proceedings

Energy Management Workshop

at Virginia Tech

Blacksburg, Va.
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PROCEEDINGS

ENERGY MANAGEMENT WORKSHOP

JULY 20 - 22, 1977

BLACKSBURG, VIRGINIA

CO-SPONSORED BY

TECHNICAL RESOURCES
EXTENSION DIVISION
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

AND

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OFFICE OF ENERGY PROGRAMS
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U. S. DEPARTMENT OF COMMERCE

EDITOR:

ROBERT H. PUSEY
DIRECTOR, TECHNICAL RESOURCES
EXTENSION DIVISION
VPI&SU

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INTRODUCTION

In our efforts to develop and implement energy conservation programming for business, industry and local governments in Virginia, we identified the need for staff of Virginia Tech to obtain in-depth information on specific energy management and conservation techniques. At the same time, we recognized that other individuals and organizations could utilize such information. Thus, we envisioned a series of workshops to fulfill these needs.

This Energy Management Workshop is the first of such a series. It was designed to provide university extension personnel, governmental officials, and plant and manufacturing engineers with practical methods for reducing energy waste in public, commercial, and industrial buildings. The specifics of the workshop program are presented below.

WORKSHOP PROGRAM

Wednesday, July 20

Coping with the Energy Crisis: The National Energy Plan and It's Impact - Patricia Spencer

Energy Management Program - Robert Massey

Industrial Building Standards - Neil Patterson

Commercial Building Standards - James Grinnan

Development of Walk-Through Teams - John Hart

Thursday, July 21

Life Cycle Costing - Charles Dorgan

Heating, Ventilating and Air Conditioning - Goodwin Taylor

Lighting - Robert Dorsey

Boilers - William Axtman

Engineering Conservation Practices in Industry - Donald Hillier

Waste Heat Recovery - Goodwin Taylor

Utilities and Energy Management - Jack Kepner

Heat Pumps - C. H. Long

Computer Energy Analysis Program - Neil Patterson

Friday, July 22

Computer Based Building Controls - Michael Shehadi

Energy Related Publications - Roy Stamm

Adaptation of Codes and Standards - James Shivar

University Interface with State and Local Government and Industry on Energy Problems and Issues - Robert Stephenson

We are indeed grateful to the Office of Energy Programs of the U. S. Department of Commerce for their assistance in identifying and securing well-qualified speakers and their financial support of the workshop.

Every effort has been made to preserve the speakers' material as presented at the workshop. These proceedings have been typed and printed directly from author prepared copy without any technical review. The views expressed are those of the authors.

The Editor

ESTABLISHING AN ENERGY MANAGEMENT PROGRAM

Robert G. Massey
Program Officer
Industry/Association Programs
Office of Energy Programs
U.S. Department of Commerce
Washington, D. C. 20230

INTRODUCTION

This discussion presents, in outline form, the elements needed for the initiation and implementation of an energy conservation program. It may be used as a guide to design your own program, tailored to your company's requirements and capabilities. Detailed information on the elements of this program is given in the publication, "Energy Conservation Program Guide for Industry and Commerce" NBS Handbook 115.

PROGRAM OUTLINE

I. Top Management Commitment

A. Inform line supervisors of:

1. The economic reasons for the need to conserve energy
2. Their responsibility for implementing energy saving actions in the areas of their accountability

B. Establish a committee having the responsibility for formulating and conducting an energy conservation program and consisting of:

1. Representatives from each department in the plant
2. A coordinator appointed by and reporting to management
NOTE: In smaller organizations, the manager and his staff may conduct energy conservation activities as part of their management duties.

C. Provide the committee with guidelines as to what is expected of them:

1. Plan and participate in energy saving surveys
2. Develop uniform record keeping, reporting, and energy accounting
3. Research and develop ideas on ways to save energy
4. Communicate these ideas and suggestions
5. Suggest tough, but achievable, goals for energy saving
6. Develop ideas and plans for enlisting employee support and participation
7. Plan and conduct a continuing program of activities to stimulate interest in energy conservation efforts

D. Set goals in energy saving:

1. A preliminary goal at the start of the program
2. Later, a revised goal based on savings potential estimated from results of surveys

E. Employ external assistance in surveying the plant and making recommendations, if necessary

F. Communicate periodically to employees regarding management's emphasis on energy conservation action and report on progress

II. Survey Energy Uses And Losses

A. Conduct first survey aimed at identifying energy wastes that can be corrected by maintenance or operations actions, for example:

1. Leaks of steam and other utilities
2. Furnace burners out of adjustment
3. Repair or addition of insulation required
4. Equipment running when not needed

B. Survey to determine where additional instruments for measurement of energy flow are needed and whether there is economic justification for the cost of their installation

C. Develop an energy balance on each process to define in detail:

1. Energy input as raw materials and utilities
2. Energy consumed in waste disposal
3. Energy credit for by-products
4. Net energy charged to the main product
5. Energy dissipated or wasted
NOTE: Energy equivalents will need to be developed for all raw materials, fuels, and utilities, such as electric power, steam, etc., in order that all energy can be expressed on the common basis of Btu units.

D. Analyze all process energy balances in depth:

1. Can waste heat be recovered to generate steam or to heat water or a raw material?
2. Can a process step be eliminated or modified in some way to reduce energy use?
3. Can an alternate raw material with lower energy content be used?
4. Is there a way to improve yield?
5. Is there justification for:

a. Replacing old equipment with new equipment requiring less energy?
b. Replacing an obsolete, inefficient process plant with a whole new and different process using less energy?

E. Conduct weekend and night surveys periodically

F. Plan surveys on specific systems and equipment, such as:

1. Steam system
2. Compressed air system
3. Electric motors
4. Natural gas lines
5. Heating and air conditioning system

III. Implement Energy Conservation Actions

A. Correct energy wastes identified in the first survey by taking the necessary maintenance or operation actions

B. List all energy conservation projects evolving from energy balance analyses, surveys, etc. Evaluate and select projects for implementation:

1. Calculate annual energy savings for each project
2. Project future energy costs and calculate annual dollar savings
3. Estimate project capital or expense cost
4. Evaluate investment merit of projects using measures, such as return on investment, etc.
5. Assign priorities to projects based on investment merit
6. Select conservation projects for implementation and request capital authorization
7. Implement authorized projects

C. Review design of all capital projects, such as new plants, expansions, buildings, etc., to assure that efficient utilization of energy is incorporated in the design.
NOTE: Include consideration of energy availability in new equipment and plant decisions.

IV. Develop Continuing Energy Conservation Efforts

A. Measure results:

1. Chart energy use per unit of production by department
2. Chart energy use per unit of production for the whole plant
NOTE: The procedure for calculating energy consumption per unit of product is presented in "How to Profit by Conserving Energy"
3. Monitor and analyze charts of Btu per unit of product, taking into consideration effects of complicating variables, such as outdoor ambient air temperature, level of production rate, product mix, etc.

a. Compare Btu/product unit with past performance and theoretical Btu/product unit
b. Observe the impact of energy saving actions and project implementation on decreasing the Btu/unit of product
c. Investigate identify, and correct the cause for increases that may occur in Btu/unit of product, if feasible

B. Continue energy conservation committee activities

1. Hold periodic meetings
2. Each committee member is the communication link between the committee and the department supervisors represented
3. Periodically update energy saving project lists
4. Plan and participate in energy saving surveys
5. Communicate energy conservation techniques
6. Plan and conduct a continuing program of activities and communication to keep up interest in energy conservation
7. Develop cooperation with community organizations in promoting energy conservation

C. Involve employees

1. Service on energy conservation committee
2. Energy conservation training course
3. Handbook on energy conservation
4. Suggestion awards plan
5. Recognition for energy saving achievements
6. Technical talks on lighting, insulation, steam traps, and other subjects
7. "savEnergy" posters, decals, stickers
8. Publicity in plant news, bulletins
9. Publicity in public news media
10. Letters on conservation to homes
11. Talks to local organizations

D. Evaluate program

1. Review progress in energy saving
2. Evaluate original goals
3. Consider program modifications
4. Revise goals, as necessary

A VEHICLE FOR IMPROVING ENERGY MANAGEMENT FOR BUSINESS AND INDUSTRY

Herbert M. Eckerlin and Albert S. Boyers
North Carolina State University
Raleigh, North Carolina 27607

INTRODUCTION

The Industrial Extension Service (IES) of the School of Engineering of North Carolina State University has developed a new program of technical assistance in the area of energy. This program is designed to assist small business and industry in improving their utilization and management of energy resources.

Implementation of this program is being accomplished in two phases. The first phase -- called the "walk-through assessment" -- consists of an IES staff member making an on-location, qualitative audit of the sources of major energy losses within requesting companies. This is followed by a written report which outlines the major corrections needed to reduce energy consumption and improve energy management. The "walk-through assessment" program has been in operation for about nine months. During that time, over sixty organizations have been visited. The results to date are encouraging.

In the projected second phase of the program, the major energy losses will not only be identified but measurements will be made to help assess these losses. Based on this information, an analysis will be made and the results summarized in a final report, along with recommendations for reducing energy losses, the approximate cost for implementing the recommendations, and the expected savings. Throughout both phases of the program, the assisted companies will be encouraged to use the National Bureau of Standards Handbook 115 as a guide in establishing and maintaining their own energy management program.

This service is offered at no charge to all North Carolina business and industry by the Industrial Extension Service. However, the focus of the program is on small companies, since these companies -- with their limited technical and financial resources -- are least able to cope with the problems associated with energy management. It is envisioned that this program will be the beginning of a series of extension activities (extension education, referral services, and additional technical assistance) to aid North Carolina industry in reducing its energy needs.

WALK-THROUGH ASSESSMENT PROGRAM

Approach

A highly qualified engineer with broad, energy-related experience visits a facility and, accompanied by company representatives, makes a thorough plant tour. During this walk-through, the company representative usually describes the plant operation -- and during the ensuing questions, explanations, and discussions, new perspectives and opportunities for saving energy are often uncovered. The plant visit (which includes the walking tour and meeting with various people) usually takes from 1 1/2-3 hours depending upon company size, complexity of operation, and the ability of company representatives to convey information. Consequently 2 or 3 companies can be visited in one day if they are located close together.

Types of Companies

Based on experience in the walk-through assessment program, the companies visited can be conveniently subdivided into three broad groups with respect to their energy conservation activities.*

Large companies (>500-1000 employees), technically intensive with full-time, qualified staff concerned with energy conservation.

Intermediate to large size companies (>250 employees) with one individual who, among other duties, is responsible for energy conservation activities. (Efforts at energy conservation are not based upon measurement or data but usually consist of the application of a checklist of ideas.)

Small to intermediate size companies (<250 employees) with no one qualified to work in energy conservation or employed in that capacity.

The last two groups of industry predominate in North Carolina (and thus in the companies visited) and consequently can profit from a program like the "walk-through assessment" program.

Since companies request the "walk-through", their representatives are usually very helpful and appreciative during the plant tour. Occasionally a plant tour is conducted by someone other than the requesting manager, and that person may at times appear defensive. Also, in some instances, the company environment (both internal and external) is either so polluted or processes so deteriorated that rational technical and economic priority dictate that they defer energy conservation considerations until other problem situations are resolved.

Reports To Company

After the in-plant visit, a report is written for the company to summarize observations and recommendations. The report might include the results of observations or engineering calculations, information from various references, or referrals to people or agencies. The report is written in letter form and consists of a series of paragraphs under various headings. A report varies in length from 2-6 single spaced, type written pages and usually takes 3-5 hours to write.

The following list represents a cross-section of recommendations from typical reports:

1. Recommendations pertaining to the establishment of energy conservation programs.

*The bulk of the facilities visited are manufacturing plants. A few commercial buildings (insurance, shopping center) and a hospital have been visited but are excluded from the above.

Record of energy usage. As a prelude to a formal energy conservation program, you should begin to keep plant and departmental records of energy usage (fuel, electricity, water, steam, etc.) on a monthly basis and compare these to production levels. This information is not difficult to record and will give you a valuable perspective on the cost level and trends involved in energy usage per unit of production.

Establishment of a company-operated energy conservation program. The most *important* step in conserving energy is the establishment of an ongoing energy conservation program, with a program director who is given top management support. *Top management support is essential in obtaining employee cooperation and participation.* The essential elements of such a program are given in a recent government publication, "Energy Conservation Program Guide for Industry and Commerce"--NBS Handbook 115--put out by the U. S. Department of Commerce.

I believe your organization is totally committed to energy conservation, and now simply needs to establish and publicize an official program. It will prove advantageous if all employees of the plant *are conscious* that there are ways in which they can help. Most employees probably will not consider the "big picture," tending to feel that energy conservation ends at the front door. If energy conservation is to work, employees must be *reminded regularly* about energy conservation ideas pertaining to both the company and their lives outside of working hours. Some suggestions could be implemented with some modification in the employee habits. Suggestions falling in this category relate to: bath water temperature, dripping faucets, room temperature levels, deactivation of electrical equipment when not in use, reduced use of products manufactured from petroleum or wood, use of the refrigerator, and policies on washing. Interesting suggestions which require some equipment modification are (a) reuse of wash water for flush toilets, and (b) replacement of commodes with urinals in men's restrooms.

To more fully involve and motivate employees in the business of energy conservation, you might want to put up ENERGY SAVING SUGGESTIONS boxes throughout the plant, and then give awards for those ideas which result in substantial savings.

NBS Handbook 115 indicates that one of the first steps of any energy conservation program is keeping a monthly record of energy consumption. For employee information and motivation, you could place large bar graphs of this information in conspicuous locations throughout the plant.

2. Recommendations pertaining to changes in operations and/or procedures.

Open doors. During the walk-through, we found a number of open doors leading to the outside atmosphere. As you know, large quantities of conditioned air (heated and cooled) escape through these open doors -- and this lost air represents a significant energy (and dollar) loss. I realize that the "state" of a door is the responsibility of the manager whose group is working in the area, but, somehow, these employees must be made aware of the significance of this action.

I understand that this is a difficult management problem, but it must be addressed since heating and air conditioning account for a large percentage of your energy bill.

Control of thermostats. As you know, employee control over individual thermostats can create serious inefficiencies in your heating and/or air conditioning systems. For obvious reasons, you cannot remove these thermostats. Some companies have gotten around this personnel problem by rewiring the system and placing the actual control in some other location.

Spring and fall operation. During the spring and fall, the climate in eastern North Carolina is quite mild. Rather than heating and/or air conditioning during these seasons, you should consider ventilating your entire plant with outside ambient air. The amount of fresh air introduced into the plant would be controlled by roof mounted exhaust fans operated in conjunction with certain outside doors. This policy has been adopted by a number of companies in your area and has resulted in significant energy savings.

Fix/maintain leaks in air, water, steam lines. I realize the difficulty of starting and maintaining a periodic maintenance program aimed at the above, particularly in some of the manufacturing operations, in the summer, however, I think you may be overlooking a considerable savings. For instance, Charles Norton of General Motors in a paper entitled, "How to Survey Your Plant for Energy Waste" reported first year savings in an energy conservation program as follows:

> "In 1972, on a production unit basis, Livonia's water consumption declined 30%, steam was reduced 23%, natural gas 19%, and electricity 3%.
>
> It is important to note that the reductions achieved to date are not the result of technological advances or major rework and redesign of our facilities and equipment . . . To date we have relied upon and obtained quite satisfactory results from some rather simple but vigorous maintenance and plant engineering efforts directed at finding and fixing the energy leaks in our plants."

Similarly there are a number of examples (ECO's) in NBS Handbook 115 that indicate the monetary savings of repairing leaks in compressed air lines, steam lines, faulty steam traps, etc.

Good housekeeping. As you know, effective energy conservation is the accumulation of numerous small steps -- in a sense, it often comes down to good housekeeping. It involves such items as repairing small steam leaks, replacing insulation that has fallen off the toaster, insulating all hot water and steam lines (no matter how small), etc. In the industrial setting, I realize that most attention must be given to maintaining or improving production. However, in this day of continually increasing energy costs, I believe considerably more attention should be given to such mundane tasks as equipment maintenance -- more specifically all equipment should be kept at an energy efficient level of operation.

3. Information from other sources.

Ventilation hoods-waxing area. The one hood you have here I believe is undersized. Enclosed is a copy of the recommended ratio for a canopy hood. Note the hood should overhang 40% of the height the hood is above the process.

In most cases you should install an individual ventilation pickup at the source rather than use a general overhead fan. Consequently, I would put a hood over the small waxing machine.

4. Recommendations pertaining to building modification.

Plant room (and die room) - install suspended ceiling. Particularly in the plant room where environmental conditions are getting high (65% relative humidity, 76° F. temperature) you should install a suspended ceiling. You don't need the overhead space and a new ceiling will reduce the room volume by around 40% and make it much easier and cheaper to maintain appropriate conditions in these rooms.

Shipping/receiving docks. You lose a tremendous amount of "heat" in the winter by having loading docks adjacent to the building which are open and prohibit the use of "dock curtains," etc., to reduce infiltration of air. You could do one of two things. First, you could build an enclosure on the docks out to the edge so that they have a typical entry way on which you can install dock curtains. Or, second, you can remove the loading docks so that the trucks can back up to the building and be shielded with dock curtains.

Exposure between air conditioned and un-cooled areas. You have a number of situations where air conditioned areas share a common open side with un-air conditioned areas in which there is high process heat release. You exhaust from the unconditioned areas to remove fumes and to reduce the temperature levels but, in turn, attempt to keep the windows closed. This is classic example of "operating at cross purposes."

It is my opinion that you should consider isolating conditioned areas from unconditioned areas, say, with movable partitions and installing considerably more ventilation capacity in the heat release areas. In this way you could open all the windows in these areas in the summer. Hopefully, the result would be a very large reduction in the cost of air conditioning, a small increase in fan electrical consumption, and cooler and happier people in both areas. Of course, I think you should seek information from other plants operating under similar circumstances as well as from air conditioning and ventilation consultants.

5. Recommendations pertaining to process changes.

Preheating combustion air. Another approach to reducing the radiant heat loss from the tunnel surface to the atmosphere is to enclose part of that surface (wall) with a pressurized air duct. In effect, what I am suggesting is that the surface and duct form an air preheater--and the resulting heated air be used as combustion and/or dryer air. Two regions of the furnace envelope that appear particularly suited for this approach are the undercar zone and the burner zone. Both zones would have to be pressurized--such that the car bearings and kiln burners are kept reasonably cool.

Most side-fired units use ambient air as combustion air to the burners. If this combustion air were heated to 550° F. in the preheaters suggested above, the following energy savings would result:

FUEL: Bunker C oil
HHV = 152,000 BTU/gal or 6.58 gal/10^6 BTU

Assume: 20% excess air on oil firing → 900 lb. air/10^6 BTU. For each 10^6 BTU fired, you could expect to save approximately 100,000 BTU or .66 gallons of oil if the combustion air were preheated to 550°F.

I'm sure you will agree that a 10% saving is significant.

Kiln stack temperature. Stack temperature is one of the most important variables which influence the energy efficiency of a tunnel kiln. Under your present operating conditions, the temperature of the flue gas leaving your stack varies from 450° to 550°F.--which is much too high for efficient operation.

For oil firing, I would recommend a stack temperature of 325° to 350°F. The minimum temperature limitation of 325° F. is imposed by the fact that the flue gas contains condensable vapors that deposit on the stack duct work, in the liquid phase, if the plant temperature falls below the dew point. In the case of sulfur bearing oil, sulfur trioxide may be formed which, in the presence of the water vapor, may in turn form sulfuric acid. The dew point of flue gas containing this acid is much higher than if water alone were present.

For natural gas firing, a somewhat lower stack temperature can be tolerated.

6. Recommendations pertaining to the purchase of new equipment.

Heat recovery systems. Since your present kiln exit temperatures are considerably higher than 325° F., you may want to consider a heat recovery system in the base of the stack. In selecting the heat exchanger appropriate for your facility, you should consider the following factors:

How will the recovered heat be used?
Preheated combustion air → heat wheel, heat, pipe, tubular airheat
Heated air for space heating → heat pipe or tubular air heater (heat wheels usually have some leakage associated with them)
Heated water for process or feedwater heating → economizer

What is the terminal difference of the heat exchanger?
Terminal Difference = (Flue Gas Temperature Leaving Heat Exchanger) - (Fluid Temperature Entering Heat Exchanger)
Note: For effective utilization of heat exchanger surface, you should design for a terminal difference of +200° F.

How large is the heat exchanger? Is sufficient space available? Will the existing structure support the heat exchanger?

What fuels will be fired in the furnace? The resulting flue gas will effect:
(a) the type of heat exchanger surface
(b) the surface spacing
(c) the tendency to plug the surface
(d) the need for soot blowers
(e) the tendency to corrode the heat exchanger surface.

Compare the cost of each type of heat exchanger on an equal recovery basis. Consider both equipment and installation costs.

Is the heat exchanger compatible with existing equipment? Can the existing fans handle the additional draft loss and/or air pressure drop?

What additional operating costs will the heat exchanger create? For example--what is the draft loss across the heat exchanger and what are the operating energy costs resulting from this additional loss?

How much energy (and money) will the heat exchanger save? As a general rule, you can expect to increase the boiler efficiency by approximately 1% for each 40° F. reduction in stack temperature.

MEASUREMENT PROGRAM

This second phase of the overall IES energy assistance program is projected for the future. Funds are being pursued with which to buy instruments to make measurements in the key areas of combustion, stack temperature, heating, ventilating, lighting, and electrical motors. In this case, the visiting engineer would spend a minimum of one day in a facility, observing operations, asking questions, looking at records, and making physical measurements. Based on this information, an analysis will be made and the results summarized in a report, along with recommendations and anticipated savings. Approximately two weeks after the initial inspection, the IES engineer will personally review the report with the company representatives and relate the losses to specific sections in NBS Handbook 115.

In addition to initiating an energy conservation plan, each company is requested to provide IES with a quarterly record of its energy consumption--and when possible relate this consumption to production quantities (on an absolute or relative basis) and degree days. Because uniform record keeping, reporting and energy accounting are important factors in an effective energy conservation plan, this information should be readily available.

Six months after the initial measurement and walk-through survey, each company will be contacted by the inspecting engineer--either by phone or visit--to evaluate the company's progress in energy conservation.

CONCLUSIONS

Educational programs in energy conservation tend to be applicable to people knowledgeable enough in energy conservation to extend their own abilities. As a general rule, these programs do not reach the smaller industries that oftentimes function without trained engineers. Consequently, direct technical assistance is deemed to have the most immediate effect on the energy saving capability of small companies. Also it is hoped that the money saved will serve as an inducement to these companies to consider energy conservation more seriously and eventually set up their own on-going energy conservation programs.

There are many situations in the companies visited that are tremendously wasteful of energy and yet are simple and inexpensive to rectify. Many of these situations remain unknown, usually because the affected individuals are not aware of the technical concepts involved. Even in cases where energy waste is known, the manager of a small company is often reluctant to act--simply because he is not technically informed and therefore uncertain of the possible consequences of his actions. This individual desperately needs competent technical assistance if he is to stay in business.

The IES program of direct technical assistance in energy conservation shows promise of being an effective means for identifying energy waste and promoting energy conservation.

BIOGRAPHIES

Dr. Herbert M. Eckerlin is Assistant Professor and Extension Specialist of Engineering and Science and Mechanics at North Carolina State University. He received his B.S. in Mechanical Engineering from Virginia Polytechnic Institute and his M.S. and Ph.D. from North Carolina State University. Dr. Eckerlin has a broad range of industrial experience, including service with Virginia Electric and Power Company, Combustion Engineering, and Corning Glass Works. He has considerable industrial experience in the design and operation of special purpose type heat exchangers, is the author of a number of technical papers, and holds 11 basic patents in fluidics and heat exchanger design.

Professor Albert S. Boyers is Extension Specialist in the Department of Mechanical and Aerospace Engineering at North Carolina State University. He received his B.S.M.E. degree at Purdue University and his M.S.M.E. at the University of Illinois and has done further graduate work in engineering and economics at the University of Michigan. At NCSU, he teaches academic courses in mechanical engineering, and organizes, conducts, and teaches continuing education courses, and does technical assistance for industry in a broad range of areas. His areas of specialization are industrial ventilation, energy conservation, and value engineering. Prior to joining NCSU in 1968, Professor Boyers worked at Cornell Aeronautical Laboratories and the Babcock and Wilcox Research Center. He has also taught at SUNY at Buffalo.

NOTE: This paper was presented by John Hart, Industrial Extension Service, North Carolina State University.

COST ANALYSIS OF ENERGY PROPOSALS

Charles E. Dorgan, P.E.
William R. Baker, P.E.
University of Wisconsin--Extension
Madison, Wisconsin 53706

Introduction

Those who approve energy reduction projects must have a base for making the decision; usually this requires a comparison with alternative means of spending capital or assigning manpower. Saving energy saves money, and usually requires an expenditure in capital investment and a change in the funds required for future maintenance, taxes, etc. Therefore, all energy management action should be analyzed to present the total time value of all expenditures and savings.

The method selected for presenting energy projects should be realistic and provide the decision maker with all the information required to adequately evaluate the proposed project. The energy analysis can be presented by several different means; however, they should all be based on the real time value of money.

The most acceptable means of presenting an energy proposal is by Life Cycle Cost (LCC) analysis. Even this results in several different alternatives depending upon tax rate, inflation, fuel escalation, productivity, benefits, etc.

In this paper, the basic forms of energy analysis will be discussed, with a major emphasis on LCC analysis.

Life Cycle Cost Analysis

Dollar expenditures made at one point in time cannot be directly compared to expenditures at other points in time. This is quite evident and is due to the fact that money has an earning capacity with respect to time. Consider an offer that would enable you to receive $1,000 today or $1,000 one year from today. These two amounts are of equal numerical value but quite obviously they have a different meaning in terms of purchasing power. Even the most unimaginative of individuals could place $1,000 on deposit in a savings account earning a minimum of 5 percent per year. Under these considerations, $1,000 today would be equivalent to $1,050 one year from today. Life cycle costing studies must then involve the basic principles of investment analysis.

Investment analysis (often referred to as engineering economics) is based upon the earning capacity of money. This earning capacity is expressed as a yearly interest rate having a minimum value equal to the least acceptable rate of return expected by the owner on any investment. Percentage returns on investments below such established rates are uneconomical for the investor, and as a result are undesirable. If a company or individuals is in a "borrowing situation," the interest rate used for analysis purposes should at least equal the yearly rate paid for loan repayment. The interest rate used for analysis purposes can be viewed as the percentage return one would expect to receive if additional funds were available for investment purposes. They are opportunity rates or simply the "worth" of money to the investor.

The mechanics of life cycle costing involves the translation or conversion of an initial investment into a series of equivalent annual expenses covering the anticipated life of the item under investigation. In this manner, an appropriate portion of the initial investment can be directly apportioned to annual operation and maintenance expenses. Another method, used in some life cycle costing studies, is to convert the time stream of future expenses to an equivalent dollar amount at the time of initial acquisition. Such a process is called discounting, or present worth, and the present value of the entire life cycle cost is obtained by adding the initial investment to the discounted future expenses.

Conversion of dollar amounts from one point in time, to another desired time reference, involves the use of interest factors. The following list of symbols explains the various commonly used symbols and interest factors encountered in life cycle costing studies.

SYMBOL	EXPLANATION
P	a sum of dollars at the beginning of an economic study
A	an annual dollar amount in the form of a series of uniform <u>end of period</u> expenses or receipts
n	the number of years, or life, covered by the economic study
i	the yearly interest rate or "worth of money" expressed as a percentage
$\frac{A}{P}$	capitol recovery factor, used to convert an initial investment to an equivalent uniform annual end of period series
$\frac{P}{A}$	uniform series present worth factor, used to discount a series of expenses or receipts to the beginning point in time of an economic study-the numerical value of this factor is the <u>inverse</u> of the capitol recovery factor
F	a <u>single</u> <u>future</u> sum of dollars
$\frac{A}{F}$	sinking fund factor, used to convert a single future expense or receipt to an equivalent uniform annual, end of period series-the numerical value is equal to the capitol recovery factor <u>less</u> the interest rate expressed in decimal form.
$\frac{P}{F}$	present worth factor, used to discount a single future expense or receipt to the beginning point in time of an economic study-the numerical value of this factor is equal to the uniform series, present worth factor times the sinking fund factor $\frac{P}{A} \times \frac{A}{F} = \frac{P}{F}$

Table I is an abbreviated table of commonly used capitol recovery factors. In addition, an accompanying example shows the method of computing other related factors that are helpful in performing life cycle costing studies. Complete tables for all factors are available in engineering economy textbooks and these should be consulted for the ease of calculations.

In practice the interest factors are all multiplicative in their usage. For example, if it is desired to convert an initial investment of $19,000 to an equivalent series of end of year payments over 12 years at an interest rate of 10%, the tabular capital recovery factor is multiplied by $19,000 (ie, $19,000 x 0.14676 = $2788.44). The "set-up" of such a problem is very simple when the symbols explained previously are used. The $19,000 by definition is designated as a P term. It is desired to compute an equivalent end of year series---by definition a series of values with an A designation; therefore,

$$A = P\left(\frac{A}{P}\right),$$

note the algebraic "correctness" of this equation. Of course, the specific capital recovery, or $\frac{A}{P}$ factor, is dependent upon the interest rate used and the span of time involved.

It is often desirable to draw a sketch, or cash flow diagram, to visually depict the flow of dollars with respect to time. Additional items that should be included on such a diagram are the interest rate per compound period used and the span of time covered by the study. By way of an expansion of the previous problem, let us assume that the $19,000 item will have a salvage or resale value at the end of 12 years equal to $900. In addition, annual maintenance and operation costs are estimated to be $1,500 and at the end of the sixth year management believes an overhaul of the item will be necessary costing $1,800. The desired output of the economic study is the equivalent annual cost of ownership if money is "worth" 10% to the organization.

The first step is to develop a cash flow diagram showing anticipated expenses and income amounts as they occur with respect to time. By convention, a downward directed arrow is used to indicate an expense and an upward directed arrow is reserved to show an income.

