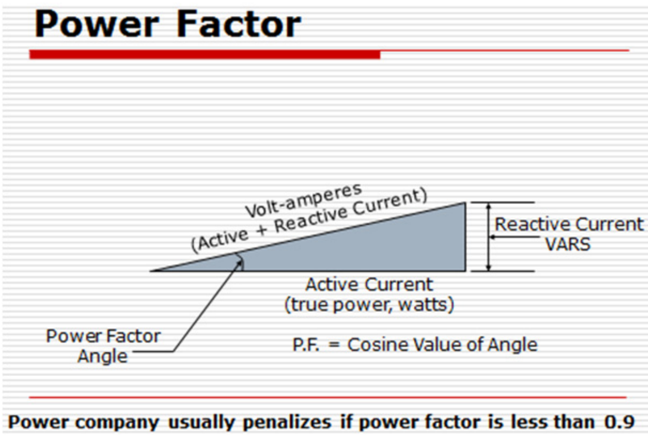
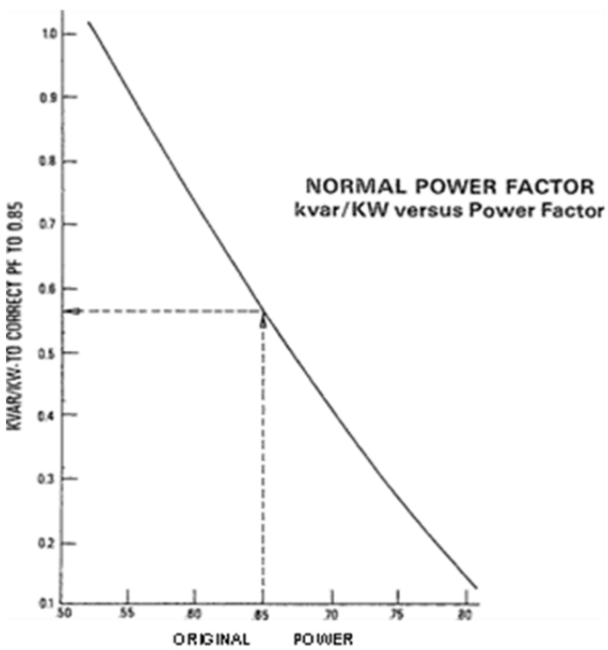


Figure 11. Normal Power Factor kwvar/KW vs. Power Factor

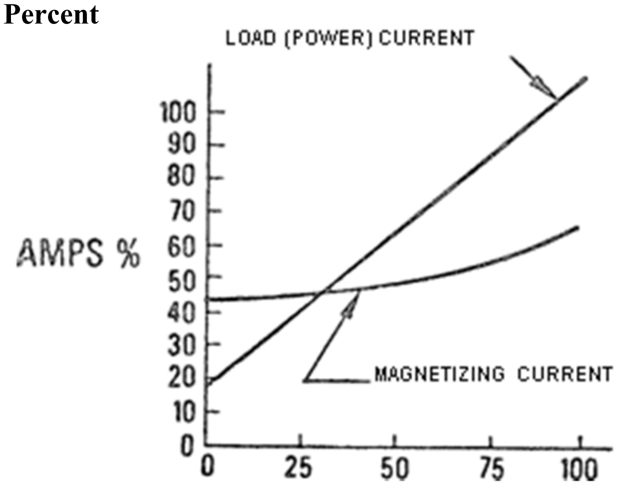


A light bulb or an electric heater, both non-inductive devices, has a power factor of 1.0. A motor, on the other hand, will typically have a power factor of 0.3 to 0.9.

Most electric utilities assume a power factor of 0.85 or more in their rate structure. If the overall power factor of a commercial customer is less than 0.85, they add a penalty in the demand charge. The usual formula, Monthly Demand Billing = Maximum demand x 0.85/Measured power factor x $/kw.