TABLE I

TABLE OF CAPITAL RECOVERY FACTOR VALUES, $\frac{A}{P}$

	Interest Rate			
Years	6%	8%	10%	12%
2	0.54544	0.56077	0.57619	0.59170
4	.28859	.30192	.31547	.32923
6	.20336	.21632	.22961	.24323
8	.16104	.17401	.18744	.20130
10	.13587	.14903	.16275	.17698
12	0.11928	0.13270	0.14676	0.16144
14	.10758	.12130	.13575	.15087
16	.09895	.11298	.12782	.14339
18	.09236	.10670	.12193	.13794
20	.08718	.10185	.11746	.13388
25	0.07823	0.09368	0.11017	0.12750
30	.07265	.08883	.10608	.12414
35	.06897	.08580	.10369	.12232
40	.06646	.08386	.10266	.12130

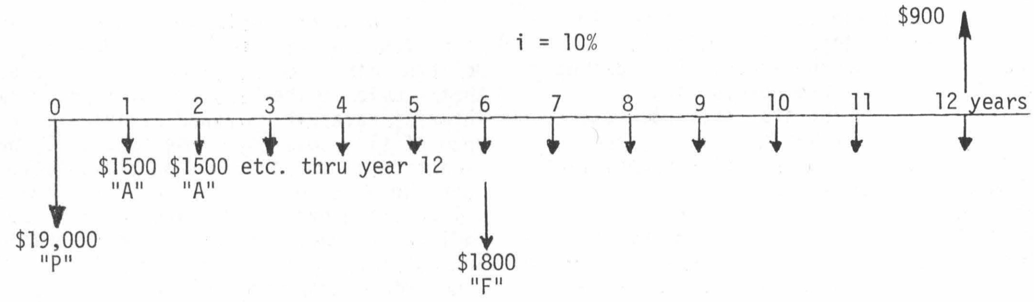
Capital recovery factor for 8% & 14 years, ie $\left(\frac{A}{P}\right)^{8\%}_{14\%} = 0.12130$

Uniform series present worth factor for 8% & 14 years, ie $\left(\frac{P}{A}\right)^{8\%}_{14\%} = \frac{1}{.12130} = 8.2440$

Sinking fund factor for 8% & 14 years, ie $\left(\frac{A}{F}\right)^{8\%}_{14\%} = 0.12130 - .08000 = .04130$

Present worth factor for 8% & 14 years, ie $\left(\frac{P}{F}\right)^{8\%}_{14\%} = \left(\frac{P}{A}\right)^{8\%}_{14\%} X \left(\frac{A}{F}\right)^{8\%}_{14\%}$

$= 8.2440 X .04130 = 0.34048$



$$A = 1500 + 19{,}000\left(\frac{A}{P}\right)^{10\%}_{12} + 1800\left(\frac{P}{F}\right)^{10\%}_{6}\left(\frac{A}{P}\right)^{10\%}_{12} - 900\left(\frac{A}{F}\right)^{10\%}_{12}$$

A = $4330 per year, the effective life cycle cost of ownership.

NOTE: The double use of the factors in conjunction with the $1800 at year 6 is as follows--the $1800 is first discounted to time "0" and then converted into an equivalent series of 12 end of year, annual expenses.

The life cycle cost for the above example could be expressed in terms of present dollars. If this approach were to be used, all monetary amounts shown on the cash flow diagram are discounted to time "0" and a summation of results is obtained. This method of expressing the equivalent time flow of costs is referred to as present value or present worth. The present worth of the life cycle cost for the previous example is computed in the following manner. Present worth at time "0" or simply -

$$PW = 19{,}000 + 1500\left(\frac{P}{A}\right)^{10\%}_{12} + 1800\left(\frac{P}{F}\right)^{10\%}_{6} - 900\left(\frac{P}{F}\right)^{10\%}_{12}$$

PW = $29,507 the life cycle cost of ownership in terms of present dollars.

It should be understood that the two life cycle cost figures computed above have the same mathematical significance--$29,507 at time "0" has the same meaning (providing interest rates are 10%) as a series of twelve end of year payments of $4330. This fact can be demonstrated by simply converting the $29,507 into series of twelve end of year payments $=\$29{,}507\left(\frac{A}{P}\right)^{10\%}_{12} = \$4330$

The value of such life cycle costing computations lies in the fact that optional items of equipment or processes can be directly compared even though both require different initial investments and have dissimilar cash flows. This direct comparison is made by converting the respective costs of each option to an annual series or by discounting all future costs to the time of initial acquisition. It must be recognized, however, that the discounting method to obtain a present value, or present worth, is only valid for comparison purposes when the service lives of all options are equal.

In computing the life cycle cost of ownership it should be evident that Federal and State income tax laws drastically effect cash flow, actual cost of ownership, and hence final decision making policy. Three main elements of income tax considerations will be considered in the following pages--investment tax credit, depreciation, and the effect of maintenance and operation expenses on taxable income.

The current investment tax credit is established at a rate of 10% and in the context of this paper will be treated as an effective cash return to the investor equal to 10% of the acquisition cost. Generally speaking, three common methods are available to owners of depreciable property--straight line, declining balance, and sum of the years-digits. Depreciation should be viewed as an accounting procedure for tax purposes. Such computations result in tax deductions and have no direct correlation with the actual value or worth of the item being considered. In the following pages only the straight line method will be considered. This should not be construed as an endorsement of this particular method, as it is selected only to facilitate the computation process. With regard to maintenance and operation expenses, it must be recognized that these are a cost of doing business and as such are tax deductible items. Quite naturally, as expenses increase, profit will decrease and, as a result, income tax payments will lessen.

When computing the true life cycle cost of ownership all of the above mentioned tax parameters must be considered along with the initial acquisition cost, the annual cost of maintenance and operation, the time value of money (ie interest rate) and any salvage value that the item under investiga tion might have at the end of its useful life. This process is best illustrated by the following example.

Life Cycle Costing Example

A 12,000 S.F. office building, owned by a corporation, is to be equipped with a 30 ton, rooftop air conditioning unit. Two systems are available--a standard system "A" and system "B" which has an economizer. Cost data for the two units is given below.

	System "A"	System "B"
Capital Cost	$30,000	$34,000
Salvage	$ 200	$ 200
Life	10 years	10 years
Operating Cost Per Year		
Maintenance	$ 300	$ 350
Energy	$ 2,360	$ 1,780

When computing the true cost of ownership, it will be assumed that the corporation pays combined state and federal income taxes at a rate of 55 percent in addition to local property taxes of \$30/\$1000 of true value. Also, consider money is worth 10 percent to the corporation and use an annual method to compare the economics of ownership of the two systems.

At first glance, the problem of analysis appears quite simple. For an investment of an additional \$4000 an annual cost reduction of \$530 is realized. Over a 10-year period this would amount to \$5,300, or a net dollar savings of \$1,300. Such an approach, however, is erroneous since it ignores the basic principles of investment analysis. The following procedure is used for combining the true yearly cost of ownership for both systems.

<u>System "A"</u>

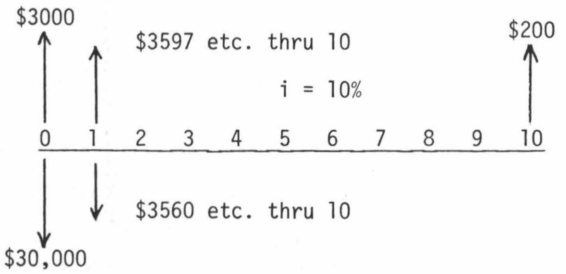
Initial investment tax credit=\$30,000X0.1 = \$3,000

Annual disbursements:
- Maintenance and Operation = \$2,660
- Property taxes = \$30 x 30 = \$ 900

\$3,560

Tax return computation:
- Annual disbursements = \$3,560
- Depreciation(30,000-200)÷10 = \$2,980

\$6,540X0.55=\$3,597



Equivalent annual cost of ownership of System "A":

$$(30{,}000-3000)\left(\frac{A}{P}\right)_{10}^{10\%} + 3560-3597-200\left(\frac{A}{F}\right)_{10}^{10\%} = \$4{,}345$$

<u>System "B"</u>

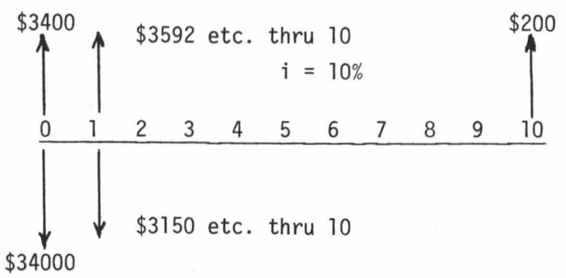
Initial investment tax credit=\$34,000X0.1 =\$3,400

Annual disbursements:
- Maintenance and Operation =\$2,130
- Property taxes= \$30 x 34 =\$1,020

\$3,150

Tax return computation:
- Annual disbursements =\$3,150
- Depreciation(34,000-200)÷10=\$3,380

\$6,530X0.55 =\$3,592



Equivalent annual cost of ownership of System "B"

$$(34{,}000-3400)\left(\frac{A}{P}\right)_{10}^{10\%} + 3150-3592-200\left(\frac{A}{F}\right)_{10}^{10\%} = \$4{,}525$$

Therefore, System "A" will have the lowest annual cost of ownership and will actually save the corporation \$180 per year.

The results of the life cycle cost analysis indicate several factors. First, in the comparison of the two systems, a cost differential cannot be measured by simply computing apparent out of pocket savings, and comparing these directly with an additional expenditure. This was the erroneous approach mentioned in the initial discussion of System "A". The reason for this, of course, is due to the investment worth of money (ie, interest rate) with respect to time. Interest factors, such as capital recovery, must be used to translate dollar sums at one point in time to equivalent dollar amounts at desired other points in time. Hence, in the previous pages, the initial investment was converted into equivalent annual amounts so that they could be directly added to other yearly expenditures.

Second, and perhaps the most important aspect of the problem, is the effect of taxes on the actual cost of ownership. The efficient System "B" has an energy consumption rate of 25% below the level of System "A". However, the cost of ownership of the efficient air-conditioning unit is \$180 per year <u>more</u> than a comparable, but inefficient unit. The reason for this, of course, is due to the fact that operational business expenses, such as payments for fuel and energy, are tax deductible. In the case of the energy efficient unit, a savings in annual cash flow will result equal to \$410. To realize this savings, however, an extra \$3,600 must be initially invested by the corporation--\$4,000 less the 10% tax credit. If money is worth 10% to the corporation, an annual savings of at least \$585 should be realized in order to justify the expenditure. This annual savings is computed by converting the actual additional expenditure necessary to acquire System "B" to an end-of-year series lasting 10 years --

$$\$3{,}600\left(\frac{A}{P}\right)_{10}^{10\%} = \$585.$$

It is interesting to note that if the corporation did elect to install the System "B", their actual return on the additional funds required to purchase this unit would be about 2.2%--far less than could be obtained from a regular bank savings account!

Problems most certainly exist with our Federal Tax System which is compounded on the State and local level. Quite simply, the present tax structure in the United States is inconsistent with any policy of National Energy Independence. Energy demands over the next 10 years must be met in a large part through an extensive program of energy conservation. Given our present system of taxation, there is often no economic incentive for business to practice energy conservation. On the contrary, rather than a reward, an economic penalty is often the result of good engineering designs that reduce the rate of energy consumption.

What is required is a change in our corporate Federal tax structure providing economic incentives for energy conservation programs. Such a proposal is "The Minnesota Plan" that contains the following provisions:

- an initial investment tax credit of 25%
- a one year write-off for depreciation purposes
- the above two provisions applying only to capital expenditures resulting in energy savings of at least 25%

An understanding of the basic elements of life cycle costing is necessary in order to make intelligent decisions about the investment of funds for capital expenditures. Such procedures, of course, should be applied with or without any changes in the existing U.S. tax structure.

Effect of Inflation on Energy Analysis

The previous discussion assumes that either inflation does not occur or that all investment values involved in LCC analysis have equal inflation. Wherever a fixed interest rate is being used in the LCC evaluation process, then inflation does change the outcome in that the energy proposal has increasingly higher monetary returns when compared with fixed interest returns. Likewise, the evaluation of energy proposals and other capital investments in production processes must include inflation on all items if the correct decision is to be made. It should be assuemd that profits (or energy savings) from a capital investment will increase at the same rate as inflation, in that inflation on labor, parts, etc., will be equal and the differential inflates at the same rate.

As an example of inflation, assume the following options:

a. \$10,000 fixed interest investment @10%
b. \$10,000 energy investment with the following cost and savings:

Salvage Value:	Zero
Life:	10 years
Energy Savings:	\$1,500 year
Maintenance:	\$200 year

Case A. First, assume no inflation, then P. (Energy Savings-Yearly Maintenance) = (1500 - 200) X 6.144 = \$7,987.94.

Case B. Assume inflation is 6% per year, then the present worth is P = (1500 - 200) X 7.738* = \$10,060.39. Therefore, the rate of return is greater than a fixed compound investment of 10% in that the present worth of our savings is greater than \$10,000 investment.

The equivalent compound interest rate required to earn a real 10% rate of return when inflation is 6% is:

$$i_e(\text{equivalent})=i_a(\text{interest})+i_b(\text{inflation})+(i_a)(i_b)$$

OR

$$i_e = .10 + .06 + 0.006 = 0.166$$

This means that when we have inflation of 6% and the interest received on our fixed investment is 10%, the rate of return in equivalent present value dollars is:

$$i(\text{realized}) = 3.77\%$$

Effect of Escalating Energy Costs

To further complicate the analysis, the rate at which energy is currently increasing is greater than the rate of inflation for other products, services and wages. Extending the above example, we see that inflation has an effect on our energy evaluation decision; but when energy increases faster than inflation, it adds another dimension to the problem.

Case C. Same as Case B, except inflation is 6% and energy costs are escalating at 11% per year. Now our evaluation of the energy investment is substantially changed:

$$PW = 1500 \text{ X } 9.472 - 200 \text{ X } 7.738$$

$$PW = \$12,660.20$$

This is clearly an economical energy proposal when both inflation and escalation of energy costs are considered.

The formulas used for inflation and escalation are (r = rate of inflation or escalation):

a. where $r > i$

$$P = \frac{A}{1+i}\left[\frac{(1+w)^n - 1}{w}\right]$$

$$\text{where: } w = \frac{1+r}{1+i} - 1$$

b. where $r < i$

$$P = \frac{A}{1+r}\left[\frac{(1+u)^n - 1}{u(1+u)^n}\right]$$

$$\text{where: } u = \frac{1+i}{1+r} - 1$$

c. where $r = i$

$$P = A\left(\frac{n}{1+r}\right) = A\left(\frac{n}{1+i}\right)$$

In the initial example, the LCC analysis was presented as comparative annual costs. This method is somewhat more difficult when cost escalations are included. The best method to present the evaluation data when escalation is included is to determine the cost and savings for each year (since taxation will vary with the yearly expenditures) and related all values back to present month to determine the best investment selection.

Effect of Uncertainty on Energy Analysis

Most capital investments have a degree of uncertainty related to the actual outcome. This includes maintenance costs, salvage values, energy usage, profit on sale of products or services, taxes, etc. Frequently, experience factors are developed which require any capital proposal to earn a rate of return larger than guaranteed investment. For example, if a firm can invest long-term funds at 10%, they may use a rate of return of 16-20% on capital investments which carry a risk.

On large projects, uncertainty can be treated statistically or through various modelling techniques. This allows decision makers to evaluate proposals on both the expected outcome and extremes which may occur, including losses and unusually high projects. This can be expressed as the Opportunity Rate, the return that is available, compared to other investments with equivalent risk.

A related analysis technique that is more appropriate for energy projects is the use of Sensitivity Analysis. This allows energy projects to be evaluated on their sensitivity to fuel prices which may have a wide range of expected outcomes. This is especially useful in evaluating projects which use natural gas and petroleum fuels.

*See section on Effect of Escalating Energy Costs for computation of present worth factor.

Presentation of Data

There are several methods for presenting LCC evaluations. Two have been given already. The methods most commonly used are:

1. Present Value. Relates all proposals as a net present value at a given interest rate. May also be presented as present worth differentials.

2. Annual Cash Flow. Relates all proposals to net annual cash income or expense. For housing where taxes are excluded, this is frequently calculated as a Monthly Shelter Cost. For commercial firms this is frequently labeled Profitability Index, the sum annual net savings.

3. Rate of Return (ROR). Comparison of proposal to determine the interest rate which will give a net present worth of income and expense equal to the capital investment. This is frequently labeled return on investment (ROI).

4. Break Even Point. At a given interest rate, the cash flow payments are used to pay off the investment in N years. Investments with the lowest Nth year are selected for investment, since they usually have the lowest level of uncertainty and reduce long-term committments. This is usually referred as the Payback period. When N is less than two years, evaluations are frequently made, neglecting interest (the time value of money).

Regardless of the method selected, it should conform to the LCC analysis methodology. Care must be taken to prevent incorrect inputs, overestimating maintenance costs, energy savings, or neglecting the costs related to productivity.

Inflation and fuel escalation rates should be included in all evaluations. Figures should be coordinated with present and future expectations of your utilities. The effect of changes, such as time-of-day differentials and load demand changes must be included in long-term proposals, especially new buildings.

The current policy of Public Service Commissions should be checked, as they may have plans that will substantially change the outcome of your LCC evaluation.

One error of many LCC evaluations is that assumptions are not clarified, nor mentioned. These must be included, along with an interpretation of the results, including uncertainty and the life-committment of various alternative proposals. Otherwise decision makers may select the incorrect project, assuming all are equivalent dollar comparisons.

Summary

To fairly evaluate energy proposals, Life-Cycle-Cost analysis must be used. The time value of money must reflect the return available for alternative opportunities to invest capital. The impact of taxes, inflation, and fuel escalation must be included in all LCC analysis which involve large investment or committments longer than two years.

EXISTING BUILDING ENERGY CONSERVATION THROUGH SYSTEM MODIFICATION

Neil Patterson
Manager
Application Engineering
The Trane Company
La Crosse, Wisconsin 54601

Existing buildings today are generally overheated, overcooled, and have an overabundance of air circulation and outside air use.

Therefore, when we, as manufacturers of equipment, go into heating, ventilating and air conditioning systems, we look at these functions of the building with our energy reduction eyes in an attempt to align ourselves with those products that can be utilized to reduce energy in each function for existing buildings as well as new building construction.

Gentlemen, we're looking at 25 to 30 years worth of buildings that were designed when energy was cheap and plentiful - at least we thought it was.

And as any owner will tell you, there is nothing more expensive today to own and operate than a building with a cheap, inefficient heating, ventilating and air conditioning system.

With this in mind, I'd like to take the next 20 minutes to give you some of the ideas that we think can be utilized effectively in existing building modification that will conserve energy and justify economically.

Keep in mind throughout the discussion one underlying thought - "Economics is the Driving Force Today for Energy Conservation." Said another way - If a change to an existing building, system or equipment is not economically justified within a reasonable payback period, it will not go ahead.

Most of the products that align themselves well with existing building modification are those energy conserving types that can be incorporated into existing systems with a reasonably low installation cost and, therefore, relatively rapid payback period.

While some products or systems are more geographically oriented than others because of climate, etc., they all offer potential for energy conservation. Today I'd like to give you a rather broad brush picture of some of what we consider to be the more important ideas that you may be able to apply.

On buildings that use large amounts of outside air such as hospitals, laboratories, etc., the use of exhaust to intake air heat recovery loops to preheat makeup air with exhaust air are generally a good energy buy that will normally pay back, particularly in colder climates, in two years or less.

In the case of heating products such things as economizers on the boiler can be used to preheat boiler makeup water or other process water from the heat normally going up the stack. These also have a relatively fast payback period well within most economic bounds to justify their use on boilers in existing buildings.

For that matter, coils in general have excellent application using up to 500° F. exhaust air for drying applications, preheating ovens, etc. They have virtually unlimited application for inter-plant heat recovery, if one really explores the processes to apply them properly.

Keep in mind that of all the climate conditioning functions within the building, perhaps the most important nationally is the heating function since it usually consumes the lion's share of the energy within a building or building complex.

The heating function is rivaled in magnitude only by lighting which also offers excellent potential where task lighting can be employed to reduce energy consumption in today's existing buildings.

Not only does task lighting reduce the actual energy draw by the lights but it also reduces substantially the air conditioning loads within the building including air moving loads which, as we all know, are sensible loads.

Lighting does, however, add heat to the building during the heating months and the removal of it may add heating load to the building. This in turn may bring forth an idea and products that have existed for some time - the double bundle heat recovery centrifugal and reciprocating product lines to recover the heat that would normally be exhausted to the cooling tower.

One must be careful, however, to apply this principle only where an internal cooling load exists within the building such as a computer room, etc., to generate the coincident source of heat that can be used on the perimeter of the building or some other heating function such as domestic hot water heating.

Beyond this, the coincident cooling and heating loads must exist for a reasonable duration of time to provide the energy conservation base to justify the additional capital expenditure.

One of the biggest potentials for energy conservation in existing buildings today is in system modification work.

There are a number of buildings that exist today that are being heated and cooled with systems that reheat or mix to maintain space temperature control.

These, of course, are the central station and terminal reheat systems, the multizone systems, and the double duct systems which, by comparison to current system hybrids available, are relatively inefficient from an energy standpoint in their conventional form.

The strongest system trend in new building construction today is the use of variable air volume as a system to cool the building. Ideally, then, we should look at existing systems with an eye toward conversion to this type of system either through control conversion or basic system hardware conversion to approach the energy consumption of the variable air volume system.

If we do this, the potential for energy conservation, on both the heating-cooling and the air side of the system can be considerable.

There are several hybrids of variable air volume available today which consist of variable air volume reheat or variable volume double duct systems that we believe adapt well into the existing building system conversions process.

When these systems are considered, one must, of course, modify the existing fan system with some form of capacity control which usually consists of speed control or inlet vane control to accommodate variable air volume system air cutback.

Today, I'd like to give you an example of the conversion energy and economics that may well apply to a typical building in this area of the country.

For our example, we're going to examine a building system equipment combination that encompasses the use of a conventional double duct system. Next, we'll convert this system to a double duct variable volume system where the cold deck side of the double duct variable system modulates to a predescribed minimum air flow. At that time, the hot deck of the double duct system modulates toward the open position as the system goes into the heating mode with subsequent reduction in cooling air volume off the cold deck.

This system uses cooling only variable volume terminals from the duct handling the cold air for internal zones and utilizes both hot and cold deck air streams in the perimeter zones which theoretically have the ability to cut back to zero air flow unless controlled to do otherwise.

Our example building is a 5-story building located in Austin, Texas which is basically a 11 hour utilization building with approximately 20% glass and major orientation facing east and west. The total square footage of conditioned space is 95,849 square feet distributed between two primary air handling unit systems.

The wall construction has a "U" value of .20, the glass has a "U" value of 1.13 and a shading coefficient of .86. The roof has a "U" value of .08.

The building is a government office building which has a people density of 180 square foot per person and a lighting intensity of 3 watts per square foot.

Fortunately the building when built will actually utilize the double duct variable system. However, we are going to assume that it currently exists and that it currently utilizes a conventional double duct system which operates on the supply air side at 5.0 inches of static pressure and on the return air side at 1 inch of static pressure. The system utilizes a enthalpy actuated economizer to reduce the load whenever possible.

For equipment, the building has a centrifugal chiller for cooling which provides chilled water to the air handling units. The air handling units have airfoil fans on the supply and axial flow fans on return side. For heating equipment, the building utilizes a hot water gas-fired boiler.

The basic double duct system has a base first cost of $1600 a ton. To convert this system to a double duct variable system, it will be necessary to change the terminals and add inlet vanes to the supply and return fans.

It will also be necessary to modify the control system to accommodate double duct variable volume. This will have an additional first cost of $200 a ton. It is this additional $200 per ton that must be justified with a reasonable payback period to justify the conversion of the conventional double duct system to a double duct variable air volume system.

In the analysis for purposes of example, we have used an estimated inflation rate on fuel for both electricity and gas of 8% which most of you I'm sure will agree is very, very conservative in today's energy market.

The installed tonnage on the building is 325 tons and the installed heating capacity is 2044 MBH.

After an analysis of utility data and completion of a preliminary energy audit, the information can and has been input to a computerized energy and economic analysis program. Also, input to the program were the current energy rate structures in effect as well as other economic factors required to perform the economic analysis such as installed cost and maintenance cost as well as replacement cost and the additional inflation factors associated with maintenance and replacement.

We were reasonably certain that the proposed double duct variable air volume system would have a significant potential for reduction in energy associated with the conventional double duct system, insofar as the heating, cooling and air moving energy.

However, the key question that needs to be answered is whether the modification cost of $200 per ton to convert the system from double duct to double duct variable air volume is economically justified by the amount of energy dollars that can be saved.

The analysis has been very revealing and I'd like to share the results with you.

The energy consumption of the existing building with its conventional double duct system turned out to be 162,859 BTU/Square Foot/Year. The current utility bill utilizing the existing rate structures was $99,692. This amounts to $1.04 per square foot of conditioned space per year.

At a 8% inflation rate the utility bill at the end of the 20th year would increase to $4.49 per conditioned square foot per year. This in effect says that energy costs for the building will double every 9 years.

I believe this puts the impact of rising energy costs in proper perspective. The average annual owning and operating cost over the life cycle of this building came to $2.68 per conditioned square foot per year.

If we break the energy consumption down by function within the building, it provides some interesting information as to where the energy is being consumed. In this case, (See Figure 1), heating accounts for 103,479 BTU per square foot per year.

Energy Consumption - 162,859 BTU/Sq. Ft./Year

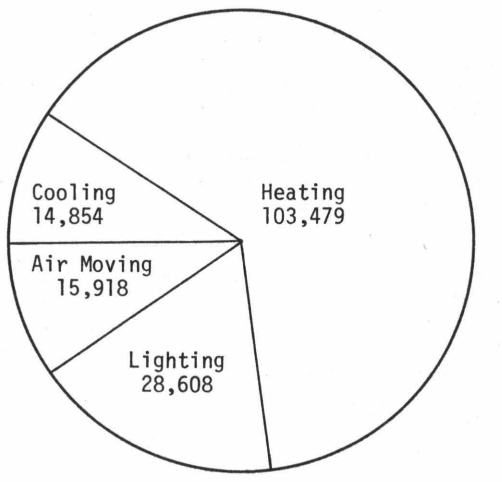


Figure 1. DUAL DUCT SYSTEM
Energy Consumption By Function - BTU/Sq. Ft./Yr.

This looks high although keep in mind two things:

1. Double duct systems requires heating or use of warm air even at design conditions on the building.
2. Economizer control can add heating energy requirement to the system. If the economizer opens on a small cooling demand it opens both hot and cold decks. It, therefore, requires heating a large segment of air from the outside air temperature to the hot deck temperature rather than air at say 78° F. to the hot deck temperature required to temper the cold deck.

The cooling function accounts for 14,854 BTU per square foot per year. The air moving function accounts for 15,918 BTU per square foot per year and the lighting and base utility consumption accounts for 28,608 BTU per square foot per year.

If we look at this in terms of the percentage of energy use for each function, (Figure 2), heating represents 63.5%, cooling represents 9.1%, air moving represents 9.8% and the lighting and base utilities account for 17.6% of the total energy consumed in the building.

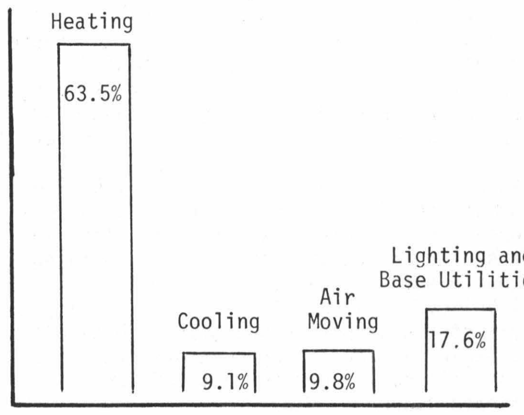


Figure 2. DUAL DUCT SYSTEM
Percent Energy Consumption By Function

If we look at the energy dollars, (Figure 3), we get quite a different picture in that the heating function, because we are utilizing gas, only consumes 32.6% of the energy dollar, whereas, the cooling represents 16.8% and the air moving 18.1%. The lighting and base utilities consume a large share at 32.5% of the energy dollar.

Remember, these are the energy and economic values for the existing building with its existing double duct system.

We not have a benchmark against which to compare the effect of the double duct variable air volume system energy and economic performance.

If we look at the double duct variable system utilizing the same rate structures, etc., the energy consumption was reduced to 83,343 BTU per square foot per year. Because we're now looking at a variable volume system, the design air flow drops to 117,408 CFM. Because of this 15% drop in air quantity, the required tonnage at design conditions has now dropped 318 tons. Keep in mind that we still have slightly over 1 CFM per square foot of conditioned space which is reasonable air flow.

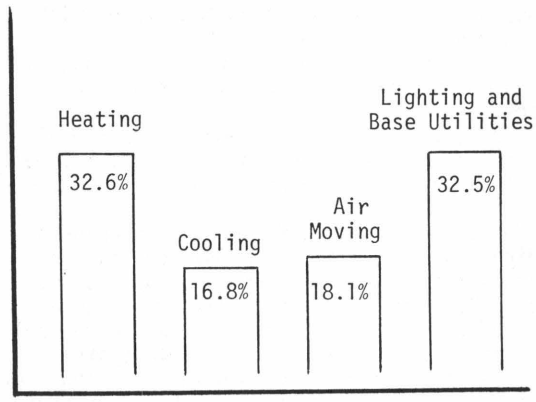


Figure 3. DUAL DUCT V.A.V. SYSTEM
Percent Energy Cost By Function

That reduced air flow is significantly important in that it will represent a sizable reduction in energy consumption and cost due to air movement in the building.

If we look at the energy consumption breakdown for the modification, we find from Figure 4 that heating represents 30,445 BTU per square foot per year, cooling is 13,840 BTU per square foot per year, air moving is 10,450 BTU per square foot per year, and lighting is constant at 28,608 BTU per square foot per year.

Energy Consumption - 83,343 BTU/Sq. Ft./Yr.

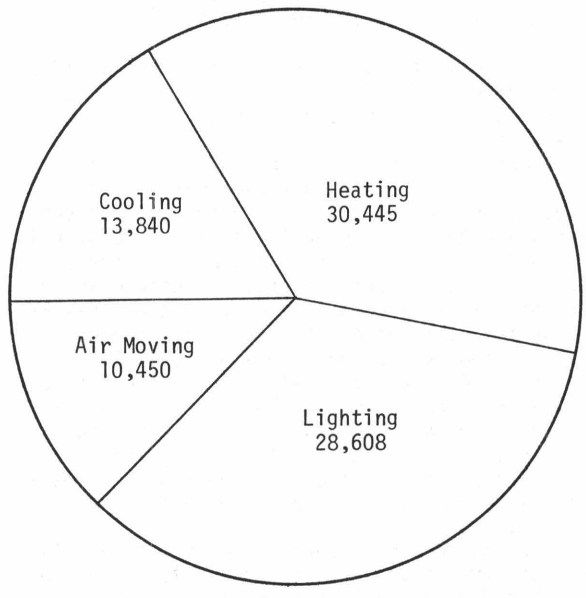


Figure 4. DUAL DUCT V.A.V. SYSTEM
Energy Consumption By Function - BTU/Sq. Ft./Yr.

Looking at the energy consumption by function, (Figure 5), the heating now has been reduced from 63.5% down to 36.5% of total energy used, the cooling now represents 16.7% of the total energy, the air moving has been increased from 9.82% up to 12.5% of the total energy and the lighting now represents 34.3% of the total energy used in the building.

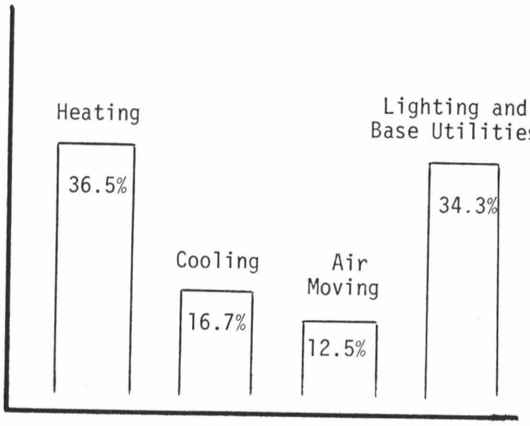


Figure 5. DUAL DUCT V.A.V. SYSTEM
Percent Energy Consumption By Function

If we look at the energy dollars, (Figure 6), we see 14.4% of the energy dollars is now utilized in heating, 22.4% is in cooling, 16.9% is in air moving and the lighting and base utility represents 46.3% of the total energy consumption within the building boundary.

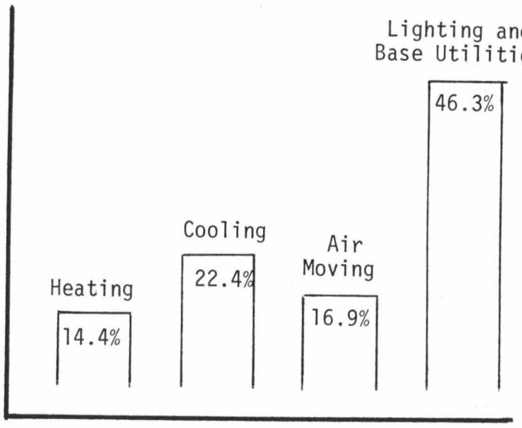


Figure 6. DUAL DUCT SYSTEM
Percent Energy Cost By Function

Overall, this represents a 49% reduction in the energy consumed per year by converting from a double duct to a double duct variable air volume system. Therefore, from strictly an energy conservation or management standpoint, this change would appear to be very desirable.

We must, however, evaluate the cost of making the change versus the energy dollars that it can save per year to determine if the proposed change is cost effective and if so, how soon will the energy cost reduction pay for the capital expenditure.

Physically, the system conversion will require that the double duct mixing boxes be removed and replaced by double duct variable air volume terminals in the perimeter and variable air volume terminals only in the interior. In addition, it will be necessary to add inlet vanes to the air foil fans to provide the turndown on air volume associated with the variable air volume system operation.

Beyond this, the only other modifications required will be the addition of sensors in the duct to control the inlet vane plus minor control modification to accommodate the double duct variable air volume pneumatic control system.

The additional capital expenditure necessary to complete the system conversion on this building was estimated at $53,065. The annual owning and operating cost reduction associated with the change was $60,081 per year which on a simple payback basis would be less than one year to recover the additional capital expenditure for the change.

If, however, we were talking about a tenant office building with developers involved, utilizing the cost of money, depreciation, and the other economic factors associated with the cash flow on the building, the payback calculation becomes somewhat more complex and with the tax base of 50%, yields a payback on investment of approximately 3 years, and a payback on equity if the conversion were 75% financed of less than 2 years.

To summarize the proposed system change would reduce energy consumption in the building by 49% going from 162,859 BTU per square foot per year down to 83,343 BTU per square foot per year. The annual owning and operating cost difference neglecting income taxes and depreciation offered a reduction of $60,081 per year, with a capital expenditure outlay of only $53,065.

If we look at the present worth of the annual owning and operating cost savings for the 20 year life of the building at 13% cost of capital, we see that the savings is worth $422,052 which leaves little doubt as to the cost effectiveness of the change as well as the energy effectiveness of the change.

With this type of information, the energy manager can now approach the decision maker to receive the approval to proceed with the energy conservation plan. The only remaining step is to put the plan into operation as fast as possible.

This is an example of only one change to the building heating, ventilating and air conditioning system. It is by no means the final optimization of energy conservation potential for this building. For example, reduction in lighting energy via use of task lighting would certainly bear careful analysis on life cycle cost basis. So, gentlemen, life cycle costing for existing building renovation is rapidly becoming a fact of life. It will provide one good result - it will require that energy be analyzed to insure that the potential for energy conservation is being realized in existing building construction. Notice I said potential: we will not save energy unless the building and system is maintained and operated efficiently.

From our experience this requires an educational program for building operation and maintenance personnel with full support at the highest administrative level. Without this, the potential to save energy will be lost even though it was designed or retrofitted into the building by the building and system designers.

So, I emphasize to you that energy management is a team effort. It requires involvement and commitment of all segments of the management team starting at the highest administrative level to be effective.

With this commitment to move forward as a team effort and get on with it, we will have energy conservation in lieu of just energy conversation.

SAVING MONEY AND ENERGY IN LIGHTING

Robert T. Dorsey
Manager, Lighting Technology Development
Lamp Marketing Department
General Electric Company
Nela Park
Cleveland, Ohio 44112

The United States uses about 70 quads of energy per year. Of this, lighting uses about 5% or about 3 1/2 quads.

What I am going to tell you has the potential to save about one-third of this through the use of higher efficiency light sources, reduced wattage light sources, and more careful operation of lighting systems. That is a saving of about a quad which is a lot of energy.

President Carter and Mr. Schlesinger have emphasized the efficient use of energy and this is just as true of lighting as any other energy use.

Let's go back to 1973 and the Arab oil embargo and the sudden realization that our resources are finite. Then came the President's request to reduce energy consumption. Almost immediately lighting became a symbol of the energy crisis. I guess that's because it is such an obvious part of our lives. It touches all of us every day in just about everything we do. Somehow we developed a "turn 'em off, take 'em out" syndrome. While this was a simplistic, easy, quick way to save some energy, it did create problems. The fact is that most lighting in the United States is dirty, outmoded, inefficient, and carelessly operated. Actually about half of American is underlighted, not overlighted. Indiscriminate delamping created poor working environments, reduced the appeal of stores to customers, and in some cases, reduced productivity. For example one weekend GSA removed half the lamps in the Social Security Administration complex in Baltimore. This clerical operation was processing 7 million cards per week. After the lighting was reduced, this fell to 5 million cards per week. The lamps were left out for six weeks. Productivity did not return. Finally the lamps were put back in and productivity returned to its normal level.

Today the lighting industry is totally committed to energy conservation. More efficient lenses and lighting fixtures are being produced (Figure 1) and the user has the option of choosing one of several systems that is far more efficient than incandescent lighting.

The consequence of higher efficienty (higher lumens-per-watt)--lumens-per-watt is exactly analogous to miles-per-gallon--is dramatically reduced energy consumption. For example, Figure 2 shows the KWH per year to light 10,000 square feet to 100 footcandles based on 4,000 operating hours per year.

The payback of converting from incandescent to metal halide and to high pressure sodium is given below. As you will note in this example, the payback is about a year which yields nearly 100% return on investment.

Lighting Investment Payback Analysis

	1000-120V	MV400/BUH	LU400/BU
Ann. Op. Costs	$29,806	$11,068.80	$ 7,035.67
Op. $ Savings	-	$18,737.20	$22,500.33
Total New Investment	-	$20,875.75	$21,816.00
Investment Years		1.11	97
Payback Interest-Months		13.3	11.6
R.O.I.		89.8%	103.1%

As you will note in this example, the payback is about a year which yields nearly 100% return on investment.

It should be pointed out that conversion to more efficient lighting is now included in the FEA list of approved energy measures. That means that, depending on how the states decide to handle it, conversion to efficient lighting may qualify for financial assistance.

Another group of lamps simply involves removing an existing lamp and substituting another that consumes less wattage. For example, the regular 4' fluorescent lamp consumes about 40 watts. The combination of lamp and ballast consumes about 100 watts for a 2-lamp fixture. Those lamps can now be removed and reduced wattage fluorescent lamps substituted. The total energy consumption with the new lamps is 86 watts per lamp. At an energy cost of 4¢ per KWH which is close to the national average, the savings per lamp over the life of the lamp is $5.60. This 4' lamp is used in 806 million sockets throughout the country. If all of these lamps were changed to the reduced wattage type it would represent a savings of 22 billion KWH.

The 8' fluorescent lamp which is widely used in supermarkets and other kinds of stores is also available in the reduced wattage type. In this case, the saving is 17 1/2 watts per lamp and at 4¢ per KWH the savings would be $11.88 over the life of the lamp. If all these lamps were changed to the reduced wattage type, it would save an additional 14 billion KWH.

The new reduced wattage type costs a little more than the standard lamp. The payback based on the incremental increase in lamp cost is about four months of operation at 4¢/KWH. Even at 2¢/KWH the user would recover the added cost within eight months.

A newcomer to the incandescent family of lamps is the ellipsoidal reflector lamp, Figure 3. This lamp has the unique property of focusing the light as it comes out of the reflector as contrasted to the regular R40 which disperses the light coming from the reflector.

The result is that in a baffled downlight about 60% is trapped inside the fixture with the R40 whereas nearly all of the light from the ellipsoidal reflector lamp gets out of the fixture.

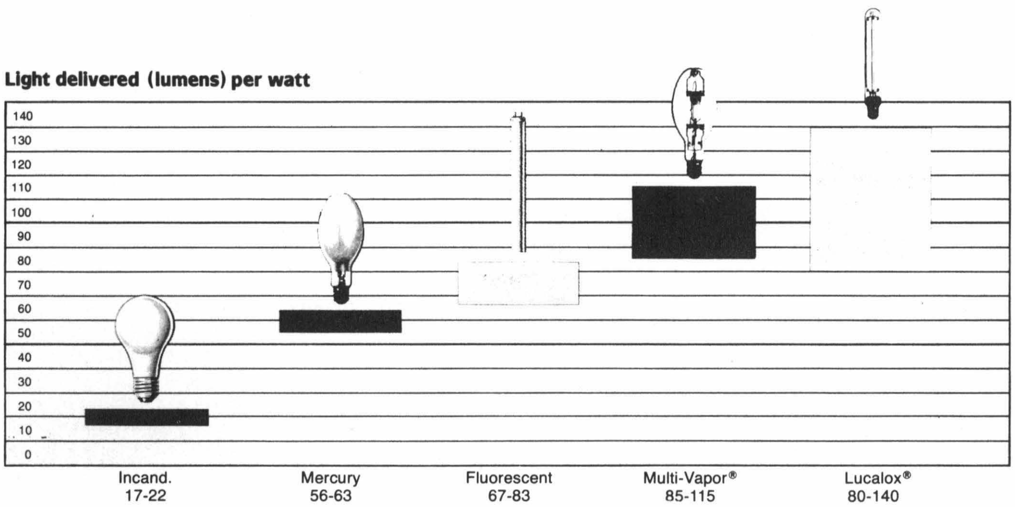


FIGURE 1

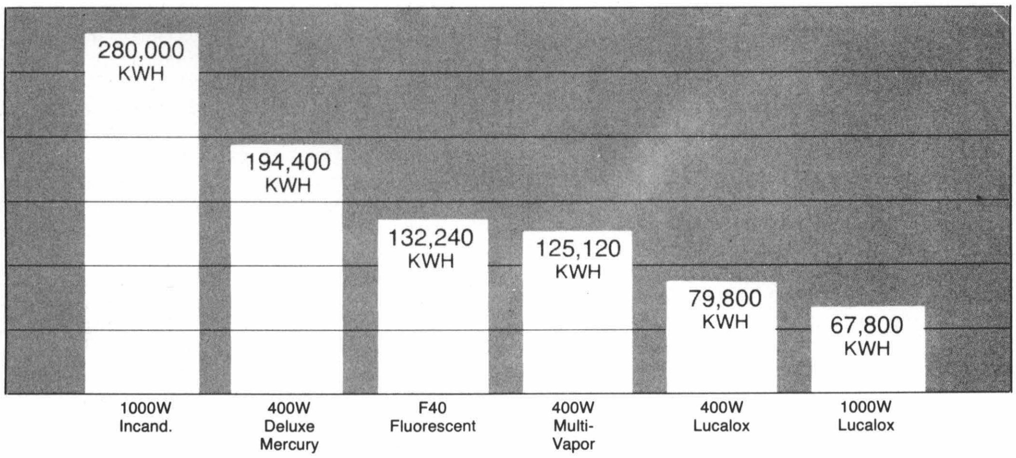
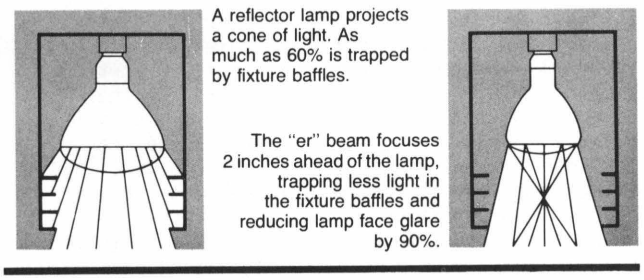


FIGURE 2



150 Watts

75 Watts

FIGURE 3

The result is that the 75-watt ER lamp produces as much useful light as the 150-watt R40 which is commonly used in this type fixture. The payback based on the incremental lamp cost is less than 200 hours of operation at 4¢ per KWH and at 2¢ a KWH is less than 400 hours.

Following are three case histories which illustrate the impact of using some of the lamps I have just described.

The Rexnord Manufacturing Company in Milwaukee, Wisconsin had bare strip fluorescent lighting which was providing about 70 footcandles. They removed this lighting system and put in 150-watt high pressure sodium lamps in a 2' square with a refractive grid lens underneath the lamp. This lens has the property of extremely high efficiency and excellent brightness control. One-hundred-thirty-five fixtures were mounted on 8' x 8' centers to produce 115 footcandles average. Operating costs were reduced 18% and the lamps last for 24,000 hours.

Stanford University in Palo Alto, California replaced 94,000 regular 4' fluorescent lamps with the new reduced wattage type. Their annual savings will be $336,000. Furthermore, they set up a system where the light output is monitored. When it drops to 80% of initial, the lamps are group relamped. In this case the same lighting level is provided with reduced wattage lamps under the group relamping plan as was provided formerly with regular 40-watt lamps on a spot relamping plan.

The Ford Tractor Plant in Romeo, Michigan was lighted with 400-watt high pressure sodium lamps in a fixture which has a 30" diameter lens for brightness control and also to help diffuse the light. Operating costs with this lighting system are 26.4% less than they would have been had the same space been lighted to the same illumination using fluorescent lamps. In this case, 3600 lighting fixtures were mounted on 20' x 20' centers to produce a lighting level of 60 footcandles.

ENERGY MANAGEMENT FOR HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

Goodwin H. Taylor
Goodwin H. Taylor, Ltd.
Consulting Engineers
6121 Lincolnia Road
Alexandria, Virginia 22312

I will attempt to cover energy conservation management for heating, ventilating and air conditioning systems in our brief time this morning. My comments will be directed to as many areas as possible. These areas will cover existing system operations, addition of new controls or subsystems as well as new design considerations. While it may seem like a sacrilege at an energy management seminar, it is appropriate to remember, however, that buildings and their innate heating, ventilating and air conditioning systems are designed and built for an end purpose. Whether this end purpose be the manufacturing of an end product or dissemination of knowledge or the accomplishment of general office work, this purpose must be considered. The point that I am attempting to make is that it may be possible, in the name of energy conservation, to markedly affect the efficiency in obtaining this end product of a specific facility. There is no question that individually we should be able to acclimate very happily to a 65° F. indoor temperature in a residence during winter operation, and a considerably higher indoor temperature than we have previously enjoyed during the summer. However, while not being an expert in the behavorial sciences, I have seen instances where energy programs have dictated working conditions which I believe markedly affect productivity.

Another general comment which needs to be covered in the preface to my remarks is that generally, a most important factor in any energy management program is sorely neglected. That factor is building system operation personnel. Our experience indicates that regardless of what heating, ventilating and air conditioning system is designed and installed, its overall efficiency remains a function of the degree of control designed into the system and conscientiousness and intelligence of the people operating the system. This is obviously a reason for computer based building control systems. Regardless of the degree of automatic control, one of the most difficult aspects of any energy management program will be educating and significantly motivating the people on the job who have the responsibility for systems operation.

Specifically now, how do we develop a good energy management program relating to heating, ventilating and air conditioning. It cannot be done without an energy audit indicating how much energy is being expended; for what aspect of the systems; and at what time period. As you can appreciate, the heating, ventilating and air conditioning loads on a facility are very transient. While we can approximate with engineering experience, it is impossible to develop a comprehensive energy audit without creating an energy model. Prior to the advent of software programs relating to heating, ventilating and air conditioning systems, this energy model was virtually impossible to accurately create. But with the software programs currently available, the task has been radically simplified. In my opinion, the initial step in creating any comprehensive energy management program is an energy model created by computer simulation. The most difficult problem in creating the energy model is to correctly simulate how the facility actually is or is planned to operate. Since this evening's session should provide details on the operation of these programs and how you obtain this simulation, I'll progress to what it can do once the model is obtained.

Basically, it is the tool for doing two things. One, it will accurately predict any energy savings obtained by modifying existing equipment operation and/or the addition of any subsystems. The other important thing that the energy model does is that it allows management to look, on a month by month basis, at actual energy consumption versus projected energy consumption to determine if their heating, ventilating and air conditioning system operations are being controlled as predicted. A little later in this discussion you will see a graph which indicates how this tool picks up non-standard building operations.

Figure 1, on the next page, is presented as an example of how close the energy model can follow actual operation. This project is a 240,000 sq. ft. office building located in Northern Virginia. I wanted to comment on it because we ran this study as a cross-check on our computer software program. For our basic energy analysis we utilized five year Washington integrated weather data which basically averages five years of hourly data. In initial runs, our attempts to correlate the energy model were disasterous. After test metering the facility to confirm that our projected input correlated with actual consumptions, a rerun indicated that we still had poor correlation. We finally resorted to utilizing the specific weather data for the eleven month period indicated in 1969. You will note that the actual curve pattern for the energy model correlates closely with actual consumption, giving a total error for the eleven month period of 7.2% between simulated consumption and actual consumption. The point of the illustration is to show how even small deviations in weather data input affect specific simulations.

As another example of how this energy model can be utilized in an energy management project, the next few figures indicate our analysis in 1971 of one of the more infamous buildings in the world. Our own Watergate Office Building. Figure 2 indicates chilled water consumption. The cross-hatch curve indicates our computer simulation projected operation for 1971 and the dash curve indicates actual chilled water consumption.

As I mentioned earlier, this tool can be utilized to pick up a conforming operation. You will note that from approximately the first part of July the actual consumption skewed from our projected curve. Investigating this situation, we found that at this date, a large major tenant went on a 24 hour operation which resulted in the increased chilled water consumption.

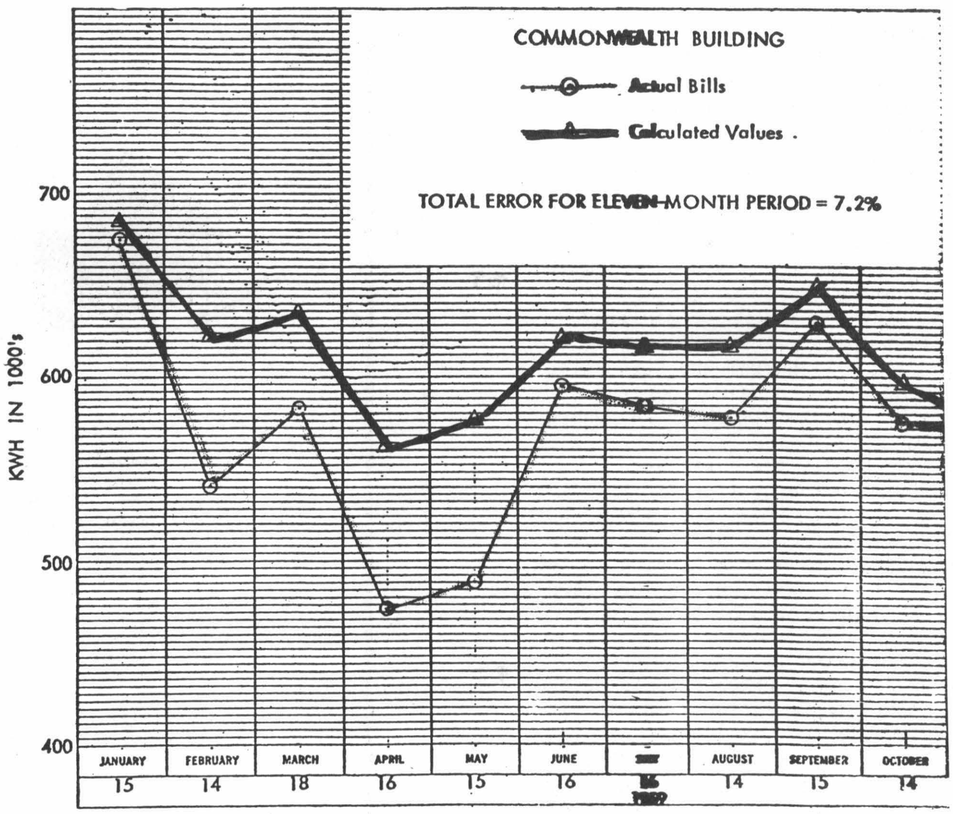


FIGURE 1. COMPARISON OF ENERGY MODEL WITH ACTUAL OPERATION

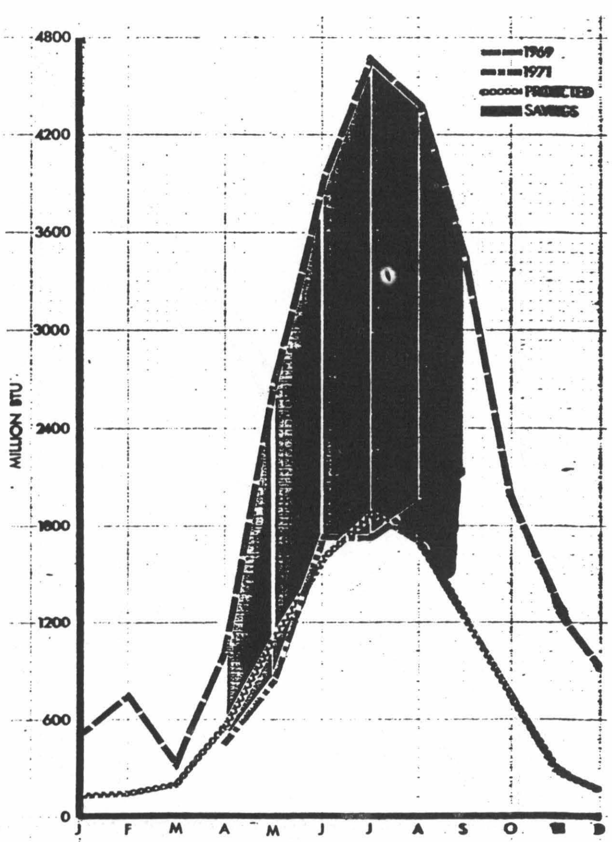


FIGURE 2. WATERGATE OFFICE BUILDING - CHILLED WATER CONSUMPTION

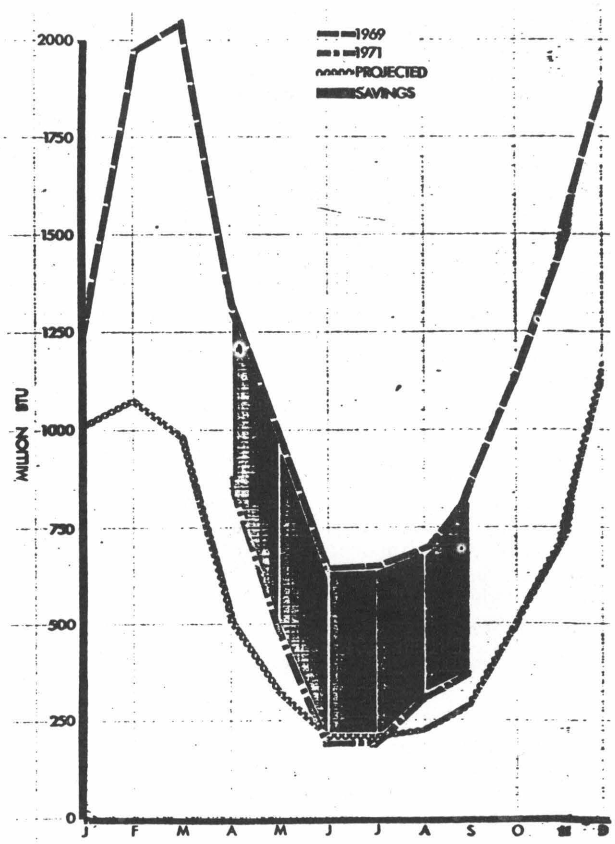


FIGURE 3. WATERGATE OFFICE BUILDING - STEAM CONSUMPTION

Figure 3 indicates again the correlation between projected 1971 consumption and actual steam consumption for the same facility.

Figure 4 indicates similar comparison for base power consumption at this facility.

Figure 5 indicates cumulative total expense reduction for a period of a year indicating approximately $50,000 annual reduction in utility costs. It should be noted that the reduction in energy for this project simply amounted to fine tuning the heating and air conditioning system. No reduction in lighting levels were made, nor were other requirements of the owner modified.

Digressing from these illustrations of what energy models can accomplish from the standpoint of energy management, let's consider general areas which we might want to attack in any energy management program.

If we look at Table I, the first area indicated is to optimize energy transfer to ambient. This is obviously related to items such as increased insulation on walls and roof, installation of storm windows, or double glazing in the case of new construction, building configuration, orientation, and shading, ratio of glass to wall, et al.

The second item listed is ventilation air. This one item probably contributes more to wasted energy than any other single factor. In the first place, code requirements for ventilation air were instituted before any concern for energy arose and in my opinion are excessive. Secondly, the absolute quantities of ventilation air being introduced to a building are normally incorrectly calibrated and do not control as per design specifications.

The third consideration relating to ventilation air is obviously the heat recovery possible from the air exhaust of a facility. This waste heat recovery will be discussed this afternoon in some detail.

The next item under general areas of consideration is the redistribution of internal heat gains. Of great significance to energy management of heating, ventilating and air conditioning is the fact that, in most commercial facilities, 50% of the energy consumed is related to base electric consumption external to the heating and air conditioning system. For the most part, this base electric load affects the air conditioning capacity and the energy consumption of same; and thus is a major factor in heating, ventilating and air conditioning systems. The use of non-uniform lighting standards, task lighting, more efficient fixtures and other systems which hopefully will be discussed in this seminar can impact heavily on this area. Again, the redistribution of internal heat gains will be discussed in our heat recovery session this afternoon.

The next item which is a major area would be the recovery and incorporation of process waste heat into the heating system. This will also be covered under the discussion of waste heat recovery systems.

TABLE I. GENERAL AREAS

. Optimize Energy Transfer to Ambient
. Ventilation Air
. Redistribution of Internal Heat Gains
. Recovery and Integration of Process Waste Heat
. Incorporation of New Subsystems

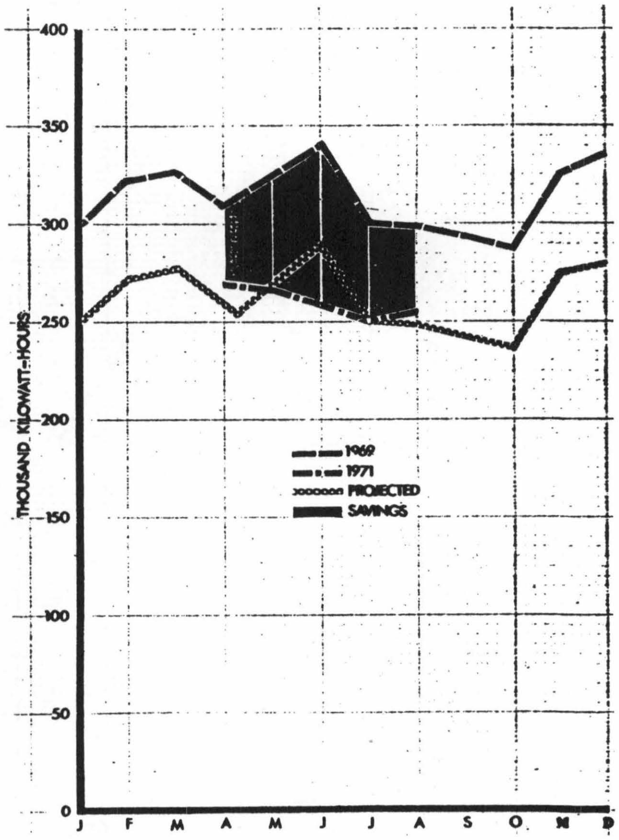


FIGURE 4. WATERGATE OFFICE BUILDING - POWER CONSUMPTION

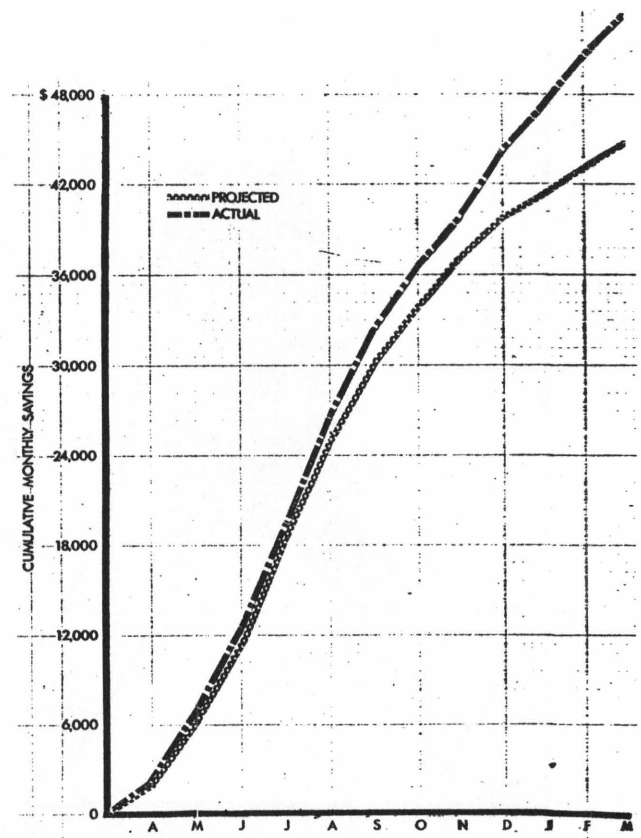


FIGURE 5. WATERGATE OFFICE BUILDING - TOTAL EXPENSE REDUCTION

The last item indicated would be incorporation of new subsystems such as solar heating or total energy systems. While the Federal Government is pushing solar systems heavily, I am of the opinion that greater economic incentives must be forthcoming if solar is to be extensively utilized. With respect to total energy plants, the same consideration of economic incentives hold today. We know that the average efficiency of utility generating plants is approximately 32% while localized total energy plants can obtain from 60 - 70%. However, the financial and capital investment costs still make total energy plants a poor investment even with increasing utility rates.