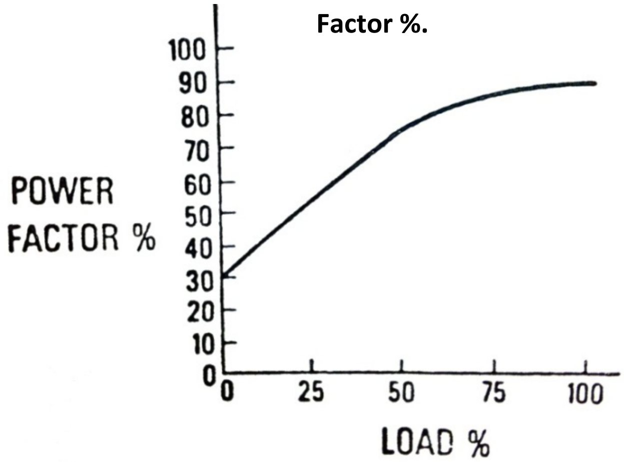
The usual cure for a low power factor is to install a capacitor in parallel with the offending machine, or across the line feeding a group of such machines. If the capacitor is properly sized, the kvar currents will not flow between motor and power plant, but will shuttle back and forth between motor and capacitor. It is important that the capacitor be as near the correct size as possible.

Figure 12. Power Factor of Industrial Motors in AMPS Percent



Suggested Actions – Determine whether or not your plant is paying a penalty charge for a lower power factor. If so, consider installing corrective capacitors. The advice of an electrical consultant or an engineer from your utility will be helpful in planning an installation. For loads greater than 50 HP, synchronous motors may be more cost effective as old motors are replaced.

Figure 13. Power Factor of Industrial Motors in Power Factor %.



5. Motor Running Not Needed

A pellet mill system consisting of –

100 HP Pellet Mill
15 HP Conditioner
½ HP Feeder
¾ HP Cooler Drive
50 HP Fan
10 HP Elevator Leg
5 HP Conveyor

A pellet mill runs an eight hour shift shut off only for 6-15 minute changeovers. The mill operates 250 days/year. Power costs are $0.055/kwh. The cooler fan, elevator leg and conveyor are not shut off during the eight hours and during a half hour lunch when the pellet mill is off. If the three motors were on a two minute timer, which cut off after the system was cleared, the savings would be:

[(15 min – 2 min) x 6] + 30 min lunch) = 108 min or 1.8 hr./day

50 HP fan + 10 HP elevator = 5 HP conveyor = 65 HP

Savings are:

1.8 hrs./day x 250 days/yr. x 65 HP

x 0.746 kw/hr. x $0.055 = $1,200/yr.

6. Electrical Invoicing and Schedules

Research of 10 utility companies billing shows ranges in the three major portions of a bill:

Demand	16-63%
Usage	34-69%
Fuel Adjustment	0-18%

What do these wide ranges tell us? There is really only one conclusion to be drawn and that is that everyone approving electrical bills should thoroughly understand electrical bills.

If the demand portion of a bill is at the 16 percent level, is it really economical to go out and purchase a demand controller at a cost of $4,000 to $40,000? If managers cannot answer questions like this, they don't fully understand what they are paying for.

BILLING METHODS

Invariably, when a group is talking about electrical energy management, there is one area that seems to have a certain mystique to it; and that is the monthly electric bill. There are some reasons why that mystique exists. One of them is the billing terminology, and another is the method of electrical billing at a feed mill. Both of these items are considerably different than that which is used in a residential bill. The following is the terminology:

1. Terminology

1. Kw – Unit of power used to express the rate of energy transfer.
2. Kwh– Total amount of energy used. Electrical energy is commonly sold by the kwh.
3. Demand – Rate at which electrical energy is delivered to or by a system for a piece of equipment, expressed in kw. A power company may bill for this as distinguished from the energy actually consumed. Demand represents investment of generating capacity, transmission and distribution equipment the power company reserves.
4. Power Factor = $\frac{\text{Mean Actual Power}}{\text{Apparent Power}}$

   Certain power companies penalize for a poor power factor. It may not be as a separate item on a bill, but it is hidden somewhere within the rate structure.
5. Fuel Adjustment – An adjustment that reflects price fluctuations in fuels purchased by the power company.

6. A simple analogy between electrical terms and automotive terms would be as follows:

Electrical	Automotive
kw	Horsepower
kwh	Fuel Consumed
Demand	Speed at any moment
Power Factors	Losses incurred operating an out of tune engine

In reviewing electrical bills, a very important item that can be most helpful in understanding a particular billing method is the rate schedule that a local power company must supply upon request. It breaks down billing procedure very clearly into several different areas, usually availability, and conditions of service, rates, determination of demand, additional conditions and contract provisions, and a rider on fuel cost adjustments. Every feed mill should have a copy of the applicable rate schedule and should periodically check it against other available schedules to assure the least cost.