At this point, I would like to digress from general areas of energy management and get down to some specific recommendations for those of you in the audience who are closer to system operation.

Considering Table II, the first item in this area is to institute automatic system operations for all items of equipment. Unfortunately, human beings being what they are, our experience indicates that very few items of equipment get controlled as designed unless it is done automatically. This does not necessarily mean the installation of an automated building control system but can be simply done with time clocks. In this area of consideration, all equipment energization should be programmed either by time or temperature. This will include chillers, condenser water pump, chilled water pump and cooling tower. These items we recommend to be interlocked not only with time, but also such that they would not operate at temperatures below a certain set point. Along the same line, all heating equipment including pumps, et al, should be if at all possible, automatically de-energized based on demand.

Economizer cycles should be controlled based on total heat rather than dry bulb. Chilled water temperatures should be scheduled rather than set at a constant temperature. Hot water for the heating system again should be reset inversely with outdoor temperature. Appropriate controls should be installed in all cases where heating and cooling systems interface to preclude systems fighting each other. Condenser water temperature (which has conventionally been set at a constant temperature) can be controlled to integrate with chiller efficiency. For all facilities which operate on an occupied/unoccuplied system, night setback controls should be installed with no ventilation unless the ventilation minimizes energy consumption during this period. The startup time for warm-up or pre-cool should be set for minimum operation, i.e., basically inversely with outdoor temperature.

As previously mentioned, the general area of ventilation control offers considerable potential energy reduction opportunities. For most facilities the requirement for 7-1/2 cfm per person is nationally recognized. We feel this is extremely excessive, and even more so in the case of schools and areas where no smoking is allowed or where occupancy is for a short period of time. Another area where ventilation becomes a significant factor in energy consumption is in multi-family facilities such as dormitories or apartments. The use of individual exhaust fans in bathrooms and kitchens can make as much as a 50% reduction in the heating consumption in these type facilities. And again reiterating what was said generally under ventilation, in all cases where central ventilation systems are installed, the quantity of air in the facility should be frequently monitored to insure that the amount of ventilation air is as desired.

The next specific item to be recognized would be the use of demand limiters, whether on the entire building, domestic hot water system, chillers, or other large single source consumers. These demand limiters are fairly inexpensive in today's market and while they have a minimal affect on overall consumption, they can be very effective in minimizing electrical demands. In relating to this item, it is our opinion that we will see power company's demand charges increase perhaps as much as ten times in the next ten years. Their current rate schedules do not truly reflect their capital investment cost required to meet the peak demands put on these plants.

In relating to chilled water production, chiller configuration affects energy efficiency of these systems; thus with smaller systems a series chiller configuration can provide increased efficiency and lower pumping horsepower with reduced water flows. In larger systems chiller-pump combinations, in conjunction with primary secondary piping systems, will optimize energy consumption. In some areas of the country, free coolers on the chilled water side represent an inexpensive means of energy conservation during winter months. It should be noted that some centrifugal machinery currently on the market will produce up to 45% capacity without running the compressor by simply utilizing a principal of migrating refrigeration (with optimum condenser water temperatures).

In summary, any energy management program that relates to heating, ventilating and air conditioning must incorporate the knowledge of what energy is being used, where it is being used, and for what periods of time. Only by creating an energy model of system operation, analyzing possible system alternatives, instituting the most viable modifications and controlling systems with motivated personnel will an energy management program produce optimum results.

I must apologize for the shotgun approach I have used in presenting heating and air conditioning system energy management techniques; however, based on the limited time schedule and diversified audience, I knew of no other way to cover this subject.

TABLE II. SPECIFIC AREAS

- Automatic Operation of Systems
- Ventilation
- Demand Limiters
- Minimize Base Electrical
- Equipment Operating Condition
- Optimize Subsystem Efficiencies

BOILER FUEL MANAGEMENT AND ENERGY CONSERVATION

William H. Axtman
Assistant Executive Director
American Boiler Manufacturers Association
Suite 317 A. M. Building
1500 Wilson Boulevard
Arlington, Virginia 22209

INTRODUCTION

There have been a number of changes affecting the fuel usage pattern of boiler sales in the past fifteen years. The changes have been brought about largely by the following pressures:

1. Environmental regulations
2. Fuel costs vs. equipment costs (Fig. 1)
3. Fuel availability patterns
4. Energy conservation requirements.

The current severe winter has emphasized availability problems affecting fuel supply and will, perhaps, accelerate the shifting fuel patterns that have already started to emerge. The Federal Power Commission and the Federal Energy Administration had previously forecast a 22% curtailment (Figure 2) of natural gas for the 1976-77 heating season. The fact that the severity of the winter has accelerated this curtailment is not news to anyone reading the daily paper, watching TV or having been laid off.

In analyzing changing fuel patterns, it is useful to consider fuel changes by boiler use category.

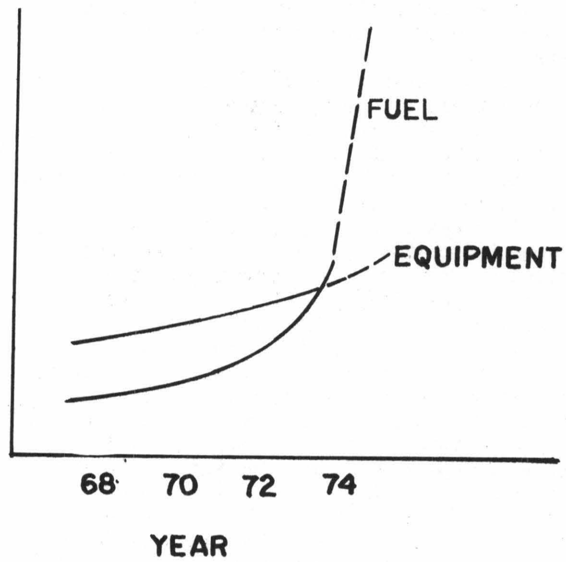


FIGURE 1. FUEL COST VS. EQUIPMENT COST

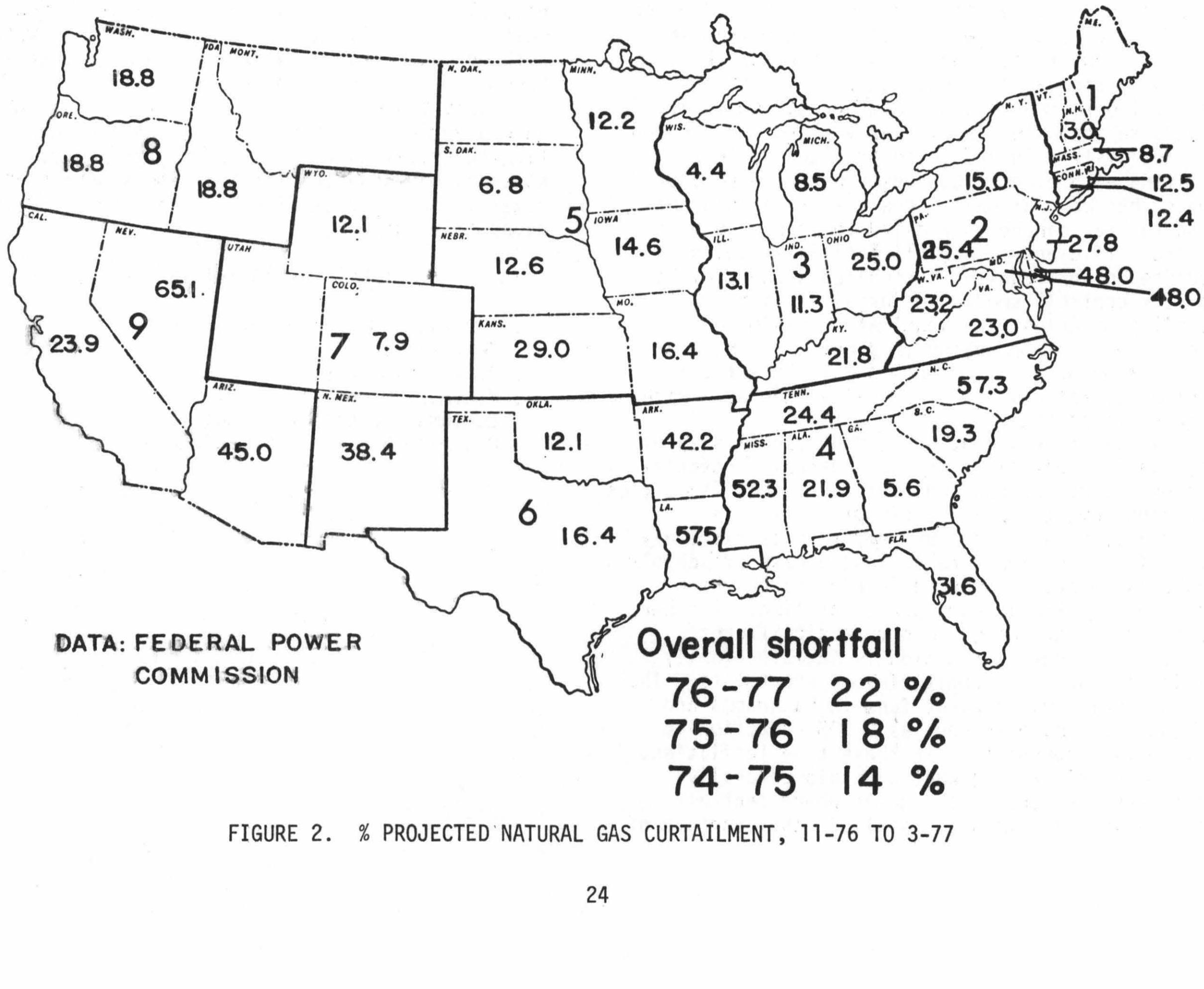


FIGURE 2. % PROJECTED NATURAL GAS CURTAILMENT, 11-76 TO 3-77

INDUSTRIAL BOILERS

An analysis of fossil fuel utilization patterns for industrial boilers for the period 1961 to 1976 shows coal reaching a high point of 19.8% of sales in 1963. Coal declined steadily from that point and with the passage of the Clean Air Act in 1970 reached a low of 1.0% in 1971. Since that time the market has had a modest recovery to 8.7% in 1975.

In contrast, natural gas went from 31.5% in 1961 to a high of over 60% in the late 60's. Pressures from projected shortages of natural gas and rate changes for industrial customers have caused this to drop steadily from the high of 61.3% in 1969 to a current 27.5% in 1976.

Oil dropped from 39.5% in 1962 to a low of 17.1% in 1969. With pressures on gas supply, oil has rebounded to 38.1% in 1976 showing an almost inverse curve to that of gas.

If one examines the total fossil curve (Figure 3) a steady decline can be seen since 1970 when fossil fuels represented 87.2% of industrial boiler sales. The area above this curve, then, represents non-fossil or waste fuel utilization which amounted to 27.2% in 1976. If you add this to coal percentage of 7.2% then units using fuels other than gas and oil totaled 34.4% in 1976 up from 16.3% in 1970. This healthy increase shows a strong trend for industrial units away from dependence on scarce gas and oil.

An analysis of selected waste fuels may also be of interest. Sales of industrial boilers fired with waste wood products has increased dramatically since 1966 when a low of 0.1% was realized (Figure 4). Since that time sales of waste wood units climbed to 6.5% of the industrial market. In contrast, black liquor boilers have been more cyclic ranging from a high of 7.7% to a low of 1.2%. Current sales of these boilers amount to 4.0% (Figure 5). Bagasse boilers are also somewhat cyclic ranging from a low of 0.0% in 1967 to a high of 5.0% in 1975 (Figure 6). In recent years heat recovery boilers have been increasing in importance amounting to 8.6% of sales in 1976. Some interest in burning municiple waste is also shown but at present it is spotty and spasmodic.

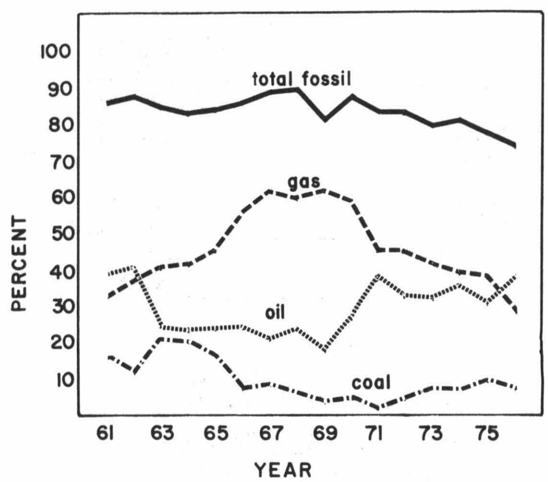


FIGURE 3. INDUSTRIAL BOILERS, FOSSIL FUELS

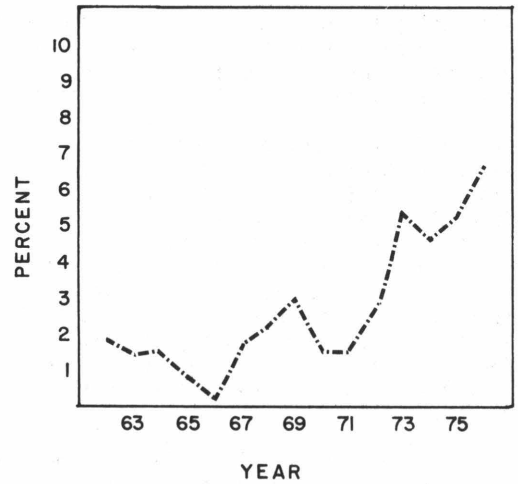


FIGURE 4. INDUSTRIAL BOILERS, WOOD FUEL

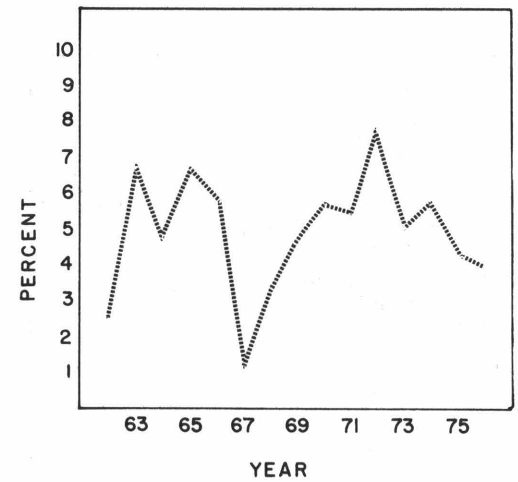


FIGURE 5. INDUSTRIAL BOILERS, BLACK LIQUOR FUEL

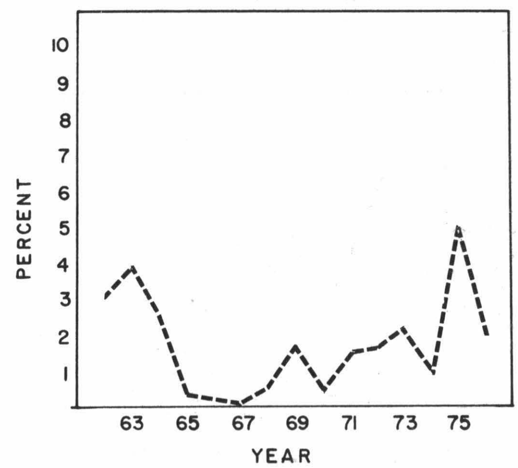


FIGURE 6. INDUSTRIAL BOILERS, BAGASSE FUEL

COMMERCIAL-INDUSTRIAL BOILERS

Boiler units in the commercial-industrial size ranges are, perhaps, of greater interest to most HVAC engineers. These boilers are used for HVAC installations and also for small process applications.

Packaged firetube boiler sales for oil fired units started with 48.7% of the market in 1963, dropped to a low of 32.7% in 1970 (the year of the Clean Air Act) and have since rebounded to 47.3% in 1976. In contrast gas units went from 28.6% in 1963 to 36.9% in 1969. In 1976 gas units dropped to an all time low of 13.8%. Combination gas-oil units held steady between 23 to 28% until 1969 when they started to climb to a high of 41.6% in 1975 (Figure 7). This reflects desires of purchasers to utilize any fuel available for this class of units.

Data on sales of other design types in the commercial-industrial market is not as well defined with oil accounting to about 20 to 25% of the market and combination units covering 15%. Gas units declined from 69% in 1971 to 21.6% in 1975 but rose to 45.4% in 1976 reflecting easing gas supplies in some areas and demands for replacement units (Figure 8).

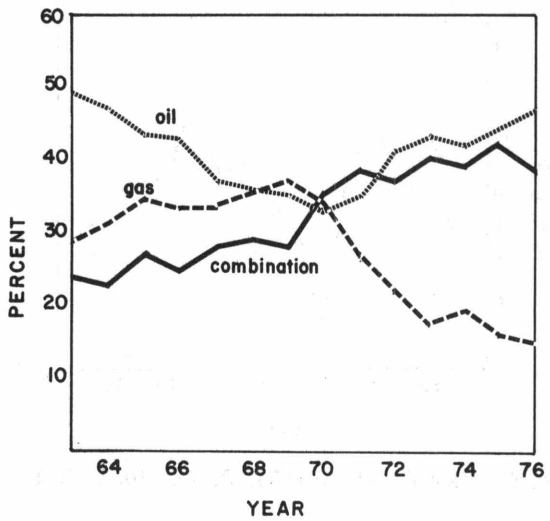


FIGURE 7. COMMERCIAL - INDUSTRIAL BOILERS, PACKAGED FIRETUBE

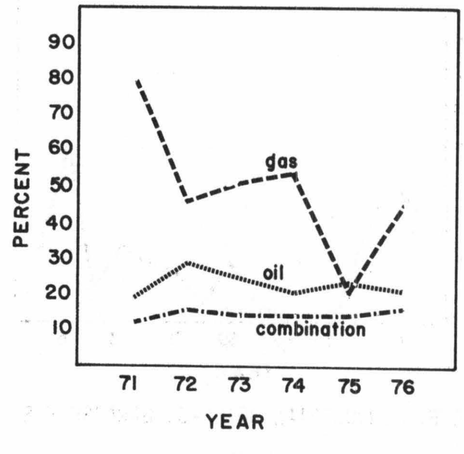


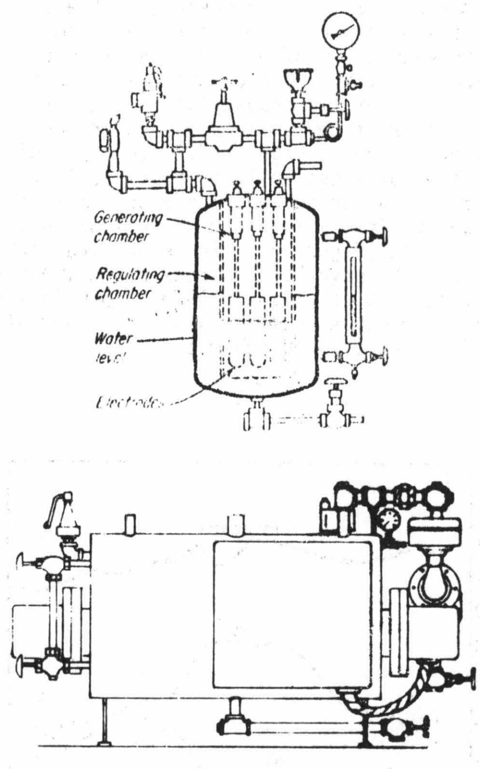
FIGURE 8. COMMERCIAL - INDUSTRIAL BOILERS - SMALL WATERTUBE, FIREBOX, MISC. DESIGNS

There has been some interest in coal and waste fuel fired units in the commercial-industrial market but units costs, environmental contracts and fuel handling problems have made use of these fuels viable only on a highly selected basis.

As we have seen, pressures from government regulation, fuel shortages and equipment costs have affected the fuels available for boilers, resulting in the changing of fuel patterns. Current trends indicate decreased reliance on natural gas and emphasis on waste fuels and coal for industrial units. It would be useful, therefore, to examine various types of boilers considering their size, application and fuel burning capabilities.

BOILER TYPES AND USES

Electric boilers are available in two types, resistance and electrode. Resistance limits are available in sizes from 3 to 3000 KW (120 to 10,236 MBh). Electrode units are available in sizes up to 50,000 KW (up to 170,600 MBh). The units are available in pressures up to 300 psig for resistance units and 900 psig for electrode units. These boilers are used for steam and hot water supply, anywhere fossil fired units are used and economic analyses makes use of electric boilers attractive (Figure 9).



Capacities

Resistance to 3000 KW
Electrode to 11,000 KW

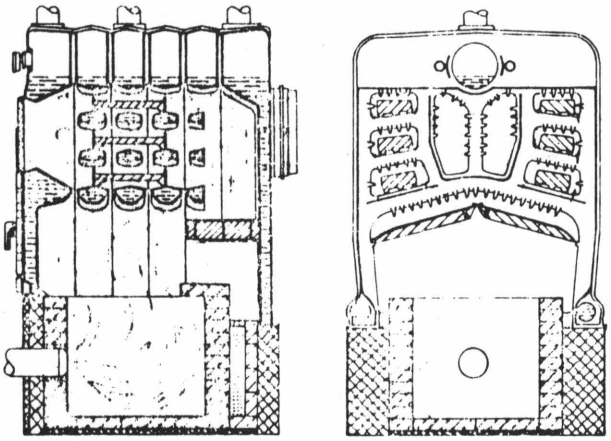
Maximum Operating Pressure

Resistance to 300 psig
Electrode to 900 psig

FIGURE 9. ELECTRIC BOILER

Cast iron boilers are available in sizes up to 13,000 MBh at maximum pressure of 15 psig steam or 160 psig, and 250 °F for hot water. They are suitable for heating applications and can be fired with oil, gas or solid fuels. (Figure 10).

Tubeless boilers are available in sizes up to 1,750 MBh at 125 psig maximum pressure. They are frequently used for small laundries or dry cleaning plants or other high pressure applications. They can be fired with light oil or gas. (Figure 11).



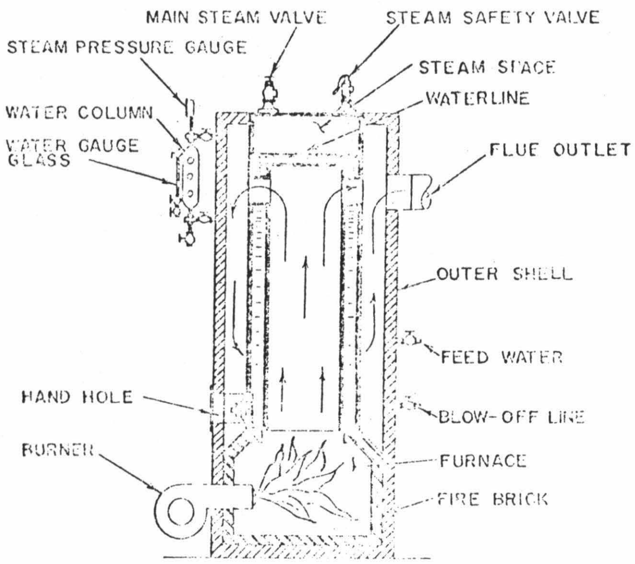
Capacities

50 - 13,000 MBh

Maximum Operating Pressure

steam 15 psig
hot water 160 psig, 250 °F.

FIGURE 10. CAST IRON BOILER



Capacities

235 - 1,750 MBh

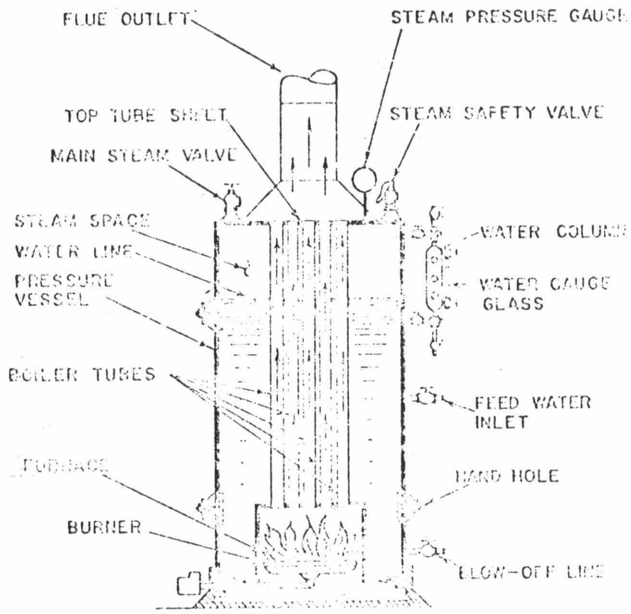
Maximum Operating Pressure

125 psig

FIGURE 11. TUBELESS BOILER

Vertical firetube boilers are available in sizes up to 2500 MBh at 150 psig maximum pressure. They are frequently used for small laundries or dry cleaning plants or other high pressure applications. They are suitable for firing with light oil or gas. (Figure 12).

Firebox boilers are firetube boilers. They are available in sizes up to 20,000 MBh at 200 psig maximum pressure. They are used for heating and process applications. The low set firebox boilers (Figure 13) are suitable for oil or gas firing. A version with an extended base is also available for solid fuel firing.



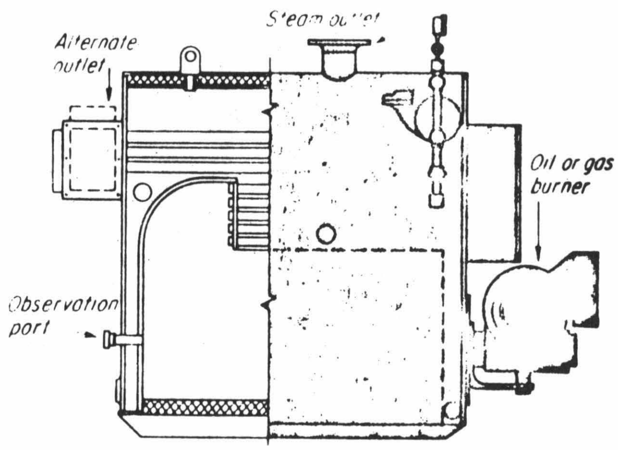
Capacities

67 - 2,500 MBh

Maximum Operating Pressure

150 psig

FIGURE 12. VERTICAL FIRETUBE BOILER



Capacities

340 - 20,000 MBh

Maximum Operating Pressure

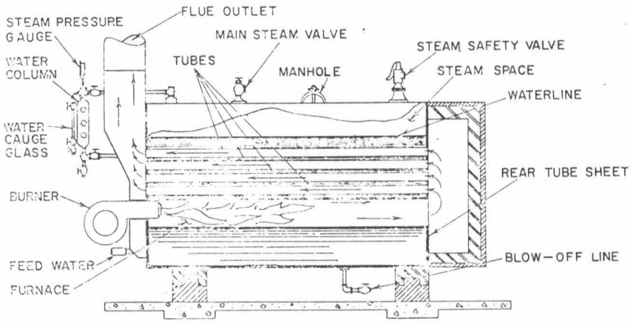
200 psig

FIGURE 13. FIREBOX BOILER

Packaged scotch boilers are firetube boilers and are available in sizes up to 69,000 MBh at 300 psig maximum operating pressure. (Figure 14) They are used for heating and process applications and are suitable for oil or gas firing. Recently some units have been manufactured with furnaces designed for coal firing with single retort underfeed stokers.

Watertube boilers (commercial-industrial) of a design configuration shown in Figure 15 are available in sizes up to 10,000 MBh at 300 psig pressures. They are suitable for heating and process applications and are usually fired with gas or oil.

Watertube (coil type) boilers are available in sizes up to 12,000 MBh at 3500 psig maximum pressure. They are used for heating and process application and are particularly suitable where a small boiler with very high steam pressures is required. They are fired with gas and oil (grades no. 2 and no. 4). (Figure 16)



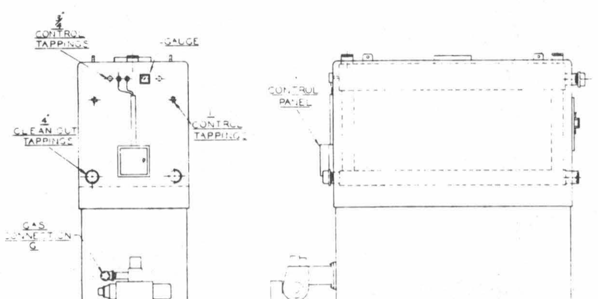
Capacities

350 - 35,000 MBh

Maximum Operating Pressure

300 psig

FIGURE 14. PACKAGED SCOTCH BOILER



Capacities

125 - 10,000 MBh

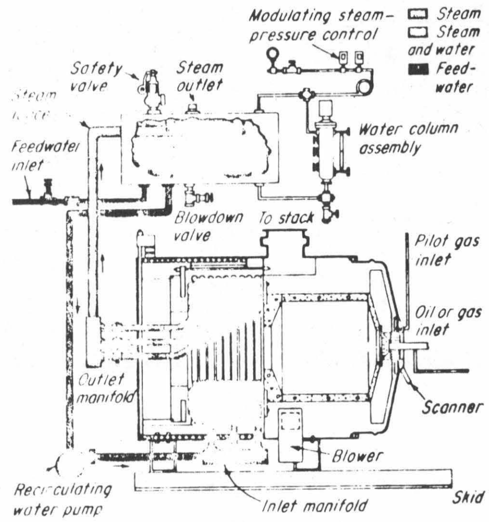
Maximum Operating Pressure

300 psig

FIGURE 15. WATERTUBE BOILER (COMMERCIAL-INDUSTRIAL)

Watertube boilers (shop assembled), of a design configuration shown in Figure 17, are available in sizes up to 350,000 pounds of steam per hour (350,000 MBh) at pressures up to 2000 psig. These boilers are suitable for all applications and are fired with oil or gas.

Watertube boilers (field assembled) are available in a variety of design configurations in sizes up to 9,500,000 pounds of steam per hour, at pressures in excess of 3500 psig. They are suitable for all heating, process and power generation applications and are fired with fuels ranging from oil, gas and coal to black liquor, bagasse and wood waste.