2. Energy Charges or Usage
First 200,000 kwh @ 2.33¢/kwh
All over 200,000@ 1.63¢/kwh
200,000 kwh x $.0233 = $ 4,660.00
887,020 kwh x $.0163 = $14,458. 43
1,087.02 kwh = $19,118.43

Another energy company may use reactive meter reading. With reactive reading, the power company can determine the power factor at the feed mill using a company chart.

Fuel adjustment, franchise fee and state tax are standard items that are explained in the applicable rate schedule.

Keep in mind that one can be charged for power factor directly without it ever showing up as a single line item on a bill.

The important thing is that one must:

- **Understand the bill -** First, check the procedure with the appropriate rate schedule. If it is not completely understood contact your utility company. They have engineers who can explain everything in detail for clarification. At first, all utility bills seem confusing, but after the power company jargon is reduced to common terms, it can be understood.

- **Review your bill -** Never take the power company's word for it. There could be a mistake in the billing.

- **Track your monthly results -** Track demand, usage and power factor. This will provide a monthly comparison. Any sudden changes should immediately be investigated.

Following these simple steps will assist in managing electrical energy and do it without any dollar expenditures.

Two of the three bills shown had a power factor penalty. This would represent a significant loss of dollars distracting from the profits of the facility. It is a manageable situation. There are two rather simple ways to control the power factor.

1. Make sure to size and buy motors correctly. Be sure they are properly loaded. For instance, a typical 100 HP pellet mill motor may have a power factor of 84 percent at one-half load and 91 percent at full load. Be sure to take this into consideration when sizing and buying any motor. This is the easiest way to correct the power factor, and probably will result in buying a smaller motor than thought to be necessary.

2. Correct the power factor by addition of capacitors. This can be done on the primary side of the switchgear or the individual load i.e., pellet mill, hammer mill or air compressors.

If capacitor addition is necessary, suppliers can help determine sizing of capacitors needed for any particular application. Three pieces of information are needed to do this:

(1) Present Power Factor
(2) Desired Power Factor
(3) Plant Load in kw

3. Capacitor Installation at the Source – Advantages

1. Allows for close control. The capacitors are electrically tied into the motor starter; therefore, they are only in use when that particular piece of equipment is in use.
2. Eliminates system voltage increase possibilities at reduced load conditions.
3. Increases plant system capacity.

4. Capacitor Installation at the Source – Disadvantages

1. Generally cannot be accomplished, cost effectively, on motors smaller than 20 HP. Small horsepower motors are usually the worst power factor offenders.
2. More expensive per kvar installed, usually \$12 to \$16 per kvar.
3. Required preventive maintenance time is higher because each load has to be checked individually.
4. Should be applied to motors that are in heavy use only, approximately 80 percent of total operating time.

5. Capacitor Installation at the Primary Switchgear – Advantages

1. Less expensive per kvar installed, usually \$6 to \$8 per kvar.
2. Easier to maintain in that all capacitors are in one area.
3. Effective at all loads.

6. Capacitor Installation at Primary Switchgear – Disadvantages

1. Possibility of system voltage increase under reduced load conditions.
2. Does not help system capacity. It simply corrects power factor for billing purposes.

If system capacity is not a problem, capacitor installation at the switchgear is the most practical method of power factor correction. Paybacks of six months to two years are common.

DEMAND CONTROL

The second electrical energy management project is "Demand Control."

All Demand Control systems are designed to do exactly what the title implies – control the demand portion of electrical usage.

There are several items of information that should be reviewed to determine if a demand controller would benefit a particular feed mill. They are:

1. Present load (kw)
2. Dollars per kw demand charge
3. Impact of demand on usage chart
4. Demand profile
5. Kw of load that can be shed

With a rate schedule and power bill, one can determine items 1 through 3. With some assistance from the utility company, item four should be no problem. They will, temporarily, install a recording demand meter for a specific length of time and, with the data generated, plot a curve showing the actual demand. Usage figures for the same period should be collected and compared to the demand profile.If, in a heavy process load area demand vs. usage curves do not follow each other, this is an indication that equipment is being left on without any throughput—a very inefficient method of operation, not only from an energy standpoint, but also from a productivity stand point. The last item, No. 5, is very important. If you cannot shed any equipment in order to flatten the demand curve, a demand controller will accomplish absolutely nothing. If you are paying \$4 to \$7/kw demand, any peak load shedding can be very profitable and should be studied very closely.

There are many different types of demand controllers presently on the market, and they can cost anywhere from \$300 up to as high as \$30,000.

If, after analyzing a particular application, it is felt that a demand controller may be of benefit, contact any of the manufacturers for their recommendation.

Just going through this process helps in learning to ask the right questions and getting the right answers.

Never be satisfied with what just one vendor has to say. Shop around to be sure to get the hardware that is right for the application.

HOW TO DETERMINE HEAT LOSS AND FUEL LOSS

Natural Gas – Producer Gas – No. 1 Fuel Oil – No. 6 Fuel Oil

On the following pages are given Tables of Heat Losses in the burning of Natural Gas, Producer Gas, No. 1 and No. 6 Fuel Oil. From this data, fuel losses may be determined with practical accuracy.

Important: In using the tables you will need to know:

1. Percent CO2 or O2 in your flue gas.
2. Temperature of flue gas.
3. Room temperature.

With this information, proceed as follows: Subtract the room temperature from the flue gas temperature and find this number (approximately) on the scale (top row of figures). Proceed down the scale in the proper column to the line opposite your approximate CO2 or O2 percentage as previously determined (extreme left hand column). The heat loss will be found at the junction of these two lines.

Note: The figures given in the tables are based on the fuel analyses given below. This should be taken into consideration when figuring your own heat loss.

Example: Suppose you are burning natural gas and your flue gas temperature is 625^0F with room temperature at 65^0F. The difference is 560^0F. Find this number on the scale in Chart B in the Appendix. Suppose your CO2 was found to be 6 percent. Proceeding down the "560" column to the CO2 line of 6 percent, you will find the figure 30. This is the percent of total heat loss in the flue gas.

How much of this total loss is PREVENTABLE depends upon how high the CO2 content of the flue gases can be raised and how low the flue gas temperature can be reduced without producing CO or increasing other losses such as carbon (smoke) or ash pit losses.

Carrying on with our example, if, by test or computation, it is determined that the CO2 can be raised to 9.5 percent and the difference between flue gas and room temperature can be reduced to 400^0F, the total heat loss in the flue gas would be 19.5%. This represents a saving of 10.5 percent in HEAT.

The Saving in Fuel

The saving in fuel is even greater. With a 30 percent loss, 70 percent of the heat is being used while with a 19.5 percent loss, 80.5 percent of the heat is being used. The consumption of fuel at the higher efficiency is therefore equal to 70 ÷ 80.5 or 87 percent of that used when burned at the lower efficiency. The actual saving in FUEL is therefore 100 percent – 87 percent or 13 percent. It is, of course, necessary that the rate of steam generation remains constant, that the fuel quality be the same and that no CO be produced or the amount of smoke or ash pit losses increased while obtaining the higher percentage of CO2.

Table 13. Natural Gas Fuel Analysis

Natural Gas (Heat Value 1120 BTU/cu ft.) % by volume	**No. 1 Fuel Oil** (Heat Value 19750 BTU/lb.) % by weight
CH4……………………………………………………79.9	C…………………………………………86.1
C2H6………………………………………………..17.3	H…………………………..………13.6
CO2………………………………………………..0.3	O…………………………………………0.2
N3…………………………………………………....2.5	N…………………………………………0.1

H-C Ratio by Wt. = .158

Table 14. Producer Gas Fuel Analysis

Producer Gas	**No. 6 Fuel Oil**
CO……………………………………………. 24.9	C…………………………………...………… 89.36
CH4…………………………………………… 2.3	H…………………………………………..…… 9.30
C3H4…………………………………………… 0.9	S…………………………………………..… 0.90
H2...14.5	N……………………………………….……… 0.20
CO2……………………………………………… 4.7	O……………………………………….……… 0.19
N2…………………………………………… 52.7	ASH…………………………………………… 0.05
	H-C Ratio by Wt.……………………………. .1041
(Heat Value 165 BTU/cu ft.) % by volume	(Heat Value 18150 BTU/lb.) % by weight

Here is a table of combustion efficiency based on the amount of O_2 being emitted:

Table 15. Natural Gas Stack Loss (%)