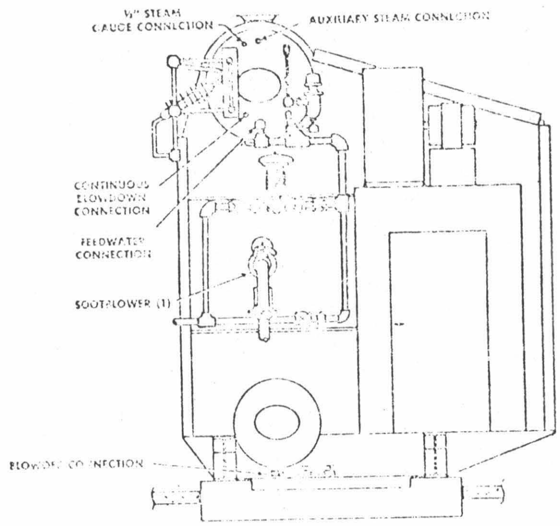
Capacities

600 - 12,000 MBh

Maximum Operating Pressure

3500 psig

FIGURE 16. WATERTUBE BOILER (COIL TYPE)



Capacities

10,000 - 350,000 PPH

Maximum Operating Pressure

2000 psig

FIGURE 17. WATERTUBE BOILER (SHOP ASSEMBLED)

ENERGY CONSERVATION

The largest energy consuming sector in the United States is Industry which comprises all manufacturing. In 1972, the industrial sector accounted for approximately 36 percent of the Nation's energy consumption, equal to some 26.4 quadtrillion Btu's (12,500 MB/D of oil equivalent). A 10 percent savings based on the 1972 energy demand during the short-term period will flatten the projected demand curve which has been increasing at 4-5%/yr. since the early 60's.

Industry has had limited economic incentive in the past to stress energy efficient processes or equipment due to relatively low fuel costs and relatively high capital costs. However, as energy costs increase as a percentage of total manufacturing costs, there will be incentive to invest in and modernize processes in order to minimize energy costs. This will result in energy conservation that will aid in solving the overall energy problem. Greater attention to energy management to ensure good operating design and practices should also substantially reduce energy consumption while not requiring major capital investment.

ENERGY MANAGEMENT

Recognizing that energy is a vital industrial resource and that the cost of this resource is now of prime economic importance, effective energy management programs take on a special significance.

First of all, top management emphasis must be applied to the energy problem. Realistic objectives must be defined, and support for effective programs given in the form of qualified, aggressive people and adequate operating and investment funding. Management must sustain this emphasis indefinitely and demand continued progress.

Establishment of an effective management program involves the following basic elements:

Understanding the basic principles of energy and its use in an industrial plant.

Undertaking comprehensive surveys to determine, quantitatively, where and how energy is used in the plant.

Application of sound principles of industrial economics to determine the cost of energy usage (This may not be possible using only accounting cost allocations, and these are tools for internal control and may not give a true picture of energy economics.)

Establishment of goals, both overall and for specific areas or plants, taking into account the variety of processes encountered, whether batch or continuous, etc.

Identifying energy-reduction opportunities and opportunities for increasing the value obtained from the energy used.

Review, analysis, evaluation, and finally, implementation are essential. A positive approach should be taken in any energy management program and opposition to change in energy use should be justified.

Periodic evaluation of results against established goals is critical and may involve measuring decreases in losses rather than trying to detect changes in otherwise variable input costs.

Establishing training programs for plant operators with special emphasis on energy conservation.

Continued emphasis by top management and a permanent program that reflects full corporate dedication.

Enlisting the support of employees through in-house education and information programs.

It is estimated that there are some 63.5 thousand industrial boilers in sizes above 10,000 PPH units in the field which produce an hourly output of some 2,342 billion Btu and would require fuel inputs of about 3,346 to 2,760 billion Btu per hour. The variance in this input depends on the maintenance and adjustment of the units which obviously will affect its operating efficiency. Looking at it in another way this is equivalent to 478.0 to 569.1 barrels of oil per hour, assuming all units were oil fired. Furthermore, an increase in overall operating efficiency of 10% would decrease the maximum fuel input by as much as 70 thousand barrels per operating hour.

Reduction of input energy used for steam or hot water generation for sources shown above can be accomplished by the following means:

1. <u>Loading Parameters vs. Boiler in Operation</u>
Analysis of steam flow meters should be made in relation to the total boiler plant output and individual unit output. Operating schedules can then be arranged so that output of boilers on the line matches steam demand as closely as possible and the number of units fired at less than optimum rate is minimized.

2. <u>Regulation of Operating Cycles</u>
Where possible loads should be scheduled or adjusted so that boiler operation at the optimum rate can be achieved and on/off cycle operation is minimized.

3. <u>Combustion Rate Control</u>
Use of combustion rate control equipment should be reviewed so that input rate tracks load demand and on/off cycle operation is reduced to an absolute minimum. This may require replacement or moderization of the combustion control system or re-adjustment to assure best operating conditions.

4. <u>Fuel Selection and Preparation</u>
While the primary fuel used should be that which the unit manufacture recommends for most efficient fuel utilization consistent with emission requirements, due consideration should be given to use of waste fuels as primary alternate or supplemental fuels. The equipment used for the preparation of fuel for burning needs careful study and checking for adequacy and adjustment. For example, liquid fuels should be at the correct pre-heat temperature and correct atomizing pressure for optimum burning. Such items as coal cleaning, sizing and pulverizing equipment; fuel pressure regulation and special facilities needed for waste fuels need consideration.

5. <u>Fuel Air Ratio Control</u>
All modern boiler units in the size ranges discussed in this report are equipped with systems of intergrated devices which automatically regulate the fuel and combustion air inputs to satisfy the rate of heat demand from the units. The selection of the particular type of systems listed below depends on an analysis of the system loading and operating characteristics.
The following list shows systems from which this selection may be made:

a. On-Off System (not recommended for units in this class
b. Modulating Control Systems
c. Full Metering and Proportioning Control System

6. Control of Auxiliary Systems
Auxiliary systems need review and a system of maintenance to be sure that items such as defective steam traps, poor lubrication, bad bearings and/or inoperative subsystems do not reduce the overall efficiency of operation.

7. Water Treatment
Proper water treatment is necessary to minimize boiler outages, protect the unit and promote high heat transfer efficiency. If encrustations of scale are allowed to accumulate efficiency can be drastically reduced. A qualified water consultant should be emloyed and his recommendations as to sampling procedure, frequency and quantity of treatment be carefully followed.

8. Maintenance Schedule and Records
Maintenance is the key to keeping a well designed and efficient system in peak operating condition. The maintenance schedule and appropriate check off sheets and record keeping procedures must be reduced to writing. It is a management responsibility to be absolutely sure this function is carried out. Record keeping is an important part of this operation and will enable supervising personnel to spot trends and off-normal conditions.

Consideration should also be given to equipment modification and/or replacement of additional equipment to maximize operating efficiency. In the past this may not have been economically feasible but with today's fuel availability and costs review is justified. Items to be considered include, but are not limited to, the following:

a. Air heaters
b. Economizers
c. Fuel burning systems
d. Combustion control systems
e. Operating instrumentation
f. Soot blowing equipment
g. Feed water systems
h. Water treatment equipment
i. Insulation to minimize losses
j. Feasibility of unit replacement

The best designed and maintained system is no good without well trained operating personnel. Because of personnel turn over and also because poor operating habits can creep into a well planned system, continuous operator training is a must. Coupled with a system for inspection and supervision this will insure that the steam generating units remain at peak operating efficiency.

The environmental impact of changes in fuel pattern has to be considered. When the fuel supply situation is such that fuel switching is necessary, the consideration of clean-up equipment (e.g. scrubbers, mechanical collectors, electrostatic precipitators) may be required. Changes in NO_x, SO_x particulate and visible emission should be considered as well as the problems of solid or liquid waste disposal from fuel burning.

Reduced emissions as a result of reduced fuel consumption and improved operating efficiency also needs to be "cranked into" this calculation. Trade-offs between solid waste pollution and air emissions should be considered when using waste fuels.

Consideration of all these factors and implementation of the decisions made will result in the best system of operation from a fuel consumption point of view.

In summary, the following offer means to conserve industrial boiler fuel (Refer to Tables I and II and Figures 18, 19, 20, and 21)

a. Add heat traps
b. Better combustion controls
c. Better maintenance
d. Effective cleaning of boiler surfaces
e. Better plant heat balance
f. Utilize waste fuels
g. Utilize waste heat

TABLE I

EFFECT OF WATERSIDE SCALING

Thickness of Scale Inches	Percent Loss of Heat: Soft Carbonate	Hard Carbonate	Hard Sulphate
1/50	3.5	5.2	3.0
1/32	7.0	8.3	6.0
1/25	8.0	9.9	9.0
1/20	10.0	11.2	11.0
1/16	12.5	12.6	12.6
1/11	15.0	14.3	14.3
1/9		16.0	16.0

TABLE II

HEAT LOSS FROM 2" PIPE
(BTU PER LINEAR FOOT)

	ΔT Pipe To Air, °F: 100	200	300	400	500
Bare Pipe	55	136	248	393	583
With Standard 85% Mag. Insul.	28	59	92	128	167

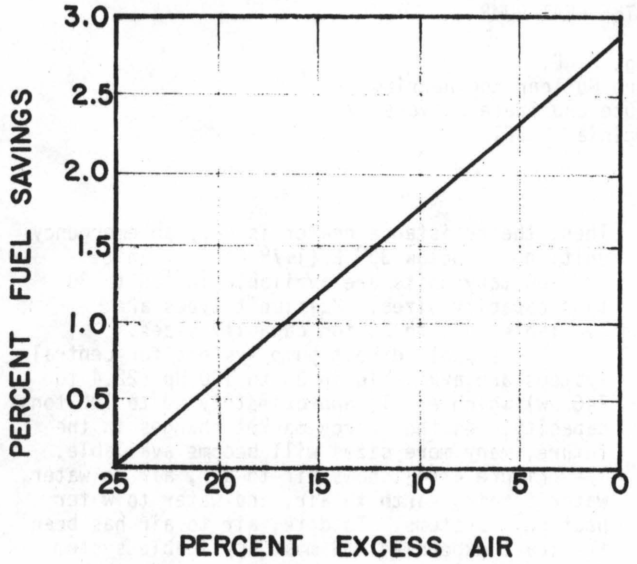


FIGURE 18. SAVINGS FROM REDUCTION OF EXCESS COMBUSTION AIR

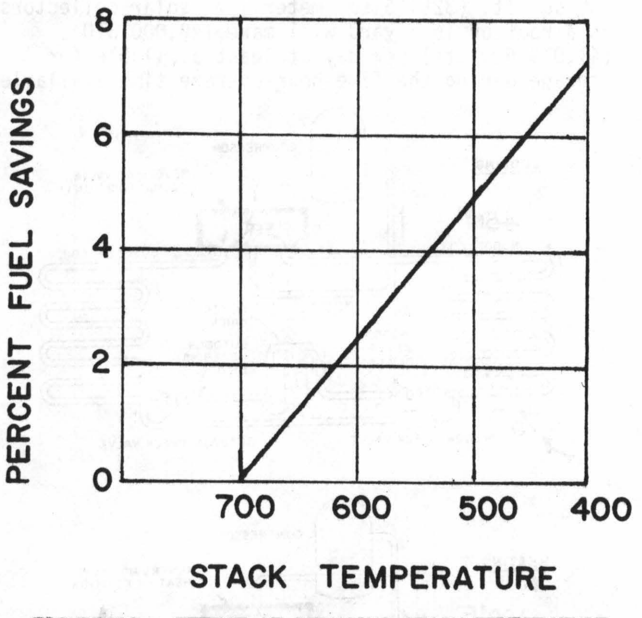


FIGURE 19. EFFECT OF REDUCING STACK TEMPERATURE

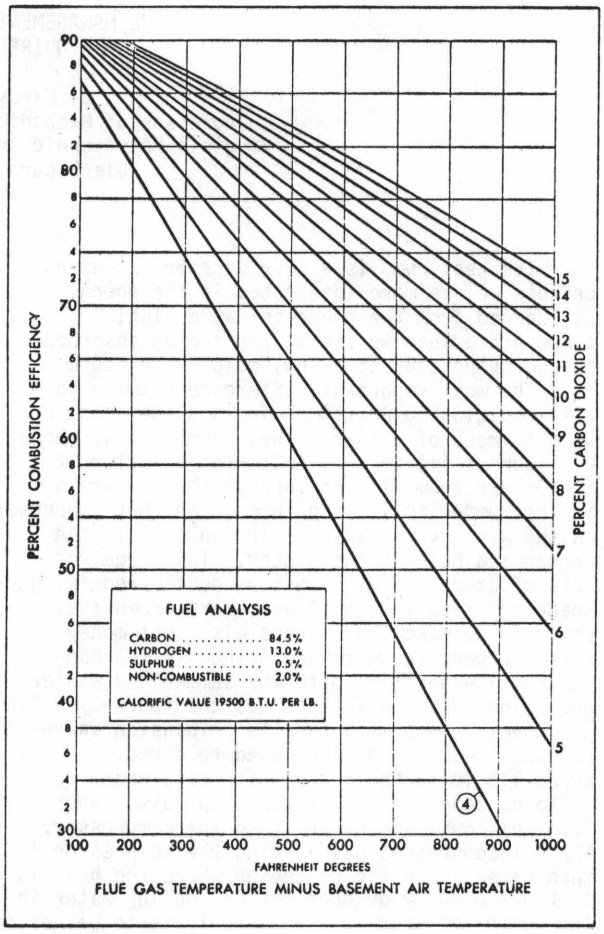


FIGURE 20. COMBUSTION EFFICIENCY - FUEL OIL

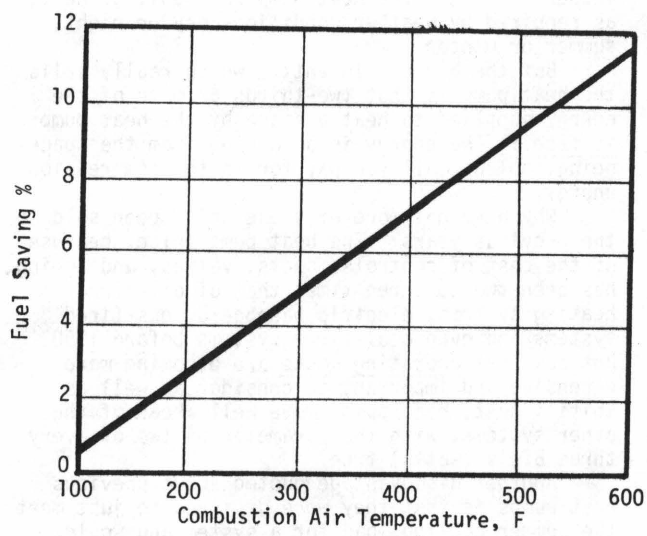


FIGURE 21. APPROXIMATE IMPROVEMENT IN EFFICIENCY USING HEATED COMBUSTION

THE MANAGEMENT OF ENERGY PRODUCED AND REQUIRED BY THE HEAT PUMP

C. Hardy Long, P. E.
Professor of Mechanical and Nuclear Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

The heat pump is a refrigerator, so-named because we are more interested in the energy discharged from the condenser at a high, hot temperature than we are in the energy absorbed in the evaporator at a low, cold temperature.

The most important difference between an air conditioning unit (meaning a summer cooling unit to most of us) and a heat pump is, as shown by Figure 1 (1) that by switching the flow of indoor air from flowing through the evaporator in the summer to flowing through the hot condenser in the winter, the indoor air can cool in the summer and heat in the winter. This requires lots of dampers and voluminous ducts, requiring space and metal, both of which are expensive. Controls to make the changes also cost money. A less expensive switching method is to change the refrigerant flow path for summer and winter operation. Figure 2 (2) shows the four-way valve and check valves with parallel expansion valves or pressure reducing devices used to direct refrigerant liquid to the evaporative coil where cooling is to be done and remove the evaporated vapor from this coil and steer it to the compressor. The hot compressed gas leaving the compressor is then directed to the condenser where the heat is to be removed by outdoor air or cooling water in the summer or where the indoor air is to be heated in the winter. The hot gas is condensed into liquid to be returned to the evaporator and repeat the cycle.

So the big difference in heat pump and air conditioner is that the air conditioner just cools indoor air while the heat pump can cool, or heat, as required by weather conditions day or night, summer or winter.

But the biggest incentive which really sells the heat pump is that two-thirds or more of the energy supplied to heat a space by the heat pump is free!! The energy is absorbing from the space being cooled. All you pay for is the compression energy.

Why have not more of these units been sold in the previous years? The heat pump price, because of the cost of controls, ducts, valves, and tubing, has been two to three times that of oil-fired heating systems, electric baseboard, gas-fired systems and even coal-fired systems before 1950. But now that operating costs are becoming more expensive and important to consider as well as initial cost, heat pumps move well ahead of the other systems, with the parameter of two of every three BTU's (watts) free!

Another disadvantage quoted about previous heat pumps is that they were designed to just meet the summer cooling load for a system and would, therefore, be too small for winter heating. Then, they would need electric resistance heating to supplement the heat pump when the outdoor temperature was below 35° F (1.7° C) shown in Figure 3 (3).

As energy managers, I suggest that you size your unit for winter and reduce the speed of the refrigeration unit in the summer to handle the smaller summer load. Some companies are already preparing such units for next season's market. Then, the resistance heater is only an emergency unit, not a below 35° F (1.7° C) must unit.

Unitary units are available in 1.5 to 20 tons capacity sizes. Multiunit types are available in 5 to 20 ton capacity sizes.

Large applied heat pump systems for central systems are available in 30 to 100 Hp (22.4 to 746 Kw) which equals approximately 30 to 100 tons capacity. As the energy market changes in the future, many more sizes will become available.

Figure 4 (4) shows air to air, air to water, water to air, earth to air, and water to water heat pump systems. To date, air to air has been the least expensive and most applicable system for small units while water, earth and other natural, or industrial heat sources have paid off, depending on their advantages against disadvantages.

A natural energy source is well water, and water from lakes, rivers, or pools. Provided you can cool this source, or even freeze it, in the winter while you extract energy these would be great heat sources. Be sure you do not kill fish, worms, plant life, or in any way disturb the natural environment, or you may loose your source of heat.

The most natural source of energy is the sun. 350 sq. ft. (3251.5 sq. meters) of solar collectors on a roof or in a yard will make 140,000 BTU (41,019.6 watts) per day at least available for storage during the five hour average time available

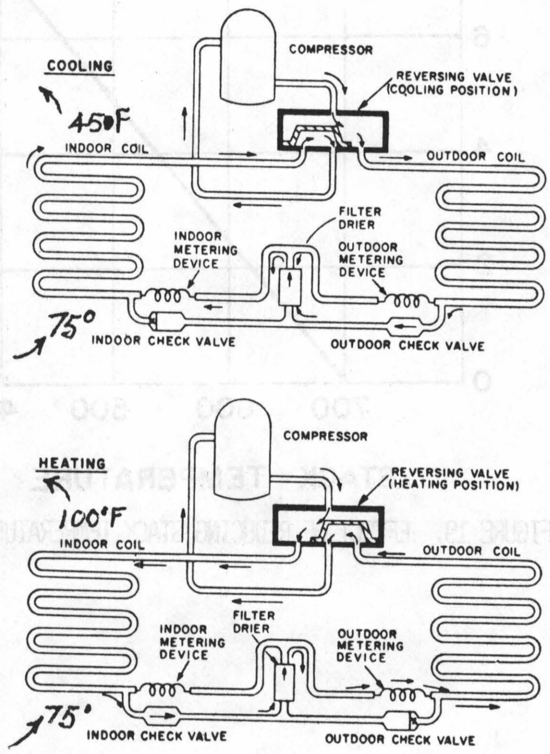


FIGURE 1. TYPICAL SCHEMATIC OF AN AIR-TO-AIR HEAT PUMP SYSTEM

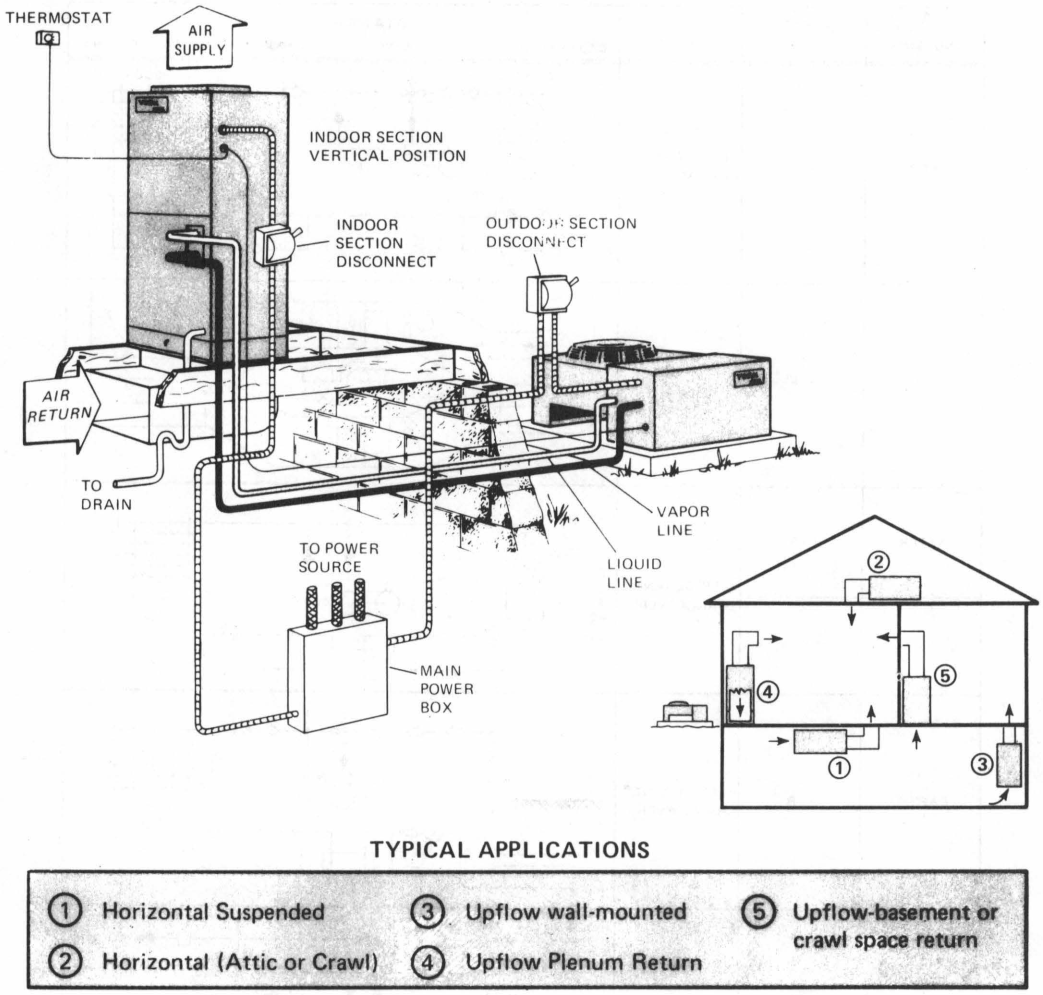


FIGURE 2. TYPICAL WIRING AND PIPING--CHAMPION SPLIT SYSTEM HEAT PUMPS

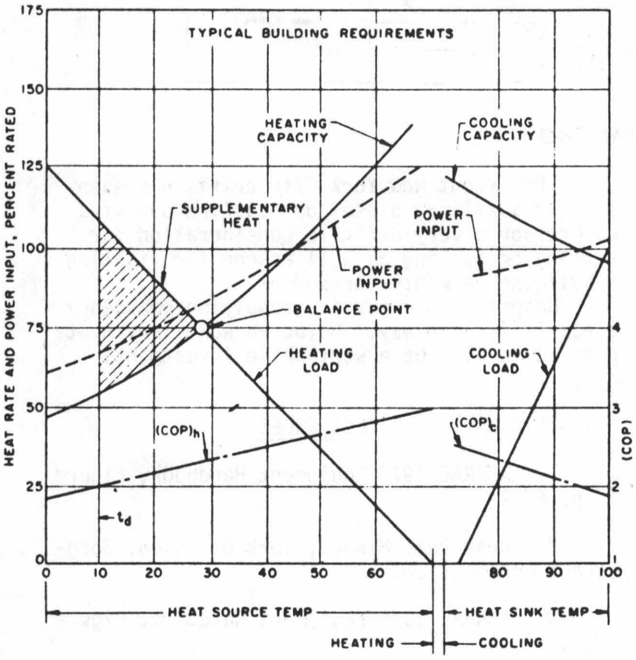
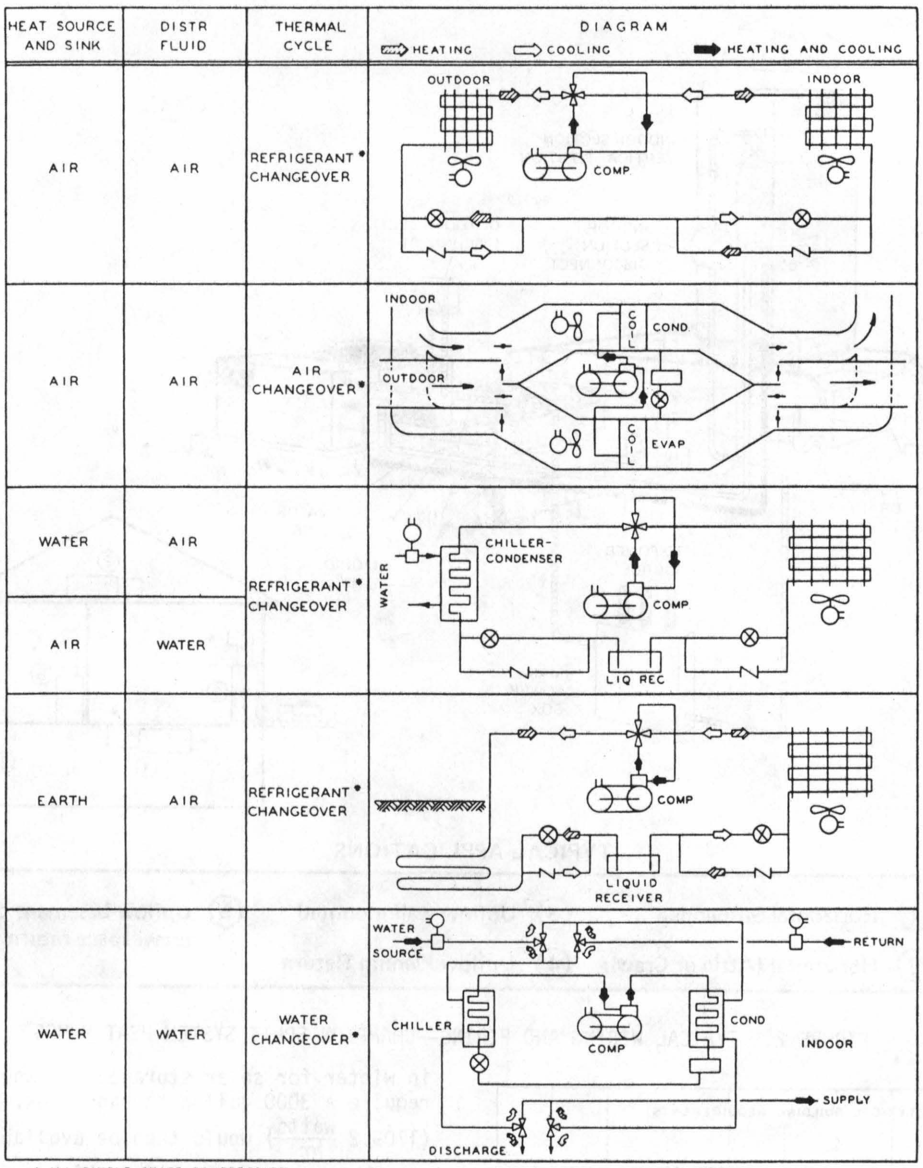


FIGURE 3. OPERATING CHARACTERISTICS OF SINGLE-STAGE UNMODULATED HEAT PUMP

in winter for solar storage. It would probably require a 3000 gallon storage tank. 5833.3 BTU/hr (1709.2 $\frac{\text{watts}}{\text{hr}}$) would then be available if this sun energy was stored in water which could be picked up by the heat pump fluid to heat the space. Many applications of solar assisted heat pumps will be seen in the future. They are a natural.

VPI&SU has had a split heat pump running on the roof of Randolph Hall and in the HV&AC Laboratory at Blacksburg, Virginia since 1960. The outdoor fan has had the blade replaced three times. The Power Companies of the Virginians, who gave us the unit, replaced the compressor once just to see how a new kind of compressor would work. No other trouble has been experienced except maybe a relay point replacement or spring adjustment. Summer or winter the unit has performed excellently. There are those which need new compressors every five years or so. Even this speaks well for a compressor that is outdoors with the outdoor coil and fan. One of the problems with heat pumps is defrost, but the removing of ice or frost from the cooling coil only takes seconds, or minutes, depending on the removal system. Then, you are back in business for an hour at least.

The heat pump earns its value in that it supplies 30,000 BTU/hr (8789.9 $\frac{\text{watts}}{\text{hr}}$) by paying only for 10000 BTU/hr (2929.97 $\frac{\text{watts}}{\text{hr}}$) which at



* ALL SINGLE STAGE COMPRESSION

FIGURE 4. COMMON HEAT PUMP TYPES

3¢/KwHr would cost $0.087/hr or times 720 equal $63.29/month compared to $189.86/month for electric baseboard heat or $137.42/month for oil heat at 50¢/gallon and $74.88/month for gas at $2.60/1000 cuft.

The oil, gas, or electric baseboard systems in the past have cost $800-$1500 while heat pumps costs $3-$6000. Today, with the cost of energy possibly heading to $1.50/gallon, or 7-10¢/KwHr, or $5-10.00/100 cuft, then, it will certainly be feasible to consider a system where two-thirds of the energy is free!

There are many communities in the country, like Pulaski, Virginia, where the heat pump has already arrived because there were knowledgeable engineers, electricians and mechanics, who knew how to install and maintain the equipment. The owners brag on their inexpensive equipment with low electric bills, $50 vs $200 this year, for example, and rightly so they should! Maybe we all will one day down the road see the advantage of the heat pump as the heating system!

The recent New York City crisis has even made an auxiliary diesel or gasoline operated compressor a very definite consideration for heating or cooling as well as one for lighting a building in winter or summer.

Hospitals already are supplying emergency electricity this way. Maybe an auxiliary heat pump would also be a worthwhile investment.

REFERENCES

1. ASHRAE 1975 Equipment Handbook, Figure 1, p. 43.2

2. Heat Pump Manual, York Division, Borg-Warner Corporation.

3. ASHRAE 1975 Equipment Handbook, Figure 10, p. 43.4

4. ASHRAE 1976 System Handbook, Table 1, p. 11.2

ENERGY CONSERVATION WITHIN INDUSTRY

Donald E. Hillier
Vice-President and General Manager
Quality Assurance - Environmental and Corporate Industrial Engineering
Johns-Manville Sales Corporation
P. O. Box 5108
Ken-Caryl Ranch
Denver, Colorado 80217

INTRODUCTION

The invitation to speak at this workshop suggested that I talk on the subject of Energy Conservation Within Industry. This subject alone could occupy the entire two days and more of this workshop. Hence, it will only be possible within my one hour time frame to cover the highlights of my topic.