Flue gas O_2 content (%)	Flue gas temperature—combustion air temperature (°F)														
	230	250	270	290	310	330	350	370	390	410	430	450	470	490	510
1.00	14.49	14.92	15.36	15.79	16.23	16.67	17.11	17.55	17.99	18.43	18.88	19.32	19.77	20.21	20.66
2.00	14.72	15.17	15.63	16.09	16.55	17.01	17.47	17.93	18.39	18.86	19.32	19.79	20.26	20.73	21.20
3.00	14.98	15.46	15.94	16.42	16.90	17.38	17.87	18.36	18.84	19.33	19.82	20.31	20.80	21.30	21.79
4.00	15.26	15.77	16.28	16.79	17.29	17.81	18.32	18.83	19.35	19.86	20.38	20.90	21.41	21.93	22.46
5.00	15.59	16.12	16.66	17.20	17.74	18.28	18.82	19.36	19.91	20.46	21.00	21.55	22.10	22.65	23.20
6.00	15.96	16.52	17.10	17.67	18.24	18.82	19.39	19.97	20.55	21.13	21.71	22.29	22.88	23.46	24.05
7.00	16.38	16.98	17.59	18.20	18.82	19.43	20.04	20.66	21.28	21.90	22.52	23.14	23.77	24.39	25.02
8.00	16.86	17.51	18.16	18.82	19.48	20.14	20.80	21.46	22.12	22.79	23.46	24.12	24.79	25.47	26.14
9.00	17.42	18.13	18.83	19.54	20.25	20.96	21.68	22.39	23.11	23.83	24.55	25.27	25.99	26.72	27.44
10.00	18.09	18.86	19.62	20.39	21.16	21.94	22.71	23.49	24.27	25.05	25.83	26.62	27.41	28.19	28.98
11.00	18.89	19.73	20.57	21.42	22.26	23.11	23.96	24.81	25.67	26.52	27.38	28.24	29.10	29.97	30.83
12.00	19.87	20.80	21.73	22.66	23.60	24.54	25.48	26.43	27.37	28.32	29.27	30.22	31.18	32.13	33.09

CHAPTER 6: METHODS OF CONSERVING ENERGY

A. Manufacturing Plant

Lighting

1. Specify sufficient size electric wiring system to handle full rated voltage at incandescent sockets and discharge lamp ballasts.
2. Consider skylights as supplemental light sources.
3. Install photocell switches to control exterior lighting for parking lots, building lights and security flood lighting.
4. Remove yellowed prismatic panels and louvers. Aged material can absorb up to 15 percent of the light.
5. Add motion sensors to turn off lights in sporadically populated space.
6. Add time clock controls to further reduce lighting after certain hours.
7. Provide separate independent light switches for particular areas in addition to the master switch. Piecemeal work can then be handled without the need to turn on all the lights.
8. Reduce lighting where it is not a safety hazard.
9. Use two levels of outside lighting, one for periods of active use and the second lower level for night time security needs.
10. Install energy efficient lighting such as T-5 and T-8 fluorescent lighting fixtures to lower operating current.
11. Consult with store engineers, designers or suppliers for an overall lighting maintenance program.
12. Even fluorescent lamps can and should be shut off for short periods—despite the widespread belief that such on-off actions greatly shorten their normally long lives. Through continued development, the life of these more efficient light sources had been extended, while competition has brought down their cost.
13. Often perimeter lighting can be replaced by natural lighting.
14. Choose the most efficient light source for each job.
15. Add task lighting over local work locations to allow the general level of lighting to be reduced.
16. Clean lamps and lighting fixtures to reduce films of dirt. Light efficiency may otherwise be cut by up to 40 percent and heat fixture heat will increase.
17. Lighting should be used only where necessary. All areas of the plant should be inspected to determine if lights are on and not needed. Inspections should be made to little frequented areas, such as electrical control rooms and pump houses, to determine if lights are on.
18. Apply light colored finishes to walls, ceilings and floors. Dark surfaces absorb more light and need higher wattage fixtures for proper lighting.