First, I would like to comment on what I am not going to talk about, namely;

The need for Energy Conservation. I am sure we are all very well aware of this and the fact that energy availability will become worse and the costs will increase. We cannot say that it will get worse before it gets better or predict there is a silver lining someplace. We have waited too long already for specific actions to reduce our energy consumption and the rate of increased usage.

I do not plan to discuss specific engineering details of waste heat utilization, heat recovery systems within industry, nor review all of the details of how to study a particular operation for better energy utilization and/or conservation.

While I am not qualified to talk on the specifics of energy conservation within all industry, I do plan to review with you these areas of energy conservation which may help in the development of even better programs for this important activity. The areas I will review are:

1. A little about my company, Johns-Manville, and their energy conservation efforts.
2. An Industrial Energy Management Conservation Program.
3. Development and implementation of "How To - Cost Benefits Energy Audits."
4. An overview of Johns-Manville's cooperative effort with the Federal Energy Administration in conducting representative energy audits.
5. A review of J-M activity on Energy Conservation Workshops and Energy Conservation Self-Help Package for plant engineers.

THE JOHNS-MANVILLE COMPANY

J-M is a large diversified company with approximately 85 plants in the United States, manufacturing many products, from asphalt roofing, fiber glass insulation, transite pipe, sprinkler systems, golf carts, etc. About four years ago, J-M developed what some might call a rather complicated but concentrated Energy Conservation Program. This Program was initiated because we foresaw future critical energy procurement problems. We use large quantities of energy and much of it is process gas. In many locations, we were on interruptable service and we found ourselves waiting at the pumps with no gas when curtailments occurred. During the past three years, J-M has spent about 10 million dollars for propane standby facilities. We spent this money so we could use a fuel that costs 5 times the cost of natural gas. This was cost reduction in reverse except that we wanted to continue to operate our plants.

Johns-Manville is a relatively large user of energy. Let's look at how the units of energy used on an annual basis are distributed.

The cost of energy as shown on Chart No. 1 is about $63,000,000 per year, which is about 7% of the total U. S. sales.

CHART NO. 1

DISTRIBUTION OF ENERGY-U. S. PLANTS

	UNITS	USAGE	M BTU'S	EQUIV. BARRELS OF OIL
Electrical Power	MKW Hrs.	848,000	2,895,456	492,000
Natural Gas	MCF	18,054,017	18,054,017	3,070,000
Propane	Gallons	20,000,000	1,845,143	314,000
Fuel Oil	Gallons	33,000,000	4,683,825	796,000
Coal	Tons	38,000	908,378	155,000
			TOTAL BARRELS OIL:	4,827,000

ENERGY MANAGEMENT PROGRAM

As Energy Coordinator for the Johns-Manville Corporation, I will be glad to present our Company's Energy Management Program. While I am not in a position to say that the J-M Program is typical of industry, I do know that energy conservation programs within industry vary from very sophisticated programs with much paper work and follow-up, to rather routine programs with minimum effort, to those companies that are now thinking about a program, to companies with no program at all.

The Johns-Manville Program, which really consists of two different programs, is rather sophisticated and in some respects may be called unique.

In 1974, the J-M Energy Conservation Program won the Power Magazine Energy Conservation Award. The Program was briefly outlined in the November 1974 issue of Power Magazine.

Prior to our Company's formalized Energy Management Program, there was energy cost reduction activity as a part of a long-time cost reduction program.

Records of completion of specific energy cost reduction projects were maintained and the dollar saving reported.

Early in 1973, we felt a pressing need to concentrate on Energy Conservation; hence, the present program was developed.

The initial objective of the program expressed in dollars was 5% reduction over prior year of the total of all types of energy used. On the basis of Annual Energy Bill at that time of 48 million dollars, this represented a savings of $2,400,000.

At this point, may I say that in any corporate organization, any company-wide program such as Energy Conservation, Cost Reduction, Housekeeping, etc., is not worth its salt and probably would not get off the ground floor without a top officer approval and backing. In this regard, I quote a paragraph written by our Company's Chief Executive Officer to all Division General Managers and Production Managers. I quote:

"While 5% Energy Conservation is a worthwhile goal, greater emphasis on Energy Conservation is very important to our operations. Failure to accomplish the ultimate may result in serious curtailment in some operations. We should review our plans and goals for Energy Conservation to reduce and save as much as 10% of the prior year's energy used."

The J-M Program has now been in existance about four years. The operation of the program is that each division, of which there are twelve, has established an Energy Coordinator within the division and an Energy Coordinator at each plant within each of the divisions. Someone has to be given the responsibility for establishing a program and follow-up of actions planned and accomplishments.

The Corporate Industrial Engineering Department developed the program and established company-wide goals using data submitted by the divisions. Monthly Status Reports on performance versus goals are issued. The Corporate Industrial Engineering Department also disseminates information throughout the Corporation on energy saving ideas through the media of what we call Energy Highlights.

I would like to explain the program. This program may not be the right one for other companies, but it meets our particular needs and the important thing to remember is to have a program to create interest and activity and to monitor the results.

The unique feature of our program is that we measure energy usage and conservation activity on a common basis across the entire company.

The common basis being Energy Consumption and Conservation in BTU's per production unit.

The quantities of the various types of energy used each month; that is, electric power, gas, propane, coal, etc., are all converted by the use of standard factors to million BTU basis.

Here is a Chart showing the conversion factors used.

CHART NO. 2

STANDARD CONVERSION FACTORS - BTU'S

		M BTU'S
Electric Power	MKWH	3.413
Natural Gas	M CU. FT.	1.000
Propane	Gallons	.092
Fuel Oil	Gallons	.104
Coal	Pounds	.014
Gasoline	Gallons	.128
Steam	M LBS.	1.000

What we call a production unit is in effect the value added concept. It is a common measure by which all physical units of production can be combined. The formula for value added may vary considerably by industries, but in our company value added briefly stated is the sum of direct labor including overtime, shift premium, incentive pay, plus absorbed indirect expenses.

For example, Chart No. 3 lists the items of cost that make up value added.

CHART NO. 3

VALUE ADDED

Usage of Direct Labor (Includes O.T. & Shift Premium)	XXXXXX
Indirect Expense	
Charge Per Facilities In Use	XXXXXX
Shop Expense	XXXXXX
Plant Expense	XXXXXX
Taxes & Employee Benefits	XXXXXX
	XXXXXX

I would like to briefly explain the derivation of the value added factor for each product line. Let's look at Chart No. 4. In this much simplified example, the physical volume for each product group is measured for a base period. For the same base period, the value added was compiled and the total value added for all products.

Note the $7500 total value added for these two products.

The total value added for the company for one month was arbitrarily chosen as 15,000 production units. This large figure was selected so that individual products might have some volume as expressed in production units.

A calculation was then made on the basis of actual value added by each product group in the base period to that portion of the arbitrary 15,000 units to establish conversion factors for each item in the product line.

Prior to the end of each year, the Corporate Industrial Engineering Department issues the Energy Conservation Program instructions for the next year. These instructions request each division's goals for the next year. The goals are based on prior 12 months actual usage.

Chart No. 5 shows the form used by each plant and mine to show the energy conservation goal for the year and to report the energy usage for the current month and for year-to-date. The lower portion of this form is a running record by month of the usage of each source of energy.

CHART NO. 4

PRODUCTION UNIT CALCULATION

EXAMPLE

ASSUME:

Product No. 1 - Physical Vol.		1000 pcs.
	Value Added	$5000
Product No. 2 - Physical Vol.		5000 lbs.
	Value Added	$2500
Total Value Added		$7500
Arbitrary Prod. Units-Entire Company		15000
Production units/$ of Value Added		2

Production Unit Factor

Conversion of Physical Vol. to Prod. Units

Product No. 1 - $5000 x 2 = $10,000/1000 = $10.00/pcs = 10 Prod. Units/Pc.

Product No. 2 - $2500 x 2 = $ 5,000/5000 = $1.00/lb. = 1 Prod. Unit/lb.

CHART NO. 5

DISTRIBUTION: CIE, DHQ　　　　SUBMITTAL DATE: ____________

ENERGY USAGE FOR MONTH OF: ____________ PLANT: ____________ DIVISION: ____________

I. ENERGY USAGE SUMMARY	CURRENT MONTH			YEAR-TO-DATE			II. POWER ANALYSIS
	QTY.	M BTU'S	DOLLARS	QTY.	M BTU'S	DOLLARS	
Energy Used:							
Electric @ 3.413/MKWH							KW (Peak) ________
Gas @ 1.00/MCF							KW (Billing) ________
Oil @ .140/gal							KVA (Peak) ________
Propane @ .092/gal							KVAR (Peak) ________
Coal, Coke @ ________							KVARH ________
							P.F. ________
TOTAL:							
Production Units							
M BTU/PU							Goal

III. USAGE/ELECTRICITY			NATURAL GAS		OIL		PROPANE		COAL/COKE		PRODUCTION
	KWH	Latest Cost/ KWH	MCF	Latest Cost/ MCF	Gals.	Latest Cost/ Gal.	Gals.	Latest Cost/ Gal.	Qty.	Latest Cost/ Unit	Production Units
JAN.											
FEB.											
MAR.											
APR.											
MAY											
JUNE											
JULY											
AUG.											
SEPT.											
OCT.											
NOV.											
DEC.											
TOTAL											

Chart No. 6 is a copy of an actual monthly report submitted by one plant. Note the goal of 1.13 $\overline{M}$BTU's per production unit versus 1976 actual of 1.25. This is a 10% reduction goal.

Chart No. 7 is a Division Summary Report. The basis of the system is to compare the present rate of usage to the rate of usage in a base year.

CHART NO. 6

Date: June 28, 1977

ENERGY USAGE FOR MONTH OF June 1977 PLANT Waukegan DIVISION BMMD Mineral Panels

May 1977 Data	CURRENT MONTH			YEAR-TO-DATE			
I. ENERGY USAGE SUMMARY	QTY.	$\overline{M}$ BTU'S	DOLLARS	QTY.	$\overline{M}$ BTU'S	DOLLARS	II. POWER ANALYSIS:
Energy Used:							
Propane @ .092/gal.	925	85	269	5,578	513	1,543	KW (Peak)
Gasoline @ .128/gal.	--	--	--	20	3	10	KWH (Billing)
Process Gas @ 1.00/MCF	44	44	104	247	247	522	KVA (Peak)
Electric @ 3.413/MKWH	323	1,102	5,715	1,955	6,672	39,618	KVAR (Peak)
Steam: Gas @ 1.00/MCF	5,820	5,820	13,071	43,382	43,382	84,131	KVARH
Oil @ .150/Gal.	--	--	--	252,033	37,806	92,681	P.F.
TOTAL	--	7,051	19,159	--	88,623	218,505	
PRODUCTION UNITS	7,179			46,118			
$\overline{M}$ BTU/PU		.98			1.92	1976 = 1.25	1977 Goal = 1.13

III.	USAGE PROPANE		GASOLINE		PROCESS GAS		ELEC. POWER		STEAM FUEL OIL		STEAM GAS		PRODUCTION
	Gals.	Cost/Gal.	Gals.	Cost/Gal.	MCF	Cost/MCF	MKWH	Cost/MKWH	Gals.	Cost/Gal.	MCF	Cost/MCF	Production Units
JAN.	914	.2613	--	--	48	1.9368	341	20.7673	67,110	.3543	10,532	1.7286	7,024
FEB.	1,127	.2681	--	--	50	1.9769	332	20.4065	99,742	.3562	6,796	1.7703	7,794
MAR.	783	.2689	20	.5093	35	1.9572	287	21.5736	58,420	.3875	6,324	1.7510	8,048
APR.	902	.2794	--	--	40	2.1484	361	20.2925	25,304	.4000	6,256	1.9327	8,633
MAY	927	.2899	--	--	30	2.3670	311	20.9895	1,457	.4229	7,654	2.3071	7,440
JUNE	925	.2910	--	--	44	2.3556	323	17.6925	--	--	5,820	2.2458	7,179
JULY													
AUG.													
SEPT.													
OCT.													
NOV.													
DEC.													
TOTAL													

CHART NO. 7

CORPORATE ENERGY CONSERVATION PROGRAM

DIVISION

YEAR-TO-DATE MARCH 1977

	MILLIONS OF BRITISH THERMAL UNITS				ENERGY RATIO TO BASE YEAR		PERFORM RATIO BTU	PRODN RATIO	ENERGY COST	PROJECT SAVINGS
PLANT	LAST YR ACTUAL	LAST YEAR AT BASE	THIS YEAR ACTUAL	THIS YEAR AT BASE	LAST YEAR	THIS YEAR	THIS YR/ LAST YR	THIS YR/ LAST YR	THIS YEAR	THIS YEAR
A	367144	342410	304880	245670	1.072	1.241	1.157	.717	725264	0
B	192999	155520	176510	121167	1.241	1.457	1.174	.779	325661	0
C	208232	214723	217845	226897	.970	.960	.990	1.057	492075	20000
D	128968	132657	156465	157791	.972	.992	1.020	1.189	307830	0
E	97407	113061	147163	167044	.862	.881	1.023	1.477	366903	0
F	148287	142681	139637	130224	1.039	1.072	1.032	.913	296970	30000
G	567588	523047	548286	499841	1.085	1.097	1.011	.956	1228353	0
H	9700	7042	8785	7620	1.377	1.153	.837	1.082	36913	0
I	250297	230357	292801	322863	1.087	.907	.835	1.402	608872	0
J	235434	200114	195345	184909	1.176	1.056	.898	.924	465743	28000
K	137526	129595	126908	96869	1.061	1.310	1.235	.747	340621	0
L	225255	175684	366997	330577	1.282	1.110	.866	1.882	1173035	255000
M	131887	159665	147533	191005	.826	.772	.935	1.196	371803	29000
N	280235	327735	416110	543053	.855	.766	.896	1.657	1351673	63000
O	215551	216895	226301	230145	.994	.983	.989	1.061	569955	0
P	290683	292540	283337	287220	.994	.986	.993	.982	864668	34000
TOTAL DIV.	3487193	3363726	3754903	3742895	1.037	1.003	.968		9526339	459000

The energy ratio of million BTU's per production unit for each plant for the base year is multiplied by the current number of production units to obtain million BTU's at base year rate. The current actual BTU's divided by BTU's at base rate is the current performance ratio. Ratios under 1.00 indicate less energy used than in the base year. For the division as shown on this Chart, the energy ratio is .968% of last year.

Chart No. 8 is an overall company summary report which is a summation of all the division reports. The way I have presented this may appear to seem like a lot of effort, but once this data is programmed, it is a simple matter to generate the monthly division and company reports.

The company summary shows last year's performance ratio to base of 1.053 versus this year's ratio of 1.046. The lower the ratio, the better, but this report is a long ways from meeting the 10% goal.

These are interesting figures because on analyses, the reason for poor energy usage performance is the result of namely two factors:

1. Constraints due to volume.
2. Constraints due to operation of environmental control facilities.

A word about constraints due to volume. We have attempted to analyze with some degree of success the variation in energy usage at different levels of volume.

I believe we will all agree that the most efficient use of energy is at 100% capacity. At zero capacity there is residual energy used which varies widely by type of plant and process.

The last column on this report shows project dollars saved. The total of $562,000 is the result of specific action by project on the part of the plants to conserve energy. These dollar figures are transferred to the monthly summary of the company's cost reduction activity report. The actions taken to accomplish the dollar savings is reflected in the energy usage per production unit.

CHART NO. 8

CORPORATE ENERGY CONSERVATION PROGRAM

COMPANY SUMMARY

YEAR-TO-DATE MARCH 1977

DIVISION	MILLIONS OF BRITISH THERMAL UNITS: LAST YR ACTUAL	LAST YEAR AT BASE	THIS YEAR ACTUAL	THIS YEAR AT BASE	ENERGY RATIO TO BASE YEAR: LAST YEAR	THIS YEAR	PERFORM RATIO BTU: THIS YR/ LAST YR	ENERGY COST: THIS YEAR	PROJECT SAVINGS: THIS YEAR
A	1026648	948075	1136010	922164	1.083	1.232	1.138	2647316	0
B	1018443	968560	1142442	1096409	1.052	1.042	.991	2326788	2000
C	79710	69424	79890	80533	1.148	.992	.864	159249	0
D	914669	894115	846148	780369	1.023	1.084	1.060	2204218	0
E	719612	698855	758961	731359	1.030	1.038	1.008	1592149	30000
F	3487193	3363726	3754903	3742895	1.037	1.003	.968	9526339	459000
G	549016	502242	580908	586675	1.093	.990	.906	1591300	16000
H	97139	81349	117501	107047	1.194	1.098	.919	403711	30000
I	322597	319346	290339	307671	1.010	.944	.934	961896	0
J	511686	502064	530395	575823	1.019	.921	.904	1424491	5000
K	429145	342294	518810	396146	1.254	1.310	1.045	1562771	0
L	38588	37583	39475	41257	1.027	.957	.932	195483	20000
TOTAL COMPANY	9194446	8727633	9795782	9368348	1.053	1.046	.993	24595711	562000

Chart No. 9 provides a few examples of energy savings projects resulting in cost reduction.

The response to this program by employees, supervisors and management has been excellent. After all, when a number of our plants have waited at the fuel pumps and in fact have had gas supplies shut off, energy conservation comes home to our people rather quickly.

We have no formalized incentive program for energy conservation accomplishments. Several divisions do run contests with awards.

We believe we have a successful program since it has created a great deal of interest among all levels of management from the top, down. Further, it has resulted in a constant demand for plant energy audits by out company's energy audit teams.

I have taken considerable time to outline results oriented energy management conservation program. Many companies do not require what one might feel as a complicated program, but any or all parts of this program may give others ideas to develop their own.

CHART NO. 9

1. $1,000,000 by substitution of self-help gas for propane. Gas well drilling program.
2. Optimized controls on ovens and replaced oven burners. - $77,000.
3. Oil fired furnaces - improved combustion through improved burners.
4. $300,000 in improved machine efficiency and productivity for less energy per pound.
5. Board plant-$200,000-reduced dryer leaks and:
   A. Improved burners and controls.
   B. Nuclear thickness gauges for more product uniformity - less rejects.
6. Return paper mill condensate under high pressure direct to boiler - $10,000.
7. Insulate asphalt tanks - $13,000.
8. Truck hot asphalt to plant, instead of rail car (less reheating) - $35,000.
9. Reduce boiler blowdown and shutdown blowers instead of idling - $43,000.
10. Reduce blower - RPM - $11,900.

HOW TO-COST BENEFITS ENERGY AUDITS

In my opinion, this is one of the most important tools of management. It requires manpower and time, but the benefits are well worth it. Without energy audits, it is most difficult to get a handle on where to look for real energy conservation activities.

Under the direction of corporate industrial engineering, J-M has established energy audit teams that visit the J-M plant locations to conduct energy audit surveys. We have established in writing for internal Use:

1. Our approach to energy audit surveys.
2. A list of equipment and instruments required to make proper energy audits.
3. A tabulation of the skills required of the audit team depending upon the type of operation to be audited.
4. A formal table of contents of what is to be included in an energy audit.

In our opinion, the most important part of any energy audit is an energy balance study. In other words, what goes in -- what goes out -- where is it used -- and how much is wasted.

We break down the recommendations in these audits into three categories as follows:

Short Term Recommendations
Intermediate Term Recommendations
Long Term Recommendations

The definitions of these categories are given in Chart No. 10.

CHART NO. 10

ENERGY AUDIT SURVEYS

SHORT TERM RECOMMENDATIONS

Accomplishment within six months involving plant changes with minimal investment.

Procedural changes and improved maintenance.

INTERMEDIATE TERM RECOMMENDATIONS

Accomplishments within eighteen months involving some expenditures, process changes, changes to equipment and engineering studies.

LONG TERM RECOMMENDATIONS

Accomplishments over eighteen months requiring significant capital expenditures, process changes, development work and technology improvements and necessary engineering studies.

I would like to say that these energy audits conducted in our plants are "How To" -- "Cost Benefits" audit.

Upon completion of a plant audit and the preparation of the report, a meeting is held with the division involved to go over each item of recommendation and make decisions on how to implement the recommendations. These may be implemented by:

1. Action on the part of the plant.
2. Division action.
3. Assignment of the project to the company's general engineering or corporate industrial engineering departments.

We have three -- two to three-man audit teams to conduct these audits within the company.

Chart No. 11, on the next page, lists our energy audits and what has been accomplished so far. We still have a lot of work to do in this area for, as we all know, things are always changing, new equipment being installed, and there is much effort being expended on improved productivity. All of these things affect energy usage and the conservation effort.

JOHNS-MANVILLE'S COOPERATIVE EFFORT WITH F.E.A.

You may be interested in the work that our company performed in cooperation with the Federal Energy Administration in conducting "How To -- Cost Benefit" audits in the meat packing and bakery industries. As a result of our company's conservation efforts, our President accepted a request by F.E.A. to conduct ten energy surveys in the meat packing and bakery industries. These audit surveys were to be made in these high intensive energy industries as representative examples of what could be accomplished in the conservation of energy.

These ten energy audits have been completed and presented to F.E.A. They have now been officially published by the F.E.A. We learned something from making these audits in industries foreign to us and we found numerous areas where there were some early opportunities for energy conservation. In fact, we received several letters thanking us for making these energy audits. These services were performed by Johns-Manville at no charge to F.E.A. or to the companies surveyed, and at a considerable cost to Johns-Manville.

Again, I would like to say that these 10 energy audits for F.E.A. are "How To -- Cost Benefits" audits. A few highlights regarding these audits are as follows:

Chart No. 12 is the Organization Chart which was developed for this cooperative effort:

Note the 2 audit teams of 3 men each, and the advisors to the audit teams which consisted of specialists in insulation for both buildings and process pipe lines, research and engineering people, and also a representative from Libbey-Owens-Ford on glazing.

Now a little about the procedure established for conducting these audits.

1. Initial plant visits were made to each of the 10 locations to review the plant operation to establish the makeup of the audit teams, to explain the reason for the audit and J-M's part in it, to leave a questionnaire to be filled out and returned so that we would have some preliminary data before the energy audit team visited the plant, and most inportant of all, to become acquainted.
2. Upon receipt of the questionnaire, we then scheduled the audit team.
3. The audit team conducted the plant survey which required from 3 to 5 days at each location, and upon returning to Denver, prepared a rough draft of the audit report.
4. A rough draft was then sent back to the plant and about one week later, a J-M man visited the plant to review the audit report to delete proprietary information and correct errors.
5. The audit reports were then prepared in final form and issued to F.E.A.

A word about the audit teams. They generally consisted of an industrial engineer, an electrical engineer, and a heating, ventilating, air conditioning and oven specialist.

The problems encountered in conducting these audits were few, the main problem being one of suspicion as to why J-M was conducting these audits in strange industries. When the plant personnel learned that these audits were being conducted for the public good, so to speak, without charge to the

CHART NO. 11

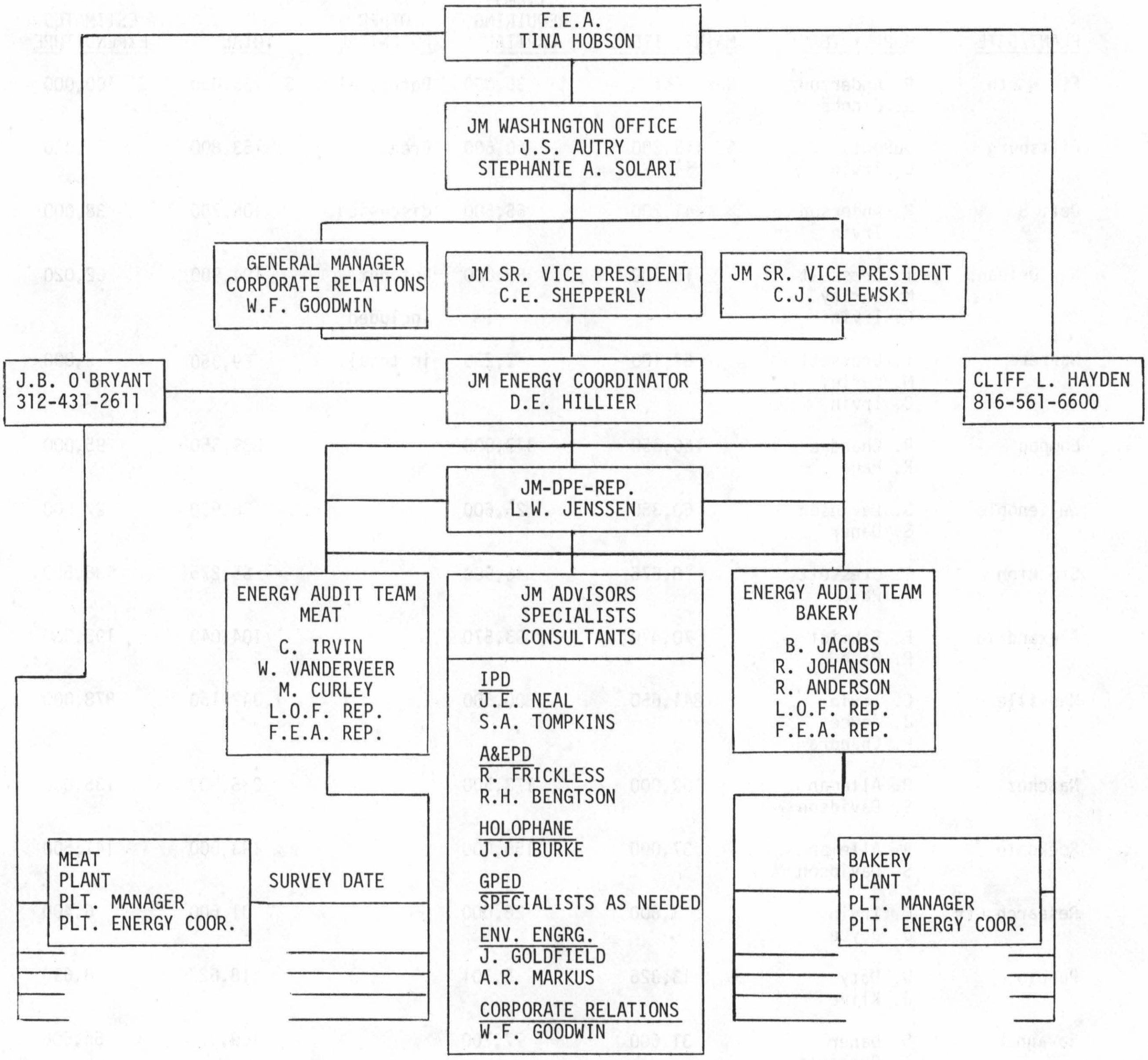
JOHNS-MANVILLE ENERGY CONSERVATION AUDITS - POTENTIAL SAVINGS

Savings

PLANT/DATE	SURVEY TEAM	MAINT. ITEMS	ITEMS REQUIRING CAPITAL	OTHER POTENTIAL	TOTAL	ESTIMATED EXPENDITURE
Ft. Worth	R. Anderson B. Jacobs	Not. Est.	$ 35,000	Potential	$ 35,000	$ 100,000
Pittsburg	DuPont C. Irvin	$ 113,200	40,600	Areas	153,800	54,020
Def. 8	R. Anderson C. Irvin	41,200	65,500	discussed,	106,700	38,000
New Orleans	T. Gressett M. Curley C. Irvin	15,900	89,000	but not included	104,900	62,020
Marrero	T. Gressett M. Curley C. Irvin	67,100	2,250	in total.	69,350	5,800
Lompoc	P. Chandra R. Page	166,350	373,000		539,350	95,000
Zelienople	S. Davidson S. Daner	60,350	26,600		86,950	27,500
Stockton	T. Gressett R. Page	8,675	46,600		55,275	136,500
Alexandria	F. Schmidt R. Page	70,470	33,570		104,040	192,000
Manville	C. Irvin J. Joyce P. Chandra	241,650	800,500		1,042,150	878,000
Natchez	R. Alleman S. Davidson	62,000	173,500		235,500	135,000
Rockdale	R. Alleman S. Davidson	37,000	156,000		193,000	141,500
Research Ctr.	C. Irvin J. Joyce	3,600	28,000		31,600	6,400
Pueblo	W. Doty J. Kline	13,326	5,301		18,627	8,690
Savannah	S. Daner T. Gressett	31,600	77,700		109,300	55,500
Jarratt	R. Alleman P. Chandra E. Caren	160,950	132,500		293,450	152,400
Springfield	W. Doty E. Caren	10,480	25,550		36,030	91,000
Parkersburg	T. Gressett C. Irvin	16,170	70,100		86,270	104,500
TOTALS:		$1,120,021	$2,181,271		$3,301,292	$2,283,830

CHART NO. 12

FEA AND J-M PILOT ENERGY AUDIT PROGRAM
COMMUNICATIONS AND FLOW OF INFORMATION



plants and without charge to F.E.A., all obstacles were rather quickly overcome. We received excellent cooperation.

One problem we thought we might encounter was that one company had a very complete energy conservation program. We thought we were being set up. However, we proceeded to conduct the survey and I would like to say that our recommendations in the final audit report resulted in an approximate 11% savings in energy over and above the program they already had.

The results of the energy audits in the meat packing and bakery plant are presented in Chart No. 13. Note the percentage savings in energy units and the percent savings in dollars based on energy costs at the time of the survey.

Why did we conduct these surveys and what does all this mean to us?

A. It is hard to convince people of energy conservation where there seems to be plenty of it.

B. By their action or inaction, even some Congressmen apparently do not believe there is an energy problem.

So it goes with industry. What have we done toward energy conservation? Some have good programs, some are thinking about establishing a program. Others haven't even thought about it.

I have often heard it said by some large and small companies, "we have done everything we could that is cost justified." My question is -- "cost justified by what means?" Last year's cost, this year's cost, or future cost?

CHART NO. 13

MEAT PACKING ENERGY SURVEY-SUMMARY STATUS AFTER FINAL DRAFTS

	ENERGY					DOLLARS			
	1974 Usage		Recommended Savings				Rec $ Savings @ 1975 Rates		
Plant	M̅ BTU	Equiv Bbls Oil	M̅ BTU	Equiv Bbls Oil	% M̅ BTU Saving	NRG $ Usage @ '75 Rates	$	% $ Savings	Cost to Achieve Savings
A)	55,240	9,363	22,112	3,748	40.0	$ 114,306	$ 26,000	22.7	$108,450
B)	211,645	35,872	37,403	6,339	17.7	355,783	41,000	11.5	120,000
C)	7,478	1,267	1,248	211	16.7	22,950	2,980	13.0	8,100
D)	2,290	380	314	53	13.7	11,791	1,140	9.7	3,635
E)	583,884	98,963	70,841	12,007	12.1	783,250	77,690	9.9	247,800
TOTAL 5 Plants	860,537	145,845	131,918	22,358	15.3% (Avg)	$1,288,080	$148,810	11.6% (Avg)	$487,985

FEA BAKERY ENERGY SURVEYS-SUMMARY STATUS AFTER FINAL DRAFTS

	ENERGY					DOLLARS			
	1974 Usage		Recommended Savings				Rec $ Savings @ 1975 Rates		
Plant	M̅ BTU	Equiv Bbls Oil	M̅ BTU	Equiv Bbls Oil	% M̅ BTU Saving	NRG $ Usage @ '75 Rates	$	% $ Savings	Cost to Achieve Savings
A)	135,774	23,091	36,788	6,256	27.1	$279,423	$49,785	17.8	$50,400
B)	34,368	5,825	6,015	1,019	17.5	94,593	11,543	12.2	8,290
C)	1,553	263	192	33	12.4	5,302	672	12.7	200
D)	80,510	13,692	12,792	2,176	15.9	165,369	23,175	14.0	29,950
E)	43,118	7,333	5,734	975	13.3	62,331	5,840	9.4	6,385
TOTAL 5 Plants	295,323	50,204	61,521	10,459	20.8% (Avg)	$607,018	$91,015	15.0% (Avg)	$95,225

Please look at the alternative. If you are using gas, what are the alternatives when there is no gas?

Propane
Oil
Electric
Coal
Shut Down

Let's cost justify in the future when the price of energy will be doubled, tripled what it is today. If you do, an entire different picture may present itself.

The sample audits made in the meat packing and bakery industries are examples of what can be done to conserve energy.

As a result of our work within our own company and the energy surveys made in the meat packing and bakery industries, we recommend the following program for energy conservation within industrial plants. These same recommendations could apply to all industry as well as commercial buildings, hospitals and other areas. I recommend:

The appointment of an individual at each plant location to be responsible for energy conservation. This should be a plant manager or plant engineer.

The individual appointed should receive some training in how to make an energy balance and conduct a survey. Let this man learn a little about energy conservation and he will do wonders for you.

Further, a little training goes a long way. In looking at ways to save energy, one begins to question the process and it may surprise you what turns up.

There are well written articles on:

Work Simplification
Elimination Approach
Value Engineering

I recommend them.

Establish a formal program for energy conservation. Don't just give it lip service. It must be an on-going program, not a one-shot deal.

Develop an energy balance. It is easy. Everything that comes in must go out -- where does it go and where is it being wasted?

Divide the program into 3 categories:

<u>Short Term</u>
6 months to accomplish, very little expenditure.

<u>Intermediate Term</u>
Up to 18 months to accomplish. Some $ required. Payback period about 1 year.

<u>Long Term</u>
Over 18 months to accomplish. Require engineering studies, design changes. Capital expenditure extended payback periods.

I repeat, do not overlook payback periods now 2, 3, 4 or even 5 years out. A year from now these periods may be cut in half.

Implement the program by making assignments to individuals, setting time periods, and follow up on monthly basis.

Establish reporting system. BTU/LBS packed or shipped, or any other unit as long as it is consistent. The real numbers mean little. It is the change. The trend that is important.

Go after the big ones first. Make the largest reduction for the least $, then tackle the harder ones.

REVIEW OF J-M ACTIVITY

Finally, I would like to say a few words about other areas of J-M activity for better energy utilization and conservation.

Any program within industry, as well as in other areas, to be successful must continue to have a "shot in the arm", so to speak, to maintain interest and motivate people. This is particularly true if various areas have not yet suffered as a result of energy curtailment and the high cost of energy.

Our company's continuing activity in this regard are at present threefold.

One being an energy conservation self-help package which has been distributed to all plant managers, directors of manufacturing, production engineers, and division energy coordinators. I have given Mr. Mashburn several copies of this self-help package in case others are interested in it.

The second activity which our company has undertaken is the establishment of an energy conservation workshop for plant engineers, industrial engineers and other operating people. This workshop, which is 3 days long, is held at periodic intervals and is attended by 12 to 16 people. This is a hands on how to workshop with demonstrations, participative practices, talks, questions, and the distribution of a manual on energy conservation. Typical subjects covered are:

1. Combustion chemistry and burner efficiency.
2. A film on heat.
3. Oven operations, energy content, heat balance.
4. Heat recovery.
5. Heating, ventilating, air conditioning.
6. Heat measurement, air flow demonstrations.
7. Steam system and steam traps.
8. Electrical
9. Class problems

We feel we have had success with this workshop as measured by the attendance and the interest created as well as the critique of the attendees.

A third item of activity which we are presently working on is a set of energy conservation standards. These standards will include such items as:

- Site Development and Planning
- Design of Buildings
- Lighting Standards
- Peak Demand Considerations
- Space Design Considerations
- Heat Recovery

In our business, there are many other areas of energy activity that will become more and more important as energy becomes less available. In fact, there may be some high intensive energy products that may not be produced at all. I believe many products will be eventually classified in this category at some future point in time.

In closing, let me say that energy conservation is good for everybody and regardless of the issues of energy conservation and shortages, an energy conservation program is in reality just plain good business because it offers cost reduction and/or cost avoidance opportunities which betters the bottom line, which is why we are in business.

Thank you!

WASTE HEAT RECOVERY SYSTEMS

Goodwin H. Taylor, Jr.
Goodwin H. Taylor, Ltd.
Consulting Engineers
6121 Lincolnia Road
Alexandria, Virginia 22312

This afternoon we are going to look at Waste Heat Recovery in four different categories (Refer to Table I).

TABLE I

WASTE HEAT RECOVERY

- Exhaust Air
  - Heat Wheel
  - Run Around Cycle
  - Heat Pipe
- Process Refrigeration
- Building A/C System
  - Closed Circuit Heat Pumps
  - Double Bundled Condenser
  - Water Cooled Light Fixtures
  - Heat of Light
- Miscellaneous
  - Waste Heat Boilers
  - Water Cooled Transformers
  - Industrial Processes

The first major category will be recovery systems that are utilized to extract heat from exhaust air. Currently, three methods are employed. They are the heat or enthalpy wheel, a run-around cycle, and the heat pipe. We will touch on each one of these techniques as soon as we review the remainder of the list.

The second major category which we consider in the commercial market is the reclaim of heat from process refrigeration systems.

The third category of waste heat recovery we will consider is that of recovering heat in typical space air conditioning systems. As we mentioned in this morning's session, the ability to redistribute heat from high internal heat gain areas of a facility to areas requiring heating offers good potential with the equipment currently available. Under this general category, we will look briefly at closed circuit heat pumps, the use of a double bundle condenser, water cooled light fixtures, and briefly at what is known as a heat-of-light system.

The fourth category I have lumped as miscellaneous which would include numerous industrial processes, such items as water cooled transformers, water cooled waste pipes, waste heat boilers, etc.

Digressing to our exhaust air waste heat recovery system, we will consider the operation of a heat wheel. This device is basically made in two types, either a straight sensible heat transfer type or what is known as the enthalpy wheel where both sensible and latent heat is transferred. This system basically consists of a large wheel, the diameter of which is a function of the quantity of air flow involved, wherein the exhaust air passes through one-half of the wheel housing, and the incoming air passes through the other half. The wheel slowly turns and a transfer of heat occurs between the exhaust air and the incoming air. Based on our experience, the enthalpy type should be utilized since either of the other two systems mentioned becomes normally a more economical alternative to obtain sensible heat transfer. We will limit our discussion to the enthalpy type heat wheel.

Figure 1 illustrates the design conditions for a project which we currently have in the design process. You will note that building condition exhaust air had 75° dry bulb/63° wet bulb being exhausted through the exhaust section of the wheel with 100% outside air at 95°/78° entering the intake side and leaving at a condition of 80°/70°.

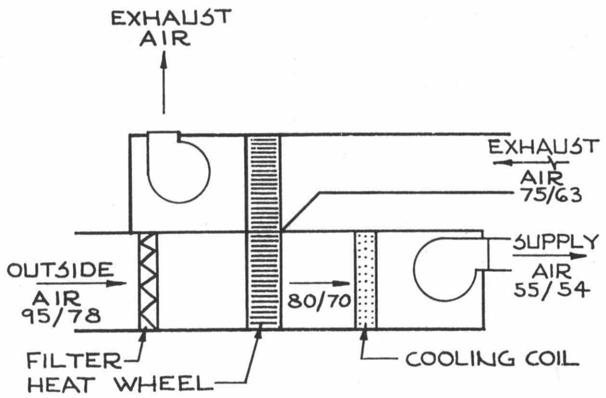


FIGURE 1. HEAT WHEEL

Figure 2 is a section through one of the mechanical rooms on this project and gives you some idea of the space requirement for this type of installation. To give you some perspective, the enthalpy wheel is 8 feet in diameter delivering approximately 14,000 cfm. Thus, the requirement to have outside air and exhaust air at the same location in conjunction with the physical size of the exhaust fan and enthalpy wheel demands a considerable amount of building area.

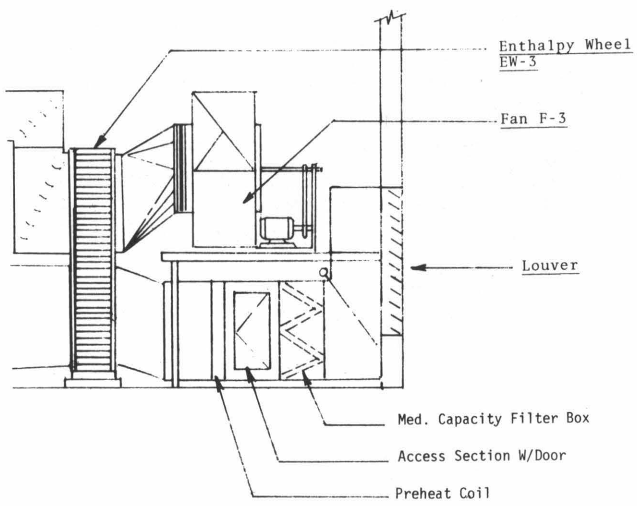


FIGURE 2. SPACE REQUIREMENTS FOR HEAT WHEEL

Figure 3 shown, indicates a schematic of a run-around system which would be employed in the same circumstance to obtain sensible heat recovery between exhaust and intake air systems. In the run-around cycle, large coils are installed in the exhaust air system as well as the outdoor air intake system with a fluid medium transferring heat from one to the other. The fluid medium is normally 30% glycol solution to preclude freezing problems.

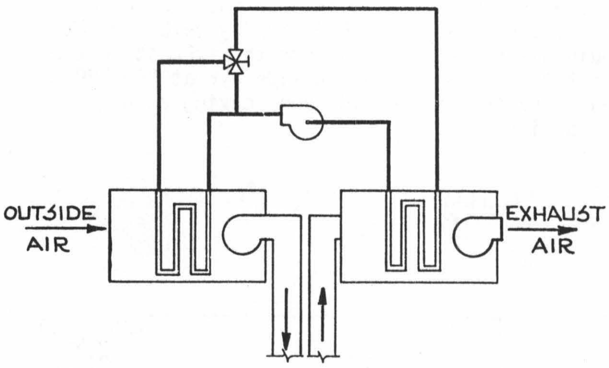


FIGURE 3. RUNAROUND SYSTEM

Figure 4 indicates the basic construction of what is known as a heat pipe. This piece of equipment is an outgrowth of the space program. It consists of a sealed copper tube with a cylindrical wick and refrigerant charge. The temperature difference between the ends of the pipe causes the liquid in the wick to migrate by capillary action to the warmer end where it evaporates and absorbs the heat. The refrigerant vapor then returns thru the hollow center of the wick to the cooler end where it gives off heat, condenses, and then repeats the cycle.

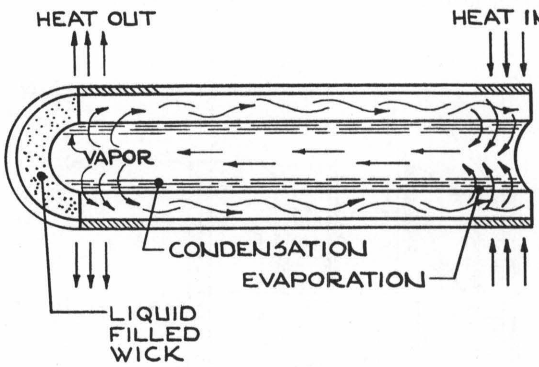


FIGURE 4. HEAT PIPES

In an air to air heat recovery system, bundles of heat pipes are installed with a barrier between the exhaust air and incoming air, thus providing the heat recovery system. The control of heat recovery can be obtained by the angle of the two bundles of heat pipes.

To review all three systems, we see each system has its advantages and disadvantages. The enthalpy wheel obviously is capable of transferring the greatest quantity of heat since it has latent capability but requires the greatest amount of space with the requirement for the exhaust and intake air streams being located adjacent to each other.

The same proximity of exhaust and intake air streams holds true for the heat pipe.

The run-around cycle allows remote location of exhaust and intake air systems but is the least efficient from the standpoint of heat recovery.

The heat pipe system has no moving parts and therefore, from a liability standpoint, should provide the least maintenance cost.

While the heat wheel incorporates a purge cycle to prevent cross-contamination between the air flows, only the other two systems preclude any possibility of cross-contamination.

Table II is a copy of one of our preliminary design work sheets for this same project. The project would not be typical of most exhaust air heat recovery systems since it involves a 100% outside air system and thus the results of utilizing exhaust air heat recovery approach maximum results. Under the inside condition of 75^{o} and 50% relative humidity, you will note that the system requires, without any heat recovery, 530 tons of refrigeration.

Utilizing a run-around system, tonnage can be reduced from 530 tons to 463 tons. Utilizing an enthalpy wheel with a 72% efficiency, tonnage is now reduced from 530 tons to 285 tons. Considering the heating analysis, you can see that for the same indoor design conditions, required boiler horsepower is reduced from 241 to 172 with a run-around cycle; and ultimately to 44 boiler horsepower with the enthalpy wheel. Due to the configuration of the building and the extreme critical nature of the building operation, our office initially recommended utilizing a run-around cycle since we were extremely concerned about cross-contamination even utilizing an enthalpy wheel with a purge system. Based on the owner's past experience and his directive, however, we did incorporate the use of the enthalpy wheel with the resulting reduction in capital cost and annual operating cost as indicated.

Obviously, you would not currently design this type of facility without some type of heat recovery; however, the numbers are indicated to exemplify the heat recovery that this type of system is capable of producing.

TABLE II

HEATING & COOLING CAPACITY ANALYSIS -
HEAT RECOVERY VS. CONVENTIONAL

BLDG. TONNAGE ANALYSIS

Assume: 40 Tons of Recirc. Systems
72,000 cfm O.A.

Inside Conditions	W/O HT. Recovery	W/ R.A.R.	W/ WHEEL 72% Eff.	W/ WHEEL 60% Eff.
75°/60%	440	375	230	
75°/50%	530	463	285	325

BLDG. HEATING ANALYSIS - Excluding Process

MBH

		W/O HT. Recovery	W/ R.A.R.	W/ WHEEL 72%	W/ WHEEL 60%
75°/50%	SENS.	5054	2721	777	2336
	HUMID	3035	3035	685	1175
	TOTAL	8089/241 BHP	5756/172 BHP	1462/44 BHP	3505/105 BHP
75°/40%	SENS.	5054	2721	777	
	HUMID	2448	2448	489	
	TOTAL	7502/224 BHP	5169/154 BHP	1266/38 BHP	

REDUCTION IN FIRST COSTS - $60K - $80K
ANNUAL REDUCTION - ENERGY - $42K

Figure 5 indicates waste heat recovery of process refrigeration used typically in chain food stores. Ten years ago, virtually all food chain stores simply wasted the refrigeration heat from the process refrigeration for all their food cases. Today, most all chain food stores utilize this heat to provide building heat during the winter months. In most operations, this waste heat recovery is sufficient to provide the total heating requirements for the building. This application typifies the use of waste heat recovery from a process system utilized in an additional subsystem. The same technique can be utilized in any similar industrial process.

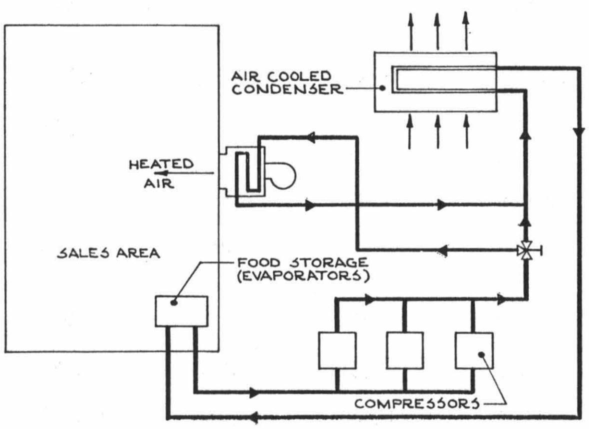


FIGURE 5. HEAT RECOVERY FROM FOOD SERVICE REFRIGERATION

We will now consider environmental space air conditioning system - waste heat recovery systems.

Figure 6 indicates a water source heat pump transfer system wherein closed loop condenser water is piped throughout the facility. The boiler in the loop provides the required heat when the heat balance is such that the heat rejected to the loop by the heat pumps providing the cooling needs of the building is inadequate to maintain loop temperature. The evaporative cooler is utilized to reject heat from the loop when the air conditioning load of the building exceeds the heating load. Since our later session will cover the heat

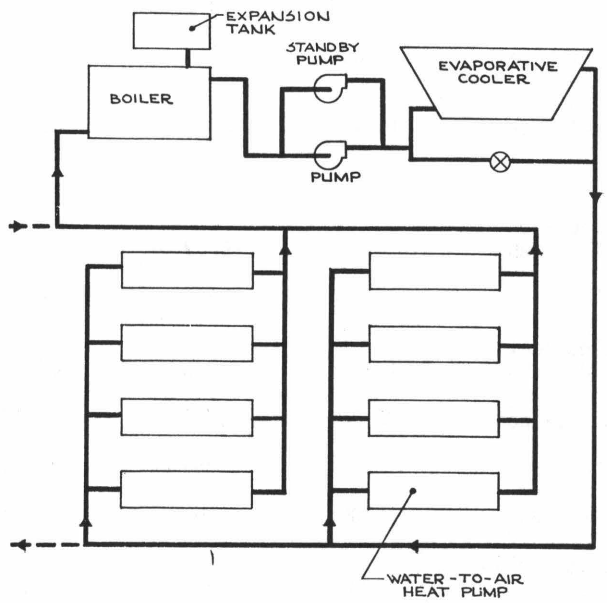


FIGURE 6. WATER SOURCE HEAT PUMP TRANSFER SYSTEM

pump system in detail, we will omit any further details in this discussion.

Figure 7 indicates the use of a double bundle condenser again to pick up the waste heat from one area of the facility and transfer it to other areas. This system is conventionally accompanied by storage capacity and the ability to false load the evaporator in order to meet the heating demands of the facility.

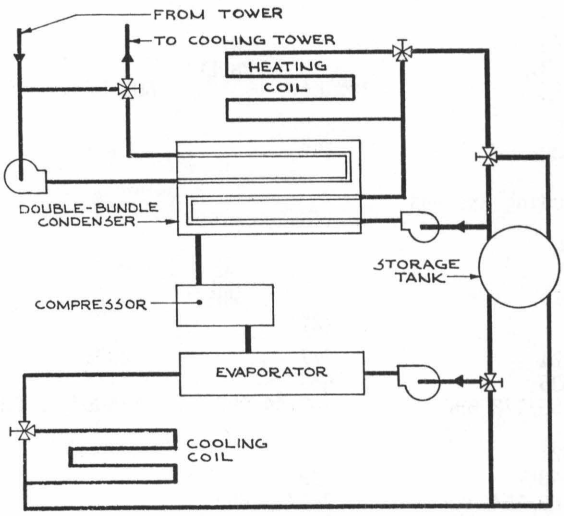


FIGURE 7. DOUBLE BUNDLE CONDENSER

Table III indicates the projected reduction in energy for a project currently under construction utilizing a central heat pump with a double bundle condenser. The base system used as a comparison was a four pipe fan coil unit system utilizing electricity as a prime mover for heat. Note that our computer simulation indicated the double bundle condenser heat pump would provide a reduction in annual operating costs of $6,000 with the primary savings being in reduction in annual cost of heating. Electric consumption was reduced from 4100 MWH to 3669 MWH. As a matter of information, this project is designed utilizing twindow, double bundle condenser, central heat and 16,000 gallons of storage and will be integrated with a water-to-oil waste heat recovery system from 200 MVA transformer substation which occupies a portion of the building. We will obtain approximately 900,000 BTU/hr. recoverable heat from these transformers. This should result in a zero energy heating input to the facility when all transformers are installed.

TABLE III

1919 PENNSYLVANIA AVENUE

	Base	Base w/ heat pump	Base w/ H.P. +H.W.	Base w/ H.P. +15K	Twindow	Twindow w/ H.P.	Twindow w/ H.P.+H.W.
elec consump 1000 KWH	4100.2	3669.5	3663.0	3591.9	3479.8	3286.2	3284.6
annual cost $	$143,507	$128,432	$128,205	$125,716	$121,793	$115,017	$114,551
△$	0	-15,075	-15,302	-17,791	-21,714	-28,490	-28,546
% of base	100%	89%	89%	87%	84%	80%	80%
base elec 1000 KWH	1964.2	1964.2	1989.9	1964.2	1964.2	1964.2	1989.9
△ %	0	-	+1%	-	-	-	+1%
elec acc 1000 KWH	477.2	267.9	267.9	269.6	418.4	255.1	255.3
△ %	0	-43%	-43%	-43%	-12%	-46%	-46%
elec heat 1000 KWH	1030.4	679.3	646.1	569.9	588.9	366.3	339.8
annual cost $	36,064	23,775	22,613	19,946	20,611	12,820	11,893
△ $	0	-12,289	-13,451	-16,118	-15,453	-23,244	-24,171
% of base	100%	66%	63%	56%	57%	35%	32%
elec cooling 1000 KWH	628.3	758.2	758.2	758.2	508.4	700.6	669.7
△ %	0	+20%	+20%	+20%	-19%	+11%	+6%

Figure 8 indicates a schematic for a system incorporating waste heat recovery from lighting fixtures. This system had its inception approximately 15 years ago and to date has really not had a market due to high first cost and potential maintenance problems with piping connections to each fixture.

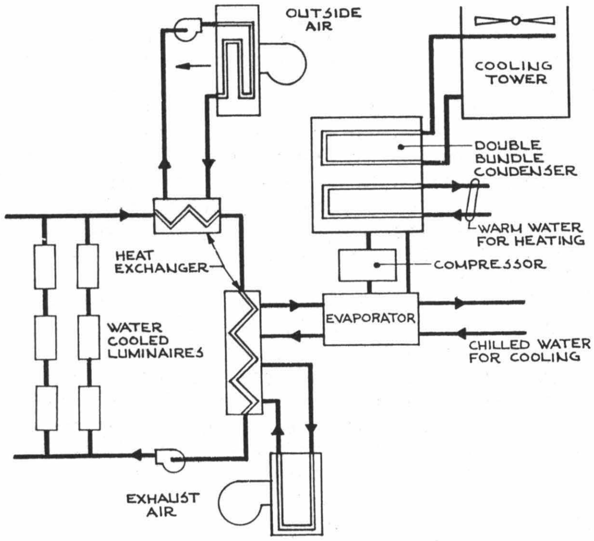


FIGURE 8. WATER COOLED LUMINAIRES

Figure 9 indicates schematically what is known as a heat-of-light system wherein cold primary air is mixed at a terminal box with space air that has been returned through the light fixtures thus picking up waste heat from the lighting fixtures. This system was initially promoted as being able to provide the ability to take heat from the interior of the building and provide heat to the exterior. While the system, from a functional standpoint, works beautifully; its ability to transfer internal heat to the perimeter of the building is minimal.

Under the miscellaneous category of waste heat recovery systems, I have indicated recovery systems for boiler flue gases, which would also include packaged economizers for watertube boilers, water cooled transformers and other industrial process heat recovery systems. These systems are applicable to specialized installations and I have itemized them for information only. While we have touched on a few of these general waste heat recovery systems, it is my hope you will be able to expand the principles into a worthwhile energy management program.

Thank you.

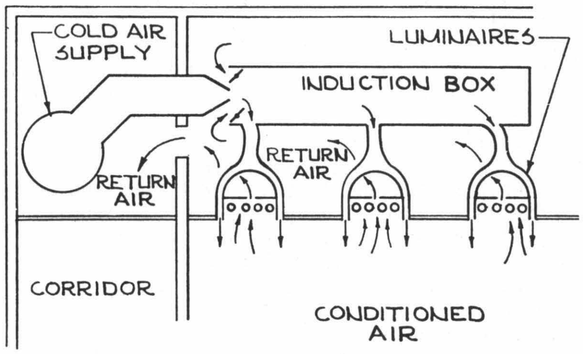


FIGURE 9. HEAT OF LIGHT

TRACE DIRECT ENERGY SYSTEM & ECONOMIC ANALYSIS EXISTING BUILDINGS -- TRACE VERSION V00200

Neil Patterson
Manager
Application Engineering
The Trane Company
La Crosse, Wisconsin 54601

Today, I want to discuss with you the availability of an all new, computerized energy and economic analysis program for use on existing buildings. This program is called TRACE V00200.

TRACE version two-hundred is based on the original TRACE version one-hundred program designed specifically for new buildings that was announced at the semi-annual ASHRAE meeting in January, 1973.

Since its introduction, TRACE has been used on several thousand major energy studies of new buildings. TRACE in the past 74 months has been studied, accepted or used by each federal agency. As of today, TRACE has been used to help prepare more than three hundred major energy studies on federal buildings.

This expansion of the capabilities of the TRACE family of energy programs is particularly important right now as federal and many state agencies are in the process of upgrading the energy efficiency of their existing public buildings.

Specifically, we feel this announcement is very timely for the following reasons:

Three states -- Florida, North Carolina and Washington -- have already enacted laws requiring energy and economic analysis of owned and leased public facilities. These laws deal with new facilities; but, these states and others are preparing similar legislation for existing, as well as new buildings.

In addition, several bills have been drafted in congress that deal with saving energy in our nation's existing buildings.

ASHRAE, at the annual meeting in Dallas in January of this year, officially commissioned the writing of energy conservation standards for existing buildings. Eventually, when completed next year, these standards will be known as the Standard 100-77 series. These new standards will be written by a nucleus of the key industry experts and other volunteers who wrote the ASHRAE Standard 90-75 that pertains to new buildings.

Approximately 2½ years ago, ASHRAE made an agreement with the National Conference of States on building codes and standards to develop a consensus standard of guidelines to conserve energy in new building construction.

The result was ASHRAE Standard 90-75 which was adopted in August of 1975. It will also be submitted to the American National Standards Institute to become an ANSI Standard.

Thirty-five states have said they are going to use ASHRAE Standard 90-75 in part or in total, as part of their building codes.

ASHRAE Standard 90-75 Chapters 4-9 establishes building component performance standards, known as the prescriptive portion, that must be followed by the designer for designing new energy efficient buildings.

Chapter 10 of the standard permits a design different from that achieved through methods prescribed in Chapters 4 through 9, but only if the new design can be shown to use the same or less energy than a building designed in accordance with Chapters 4-9.

The importance of Chapter 10 is that it provides the designer with the flexibility to use an alternative design if he can show that it consumes equal or less energy. For example, it allows the designer to make architectural and system trade-offs for lower energy consumption. Fortunately, the computer makes such analyses relatively easy.

In fact, "TRACE" not only allows comparison of up to four energy design options in one analysis, but shows the economic impact of these options on the building first cost and total owning and operating cost over its design life.

Most experts who have carefully analyzed our energy situation today indicate an immediate and urgent need to reduce energy consumption in existing buildings. They further indicate that this must be done in order to provide the lead time necessary to develop new energy resources.

For this reason, ASHRAE has undertaken the development of these new energy standards to conserve energy in existing buildings. Once developed, these standards, like Standard 90-75, will offer the system designer the methodology to significantly reduce energy consumption in our existing buildings.

Again, the need will exist to evaluate the economic impact of possible energy saving alternatives to justify renovation of the existing building through architectural, HVAC systems and equipment modification or replacement.

To fill this need for existing building energy analysis, The Trane Company is prepared and pleased to now announce the availability of the TRACE version two-hundred. This new TRACE program brings to the system designer a computerized energy and economic analysis program specifically geared to analysis of energy conserving alternatives of existing building construction.

To best understand the TRACE version two-hundred, it is necessary to understand the basic TRACE program. TRACE, as you know, allows you to consider each energy and energy-related economic aspect of a building, its architectural design, its system, its equipment, its use occupancy, and economic goals. Here is how it works. (Refer to Figure 1 on the next page)

Load -- On new buildings, you do not have to input thermal loads with TRACE. TRACE accepts your building's architectural description and location and then calculates peak and hourly loads by zone using hourly climatic data from U. S. weather bureau tapes.

Design -- Zone CFM, Fan CFM, and fan supply air dry bulb temperatures are calculated in addition to design heating and cooling system loads.

System Simulation -- The TRACE program tracks the performance of the air conditioning, heating and ventilating system by hour, by zone over a year's system operation. It translates building heat gains and losses into equipment load.

Equipment Simulation -- The equipment loads are applied to full and part load performance of all heating ventilating and air conditioning equipment and accessories. The program already contains part load equipment performance data, designers are not required to input part load performance.

Economic Evaluation -- Energy consumption is converted into energy dollars using the actual utility rate schedule. Life cycle economic factors such as bond life, first cost, maintenance cost, taxes, depreciation, and insurance, etc., are used to obtain economic comparisons for the various alternatives on a life cycle cost basis to determine the best life cycle cost design.

From experience, we have learned that an existing building energy analysis can be more complex than a new building energy analysis. The complexities are caused by the living patterns that have developed in the building since it was originally constructed. Also, complexities are caused by the fact that air conditioning is still a relatively new technology and, in the past 25 years, air conditioning technology has become much more of a precise science. For this reason, in many existing buildings, the systems and HVAC equipment already installed are significantly oversized by today's design standards.

Obviously, an accurate energy analysis must model the existing situation in an existing building before it can assess the energy impact of new changes to upgrade the building-system-equipment energy efficiency.

TRACE version two-hundred has the capability of modeling the existing building situation. Specifically, it allows setting of values that exist in older buildings that might not be taken into account in new designs (Refer to Figure 2).