Space Heating

1. Cut off heating equipment, when not needed; when in use operate at low temperatures. Install programmable thermostats to automatically control.
2. Reduce ventilating air during unoccupied times and where safety permits. Cutting ventilating air quantities by 50 percent can reduce the power load by as much as 13 percent. Check applicable codes.
3. Use modular heating boilers, so that when heating requirements are lower, only one smaller boiler will be fired up and it will operate close to its maximum efficiency.
4. Consider the use of infrared heaters in high bay areas and warehouses. Infrared heat provides comfort and prevents condensation on stored materials. It requires less fuel than other kinds of heating, because it heats solid objects in the radiation path without having to heat the air in the room. Savings of more than 20 percent, when compared to conventional heating, are common.
5. Check with equipment suppliers or qualified engineers to determine the extent to which the heating, ventilating and air conditioning equipment is optimally suited for the job to be performed. In many cases HVAC equipment is oversized and occasionally one boiler in a multi-boiler system can be eliminated by more efficient use of the others.
6. Have heating equipment checked for efficiency at least four times per year.
7. Waste heat from burner stacks and industrial processes can in many cases be recovered and used.
8. Heated areas should be checked to determine if they are being overheated. Provision should be made for lowering the heat when the area is not in use.
9. Keep delivery and warehouse doors closed when not in use.
10. Keep internal doors between heated and unheated areas closed when not being used.
11. Install air curtains or rolling doors on high use openings.

Building Insulation

1. Add air curtains to entrances, dock seals in warehouse bays and automatic door closers to prevent heat loss.
2. Install energy efficient glass where window area is large and climatic conditions severe.
3. Inspect window and door seals for leakage. Install weather stripping and caulking in all heated or air conditioned buildings.
4. Install smaller windows and heavier insulation on the north wall, with larger (shaded) windows, conversely, on the south side, which will receive the sun's rays.
5. Make extensive use of high-grade insulation in the out walls and roof. As a result, only a third as much heat will pass through the outer skin compared with conventional uninsulated walls of brick, concrete or glass.
6. Some windows that open will permit natural ventilation on mild days in the spring and fall. Only a few windows need to be operable on each floor and exposure, since the fewer windows that open the less leakage of heat in winter and cool air in the summer. In most buildings, air infiltration doubles the heating and air conditioning load.
7. Use storm windows and doors where appropriate. In some cases, an entry room can be constructed as a buffer zone for the heated indoors.
8. Use manually operated shading devices for those windows exposed to the direct rays of the sun. The most effective shades are mounted on the outside.
9. Use fewer and smaller windows in construction because of reduced size of needed space conditioning system and lower operating costs.
10. Use curtains or shades for window insulation.
11. Keep windows free of obstruction for maximum sunlight in winter.
12. Spray-on insulations or insulation board can be applied to the ceiling and high enough up on the wall where no one can come in contact with them (the spray-ons have a rough texture). Such treatment is comparatively inexpensive. Insure that all fire and safety regulations are observed with these materials.

Electrical Power

1. Reschedule for "off-peak periods." Consider running selected operations during off-peak periods specified by the electric utility.
2. Keep wiring in good condition to cut power loss.
3. Keep amps at lowest possible energy input.
4. Investigate demand response programs with the electrical provider. By turning off non-critical loads during periods of high demand, the company can receive payments for reducing the demand.
5. Schedule proper loads so that equipment can perform at optimal levels of efficiency. Survey the plant for improperly loaded motors, etc.
6. Investigate the practicality of heating liquids by immersion or submersion heating rather than under firing.
7. Use direct flame impingement or infrared heating for chamber-type heating where applicable.
8. More than one large motor should not be started at the same time. For instance, when starting more than one pellet mill, several minutes should elapse between starts. This is to control starting current demand.
9. Equipment not in actual use should not be permitted to operate.
10. Check and maximize the power factor in the plant. Make sure that plant is equipped with enough properly functioning capacitors for correcting the power factor.
11. Consult with the utility or suppliers for survey of total plant energy load. A balance, or system, approach should be considered rather than concentration on a single area.
12. Convert to higher voltage where practical.
13. Other manufacturing facilities are adding under and overvoltage protection devices to machines that would be damaged by voltage drops and peaks (the latter occurring when a heavy motor ceases operating or lightning strikes the line). These inexpensive devices protect equipment from sudden peaks and dips.

Machinery Operation

1. Operate all machinery at optimum capacity.
2. Special attention should be given to hammer mills. They should operate at full load. Do not use excessively worn hammers or screens.
3. Turn off the power supply to machines not in use. This includes turning power off during lunch and other breaks in work schedule. Train operators to shut off conveyors, feeders, sewing machines, etc., when they leave their stations.

4. Adjust pellet mill rolls daily to improve operating efficiency and replace dies as pellet quality decreases.
5. You can reduce the maximum pressure setting for compressed air without affecting your operation. A reduction of 5 lbs. will save energy.
6. Maintain electrical equipment in peak running order for maximum energy efficiency.
7. Turn off forklift and other vehicle motors when not being used.
8. Conduct a compressed air draw down test at least monthly. By recording the time the air system to reach a lower air pressure with the compressors off, one can estimate the annual value of the air leaks.

Steam

1. Repair or replace leaking steam valves, regulators and repair or replace leaking steam pipes.
2. Inspect hot water tank temperature setting; reduce if possible.
3. Adjust steam in pellet mill mixing chamber and rolled grain steamer to keep live steam from escaping to the atmosphere.
4. Over weekends and long plant shutdowns, have boilers revert to low fire or low steam pressure.
5. Clean heating surfaces of boilers on a routine basis (both water and fire side).
6. Check condensation return—return as much as possible.
7. Tune boiler to secure optimum fuel-air ratio at least monthly.
8. Install direct-fired hot water heaters to generate hot water.
9. If once through cooler water is used in compressors, install a system to use it as boiler make up water.
10. Utilize optimum production on all equipment using steam.
11. Lower the low pressure settings on your boilers. Low pressure can be held to 20-25 psi.
12. Install a day/night or day/weekend switch to allow the boiler to operate at a very low pressure during non-production times.
13. Use time clock controls on heating devices and motors where practical and automate combustion system controls, which are more responsible and flexible.
14. Direct or confine flames to the spot where needed. Optimize flame geometry to help accomplish this.
15. Seal all cracks in heating equipment, no matter how small. Replace heat warped doors.
16. In plants with high pressure condensate, install high pressure condensate pumps to return condensate without flashing.
17. Check for complete insulation on all steam lines.
18. Close or reduce openings in equipment.
19. Examine burners. Black exhaust from your stack, for instance, will tell you that your burner is not well regulated.
20. Utilize waste heat for space conditioning and preheat boiler feed water or incoming materials that are to be heated.
21. Install recuperates on combustion equipment to preheat incoming combustion air.
22. Limit the amount of fuel you use so that flames do not reach out to flues or through the furnace openings, where they're being wasted.
23. Close doors on all gas-fired equipment quickly. Preheat only as much as needed, and not long hours beforehand.
24. Review production schedules to avoid short runs. Try to consolidate short runs so that boilers do not have to cool off in between.
25. Steam "plumes" are evidence of leakage, and thus energy waste, in processing plants. Because "they've always been there" too many companies ignore this common condition that amounts to thousands of dollars of lost energy each year. And all it takes to remedy this "minor" problem is an inexpensive steam trap.
26. When steaming railroad tank cars, a valve should be placed on the end of the discharge line. The valve should be opened sufficiently to permit the condensate to drip with only an occasional small puff of steam. The steaming of tank cars without restriction of the discharge line would consume considerable steam.
27. Inspect the pellet conditioner for proper operation and optimal steam utilization.
28. If a trap is not functioning properly, it could fail to remove the condensate or emit steam along with the condensate. From the standpoint of conserving energy, one should be concerned with the emitting of steam.
29. Intensify boiler maintenance. In particular, make sure that all scale is removed from waterside furnaces. Caulk cracked or eroded areas of refractory surfaces. Check all gaskets on boiler doors to make sure the seals are tight. Keep all combustion equipment clean, from burner surfaces to flues.

30. Check frequently for the presence of carbon monoxide in the furnace. Not only do OSHA regulations permit no more than a trace of this dangerous by-product of incomplete combustion, but CO also means that fuel is being wasted (combustion analysis kits are available that check for CO). CO can be eliminated by preheating of the air entering the furnace, and by closing off all cracks.

Pipes and Tanks

1. If you can store your liquids in heated vessels, bypass any intermediate preheated tanks.
2. Insulate liquid storage tanks that are heated.
3. Insulate hot liquid pipes, furnaces and other heated containers where possible. Keep openings in equipment closed and sealed and use reflective heat shields where openings are necessary.
4. Check insulation on all fat, molasses and liquid tanks and keep heat at specified levels so as not to overheat.
5. Reduce temperature of liquids in storage.

Scheduling

1. Use natural drying of grains to the optimum.
2. Schedule all feed runs so as to get long runs, and avoid stops and starts as much as possible. This pertains to unloading, loading, mixing, pelleting and cleanout.
3. Avoid short runs on thermal process equipment and shutdown or idle equipment during production interruptions.
4. Shift production of part or all of the energy-intensive products to the night shift, when demand for electricity usually drops.
5. Subcontract out production of the energy-intensive products to a contractor in a region with abundant sources of needed energy.
6. Study the cost of special processing (steam flaking grains, pelleting, double screening pellets, crumblizing and screening, etc.) requiring relatively large amounts of energy to be sure the additional processing is justifiable.

B. OFFICE BUILDING

Insulation

1. Install vestibules or storm doors.
2. Install energy efficient windows and doors in offices and other heated areas.
3. Install weather stripping; check for other air filtration that can be plugged.

Heating—Air Conditioning

1. Turn off heat in unoccupied areas such as halls and storerooms at times of non-occupancy.
2. Observe emergency building temperature regulations; winter – maximum 65°F, summer – minimum 78°F.
3. Open curtains and shades during sunshine and close at night to contain heat.
4. Use indoor-outdoor carpeting wherever possible to keep floors warmer.
5. Consult with equipment suppliers for optimum HVAC system.
6. Concentrate off-hours work in small areas of building when practical so heat can be turned off in remaining areas.
7. Keep doors and windows closed to conserve heat.
8. Energy is expended to heat or cool, fresh (outdoor) air drawn into buildings for ventilation. The air in the building could be refreshed by filtering. Reduce air drawn to 3 or 4 cfm per occupant. Follow local codes.
9. Reduce or eliminate heating or cooling during those times when the space is unoccupied. Time clock controls can be very useful here. Programmable thermostat.
10. Use a heat exchanger through which outgoing air is exhausted and incoming air is drawn in through separate ducts. In winter, the outgoing warm air will raise the temperature of the incoming cold air, with the opposite beneficial effect in summer.
11. Consider an incinerator that burns waste paper or garbage to heat water.
12. Keep air-cooled and water-cooled condensers clean.
13. Keep filters on heating/ventilating/air conditioning equipment clean. Change as needed.
14. Reduce air conditioning usage in warm climates, and advise personnel to dress lightly.
15. Install an arrangement of glass "solar cells" on the roof to trap energy from the sun's rays for heating of water.
16. Plant coniferous (evergreen) trees paralleling the north wall, which will be hit by prevailing cold winds in the winter, with deciduous trees (which lose their leaves in winter) along the other walls to block the sun's rays in summer, but permit them to come through in winter.
17. Install a cold water reservoir to lower the peak load on air conditioners. At night, when the air conditioning load is light the system could be cooling a lot of water that is stored in the insulated metal or concrete tank. During the day, the icy water is drawn off to help cool the building.
18. In summer, the roof of a building is a major source of heat entry, adding greatly to the air conditioning load, or to the discomfort of those in un-air conditioned buildings. One way to cut down on this undesirable heat flow is the use of white spar on roofs instead of the black slag commonly used.
19. Install insulation. Rapidly increasing fuel costs have made insulation cost effective in more applications than ever before.

Lighting

1. Greater use should be made of natural light. Photoelectric controls are available that automatically shut off lights when outside is sufficient.
2. Even fluorescent lamps can and should be shut off for short periods—despite the widespread belief that such on-off actions greatly shorten their normally long lives. Through continued development, the life of these more efficient light sources has been extended, while competition has brought down their cost.
3. Post instructions for proper operating, cleaning and maintenance procedures and audit custodial staff compliance periodically.
4. Wash walls and ceilings periodically and repaint as necessary with light color paint.
5. Carefully arrange lighting fixtures with dimmer general lighting but brighter "task lighting." As a result, the electricity required for lighting should be reduced, also meaning that the air conditioning plant need not be as large.
6. It may seem like cost cutting by the "paper clip method" when we tell you that saving electricity involves shutting off lights. But in fact, 50 percent to 60 percent of the electrical energy consumed in office buildings (not including heating and cooling) is due to lighting—and a proportionately large amount in factories also.
7. Time clock controls or photocell switches should be considered for exterior and decorative lighting. In many cases, most indoor lighting close to the perimeter of the building can be turned out during the daytime.
8. Install motion sensors to turn off the lights in unoccupied areas.
9. Install T-5 and T-8 florescent lighting fixtures.
10. Install lighting fixtures to obtain the correct lighting level.

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