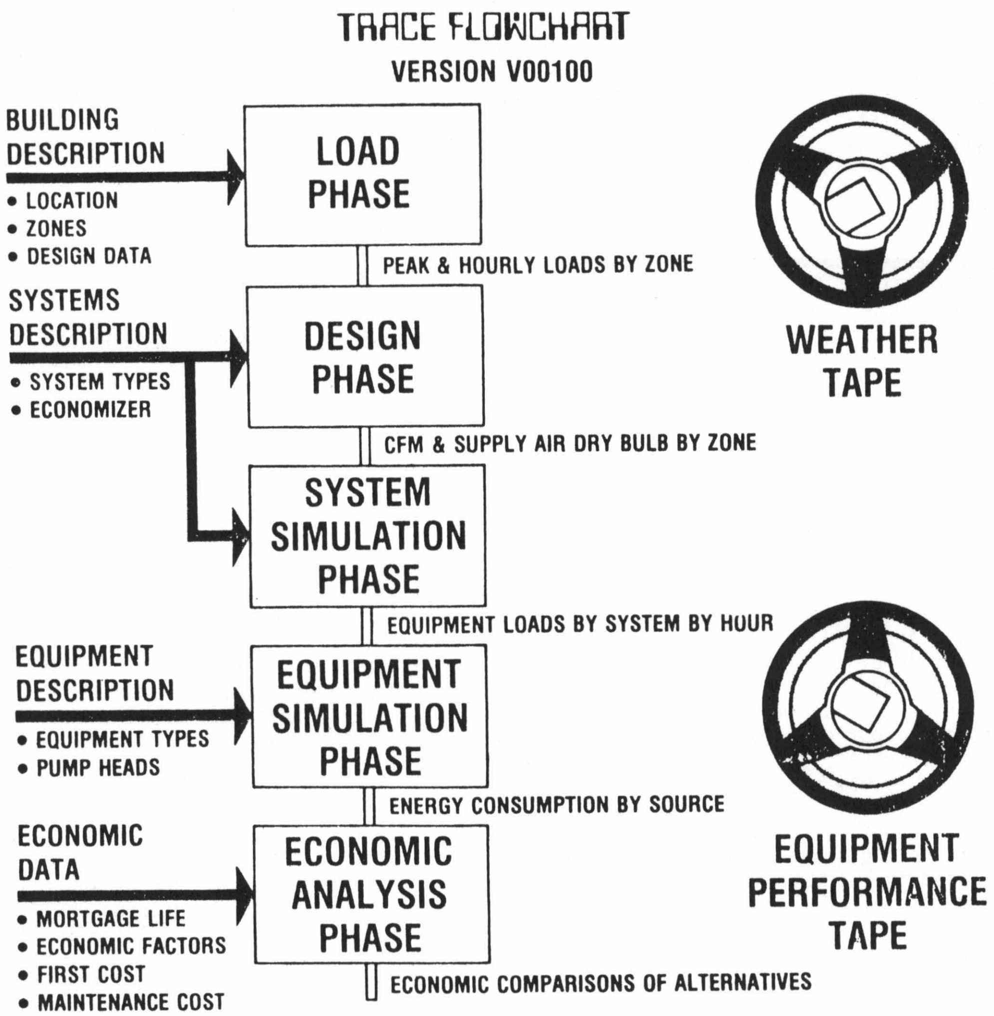


FIGURE 1

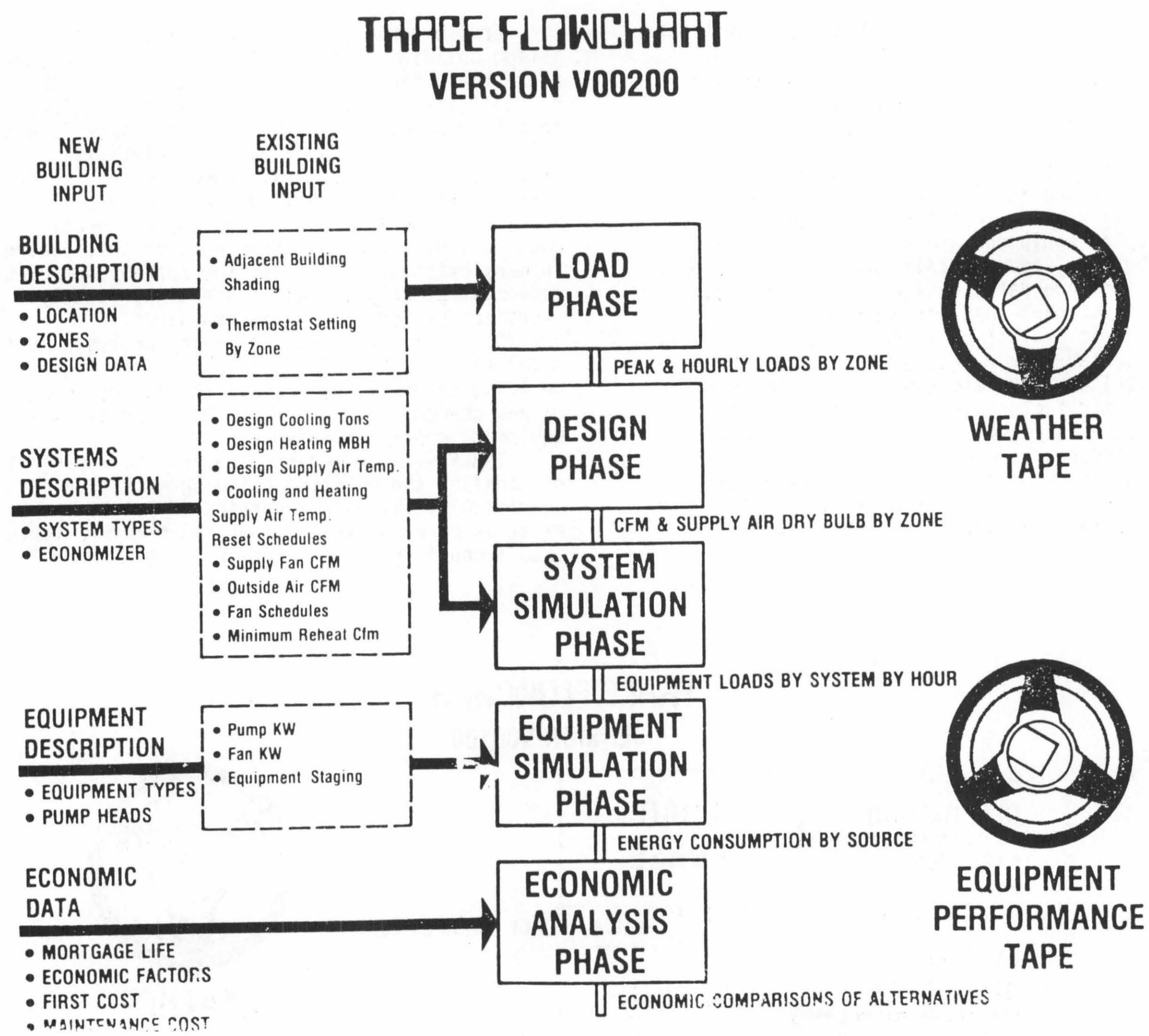


FIGURE 2

For example, it allows the user to account for adjacent building shading.

It allows individual thermostat settings per thermal zone of the building to reflect its actual utilization.

It allows input of actual installed cooling, heating and air moving capacities as well as measured outside air quantities.

It permits input of actual supply air temperatures and their reset schedules to reflect actual building system operating procedures as the building exists today.

It allows input of the actual operating schedules of cooling, heating and fan equipment as it's being used in the building.

It allows input of measured pump KW, and fan KW reflecting equipment actual operating points as opposed to designed operating points when the system was originally designed. This reflects equipment fouling, wear, etc.

It allows input of the equipment staging as it is actually being operated to satisfy the building environmental control requirements.

These are the all-important items because they allow the program to reflect the actual situation of building operation as it exists rather than how it was designed to exist years ago. This is important because using TRACE on an existing building energy reduction program is a two step process.

The first step is to determine how well the building's energy system is performing at the present time versus the performance of the energy system as intended when originally installed. This helps ascertain what needs to be done to trim or adjust the energy system to obtain the original efficiency of operation. Running TRACE Version Two-Hundred and then comparing these results against the actual building utility bills tells one how the present building is performing. The detailed output values in TRACE Two-Hundred then provide the data necessary to analyze and find the areas that need trimming or adjustment.

The second step is to evaluate physical changes that can reduce the energy. These changes are input into TRACE 200 and the output compares them to the present building. At the same time TRACE provides an economic life cycle comparison to help determine whether or not the contemplated changes are economically justified.

Most engineers recognize that energy analysis is a very complex business, and experts aren't made overnight.

For this reason, The Trane Company has developed a means for building and system designers to become proficient in Energy analysis with a minimum investment of time and money. This means is -- the TRACE-DIRECT program.

The purpose behind the TRACE-DIRECT program is to permit the average building system designer to easily use TRACE without help and through its use have energy analysis capability.

Since TRACE was originally introduced, there has developed the need by frequent users to have fast turn-around time of computer outputs. Further, there has developed a need by many users to have a knowledge of the exact mathematical composition of TRACE as well as the function by function flow procedures used by TRACE. This is needed by users to insure the simulation procedures are correctly duplicating the operation of the specified HVAC system.

Consequently, Trane made two important moves in the first quarter of this year in regard to TRACE.

First, the TRACE program was placed on the computer facilities of MCAUTO, formally known as McDonnell Douglas Automation Company, and BCS, formally known as Boeing Computer Services, Inc. This allows the use of TRACE on a time-sharing basis. The turn-around time of outputs is now a matter of a couple of minutes instead of days as before.

Second, to allow the TRACE-DIRECT user to gain an understanding of TRACE and to insure the program can be used successfully, an extensive and intensive training program is conducted. This training program teaches the exact mathematical composition of TRACE on a function to function basis. Since these active users have already gained an operational understanding of TRACE, this detailed knowledge allows them to accomplish very sophisticated energy analysis very simply and quickly without errors.

In addition, in support of each TRACE-DIRECT user we have a locally based engineer to answer questions relative to the use of the TRACE program on specific projects. Further, these on-the-spot engineers support the local McDonnell Douglas and Boeing personnel relative to the access of TRACE. The field engineers have a working proficiency with TRACE and have been especially trained to have an overall HVAC economic capability. As a result, they are very valuable to the TRACE-DIRECT users.

Since the introduction of TRACE in 1973, 677 firms have begun using TRACE on a frequent basis. The TRACE-DIRECT program was conceived primarily for these firms.

One-hundred and sixty-nine TRACE-DIRECT users have been trained since the beginning of the second quarter of this year. This represents 66 engineering firms located in 18 cities throughout the USA. Some of the most prestigious consulting engineering firms in the nation were the first firms trained. At present, scores more are scheduled for TRACE-DIRECT training.

The use of TRACE by these firms is indicative of the level of acceptability and genuine benefits offered by TRACE and, shows it to be a viable tool in helping prepare accurate energy analyses.

COMPONENTS AND COMPUTER BASED CONTROLS IN SMALL TO LARGE BUILDINGS

Michael T. Shehadi
Regional Engineer
Mid-Atlantic Region
Johnson Controls, Inc.
10601 Decatur Road
Philadelphia, Pennsylvania 19154

I am thankful that I have been given this opportunity to be involved in an energy efficiency sharing seminar which presents subjects about which we are all interested. The main theme must be energy conservation. We mush direct our efforts toward the design or redesign of buildings and building complexes toward more energy conscious structures. It is our obligation to look to and evaluate all possible energy saving techniques.

The areas to be investigated are as follows:

A. Installation
B. Building Leakage
C. Overheating
D. Overcooling
E. Overluminating
F. Domestic Water Temperature

As each of us know, this list could go on and on. What each of us must recognize is that there is a list that can be generated. This list naturally, will be different for each complex. Each of us should generate a list for his particular project, proprietarize it and set about resolving the solution to each problem. As cognizant as all of us are of the energy crisis, we are also cognizant of the financial needs and motivators. Without a return on investment, it is questionable whether or not any of us would proceed with energy conservation measures. Therefore, the list will be proprietarized, not only by energy savings, but also by dollar savings.

The portion of this program assigned to me is "Components and Computer Based Controls in Large Buildings." At this point, I would like to modify that title to "Components and Computer Based Controls in Small to Large Buildings."

The components involved are the room thermostats, the return air humidostats, discharge controllers, pressure controllers, enthalpy controllers, etc. If any of us have applied the basic fundamental control systems to their buildings, they are in effect conserving energy; however, it is well known that thermostats are set too high or too low causing different entities of a given system to fight each other. A good example of this was the installation of a brand new central plant on a major university that tied into eleven (11) of the existing buildings. The first year the central plant was on line it was operated at full capacity which is 6,000 tons. The next year a computer based automation system was installed and implemented that gave the operators the ability to check each of the buildings tied into the central heating and cooling plant. The operators and the computer based system detected that hot decks were too high and cold decks were too low, resulting in over heating and over cooling. From the central plant the operators reset the hot decks and cold decks to an optimum point. The result was the university added six (6) more buildings to the central plant loop and reduced the plant output by 33% down to 4,000 tons.

The physical plant director has told us without his computer automation system his people would not have been able to see the waste that existed and would not have reduced the output. He realized that they were actually wasting steam and chilled water by allowing the hot decks to control at too high a temperature and to compensate for this the cold decks were overcooling.

Before the energy crisis, the justifications for automation and centralization were:

A. Manpower Savings (Time)
B. Equipment Protection
C. Extending Equipment Life
D. Occupant Satisfaction
And, Last But Not Least
E. Energy Conservation

Unfortunately, the fact did exist that other than the dollars saved by reducing power consumption, energy conservation did not concern us. The energy crisis is real -- we all recognize that; the fact we are here to explore the developments upon which we must embark is proof of that.

The proper application of controls and automation will indeed help us attain our goal of energy conservation. We should look upon our efforts as EC^2, energy conservation control.

Many times the question, "Why control or automate?" is asked. It is my conviction that any building or complex of buildings should be controlled and automated. The degree of control and automation, naturally, will depend upon the project's requirements. Buildings that should be centralized are not only new projects, but also existing buildings or complexes.

A single automation center can serve any number of buildings. Automating functions such as:

A. HVAC Control
B. Lighting Control
C. Fire Alarm Inputs and Outputs
D. Smoke Alarm Inputs and Outputs
E. Security Inputs and Outputs
F. Communication Systems
G. Life Safety Systems
H. Management Systems
I. Optimization
J. Maintenance Management Systems

Proper control of most of these functions will conserve energy. To help substantiate this, the following calculations are offered:

<u>Utility Savings - Programmed Start-Stop</u>

(Morning Start-Up and Evening Shut Down)

<u>Objective</u>:
Reduced running time hours of mechanical equipment results in less electrical energy expended through manual or programmed start-stop.

<u>Considerations</u>:
There are 98 days that require warm up. Each day 1.9 hours run time can be saved. Assume .75 KW per HP; cost of electricity .026 cents per KWH. Each motor operates at an average of 85% of its rated power.

For each horsepower:

$$\frac{1.9 \text{ Hours}}{\text{Day}} \times \frac{98 \text{ Days}}{} \times \frac{.75 \text{ KW}}{\text{HP}} = 139.65 \text{ KWH/HP/YR}$$

Formula: Using 300 HP available to program
139.65 KWH/HP/YR X 300 HP=41895 Annual Power Savings
41895 KWH/YR X .026/KWH=1089.27 Annual Savings
There are 189 days that require pull down.

For each horsepower:

$$\frac{1.9 \text{ Hours}}{\text{Day}} \times \frac{189 \text{ Days}}{} \times \frac{.75 \text{ KW}}{\text{HP}} = 269.33/\text{KWH/HP/YR}$$

Formula: Using 500 HP available to program
269.33KWH/HP/YR X 500HP=134665 Annual Power Savings
134665KWH/YR X .026/KWH=3501.29 Annual Savings

Light Savings - Programmed Start/Stop

Objective:
Use of programmed start/stop established per building use schedule to reduce the lighting load.

Considerations:
Assume that 1.5 hours of time can be saved per day, 5.5 hours per week, 52 weeks per year. Tennant lighting is 2456 KW.

Formula:

$$\frac{1.5 \text{ Hours}}{\text{Day}} \times \frac{5.5 \text{ Days}}{\text{Week}} \times \frac{52 \text{ Weeks}}{\text{Year}} = 429 \frac{\text{Hours}}{\text{Year}} \text{ Saved}$$

$$\frac{429 \text{ Hours}}{\text{Year}} \times 1456 \text{ KW} \times .026 \text{ \$/KWH} = 16{,}240.22$$

Note: If lighting is controlled it could be used to reduce demand by 728 KW.

Other EC^2 programs that can save energy are:

A. Optimal Start-Up Time
B. Chiller Optimization
C. Boiler Optimization
D. Program Lighting Control
E. Load Limiting
F. Load Cycling
G. Enthalpy Control
H. Supply Air Reset
I. Supply Water Reset

There are many systems on the market that are partial solutions to the above. Systems such as time clocks and demand limiting controllers. Individually these systems should cost less than a computer based automation system; however, if you desire to implement a number of these special purpose systems, the computer based system will cost less.

When we evaluate the cost of systems, we must not overlook the installation costs. Special purpose systems must be hardwired from each point of control to the control device. All too often these costs are so high the system isn't installed. If 50 loads were controlled, 150 to 200 wires must be installed. With this approach you would not know the status of the equipment. To indicate status another 100 wires would have to be installed.

Computer based systems operate over coax cable, dedicated line or leased line. Remote terminal units (multiplexes) are located close to the equipment to be monitored and controlled, reducing installation costs.

All of this information can be economically centralized because of the advancements made in the industry in the past fifteen years. One of the advancements that has been made in the industry is the use of solid state switching, multiplexing and time sharing. Multiplexing is very similar to the telephone circuits with which we are all familiar, that is, time sharing the wires to do a number of things. For the telephone, this would be a number of people able to talk over the same pair of wires at the same time. Multiplexing replaces the need to run wires from a sense or control point all the way back to the central location. The wires that the information travels on would be called information wires. If multiplexing were not used, wires for each bit of information brought in would be required. If multiplexing were used, equipment would be decoding equipment and would be located in the field near the information point and the decoding equipment addressed through the multiplexing network in order that only a common set of information wires for all the points in the field would be required. In this way, only one information point would be in address through the multiplexing network at any given instance. This is what is meant by time share the information wires.

The multiplexing that a standard telephone uses is again, one that would be very complex if a telephone were directly connected by wire to each telephone that it could dial. Likewise, if each of these other telephones were connected by wires directly to each telephone it could dial, we would not have enough room in our cities to house all of the wires that would be required. Therefore, the telephone company uses the time sharing method so they may use a smaller cable and connect all these telephones on a time sharing basis.

At the present time, there are hundreds of projects installed using computers as the building automation system. We have installed over 300 systems and have under contract over 200 more systems. Generally speaking, the computer operated system *offers the only simple answer* for accommodating the expansion and renovation capabilities required by the projects we are working on and designing today.

Initially, the computer systems were doing chores similar to those that were being done by the special purpose systems. However, the operators had a better presentation of data. For instance, he is able to request display of alarm values and make changes if desired, with automatic generation or permanent records of such changes appearing on a log sheet. All information is written out so it can be understood (not in code that requires a look up directory). In addition any type of arithmetic operation could be performed. Presently, there are programs available for calculation of flows, BTU's with totalizing, controller setpoints, equipment running times, energy balances, optimization packages and maintenance programs.

As mentioned earlier, any system would be cost justified. Your requirements should be evaluated and the system or system's costs should be evaluated. A building survey should be made in order that economic analysis may be derived. In most cases it will not take more than three years to return your investment. The net cash flow, energy savings and time value of money and payback period should be calculated in order that you may determine if you are undertaking a wise investment.

In summary, make sure:

A. You have a need.
B. You evaluate a short term and long term need and solution.
C. The system selected is not dead-ended (it can grow or change with your needs).
D. The outlay is an investment not a cost.

ELECTRIC UTILITY AND LOAD MANAGEMENT

J. W. Kepner
Executive Assistant to Vice President and General Manager
Appalachian Power Company
P. O. Box 2021
Roanoke, Virginia 24022

The heart of designing and building an electric utility system is the daily load curve created by our customers. The daily load curve is the hourly demand. As an electric utility, we are charged with the responsibility of providing reliable service at the lowest possible cost. We are government regulated to see that there is an adequate supply of power and the company makes a reasonable return on its investment. The behavior of the customer use pattern of electricity certainly influences the cost of providing service and is reflected in the rate making process. Load management by our customers is of real concern to us and this is reflected in the way we operate.

In order to orient ourselves to the challenge of the electric resource utilization, let us review briefly the growth of an electric company like Appalachian Power. It is this development that brings us to a Load-Management Workshop in Blacksburg in the summer of 1977. The electric utility is relatively young compared to many industrial businesses. In fact, Appalachian Power Company celebrated its 50th year in 1976. In the very formative years, the company had to sell its product with lighting and street car operations being principal loads. This was soon followed by industrial application of motor drives, heating, chemical processing creating greater demands. Coal mines originally developed their own power at the mines and the coal operators had to be convinced we could provide power cheaper and more reliable. In order to build load, promotional rates were introduced to get greater use on home appliances such as clothes dryers, electric water heaters, and air conditioners. In these early days, the promotion of electric energy was very competitive with gas, coal and oil. The company could see a real advantage to having a good load factor and directed industrial development to high energy use and continuous processing such as chemicals, electric chemical and interruptible alloy loads. This helped to develop the load pattern we have today. On Figure 1 is the winter peak day in January 1977; Figure 2 is the summer of 1976; and Figure 3 is the spring of 1977. The load curve compared to many electric utilities' systems is extremely well balanced. Appalachian Power Company had a load factor which reached a high of 69.8% in 1969. So far in 1977, the load factor is 60.8%. There has been a gradual deterioration caused by a number of factors with economic conservation of electricity being one. This past winter was the coldest in 50 years and created record peaks. In recent years regulatory commissions have virtually eliminated promotional rates.

APPALACHIAN POWER COMPANY
HOURLY LOADS

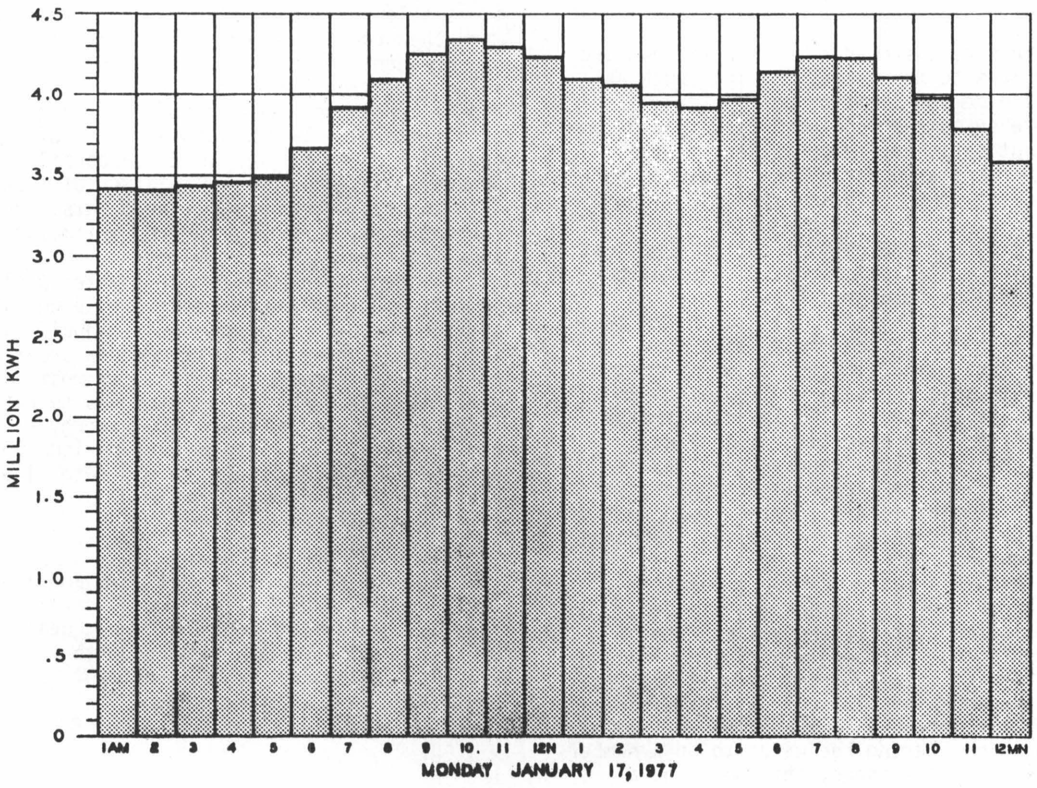


FIGURE 1

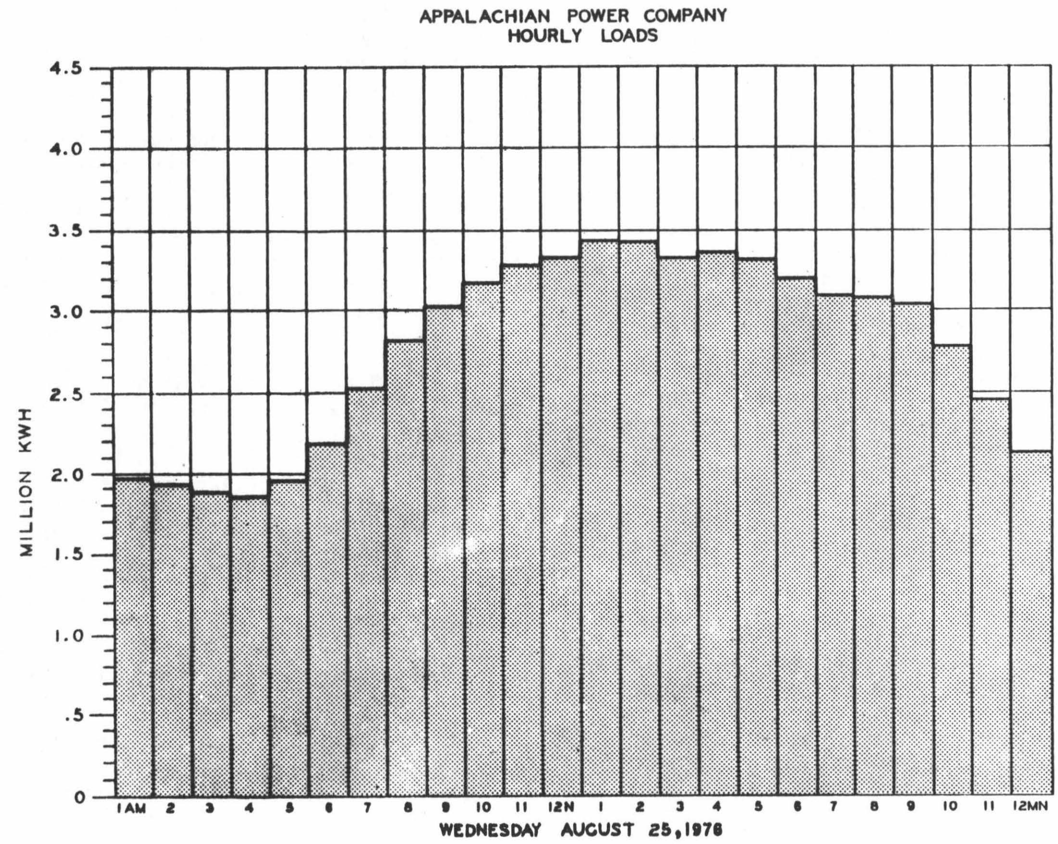


FIGURE 2

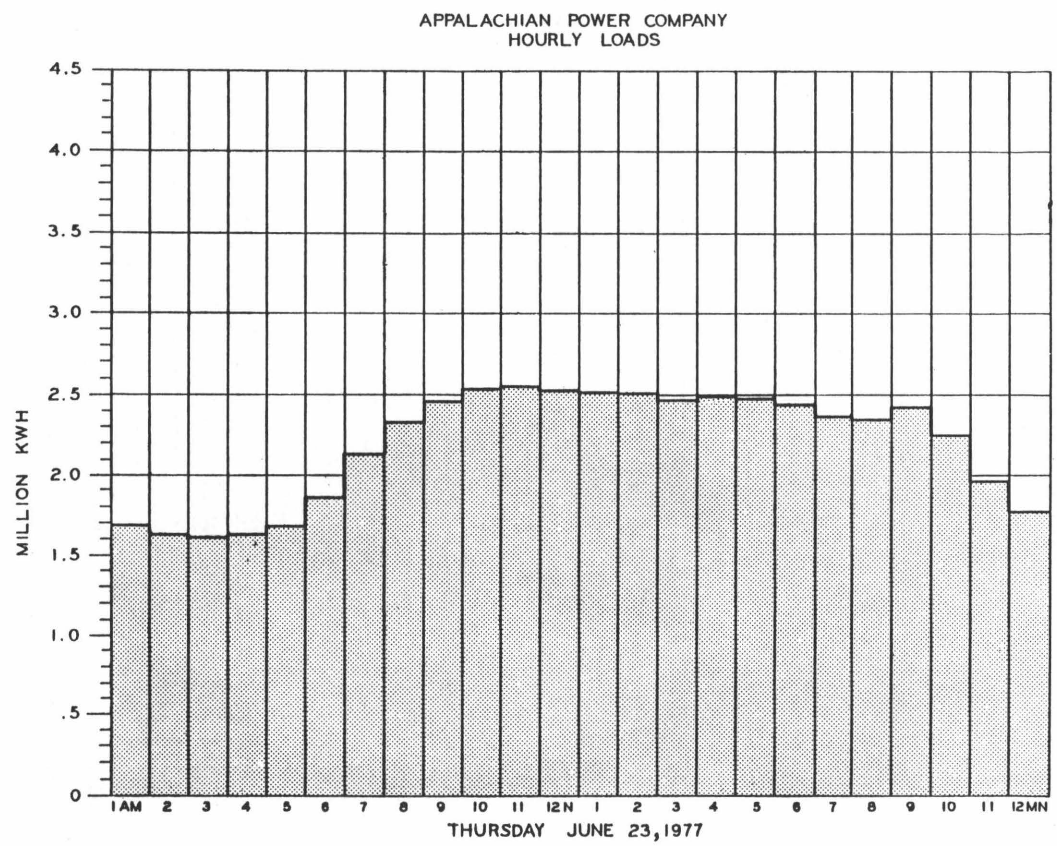


FIGURE 3

Now, let us take a look at how Appalachian Power Company manages the operation and installation of generating units to meet our customer demands. The demand has been doubling about every 10 years with a growth of approximately 7% per year. Figure 4 shows the American Electric Power Company demand curve for 1973 projected through early 1987. Since we operate the AEPCo. as an integrated system with APCo. as one principle operating company, this indicates the need for future generation. For many years, our primary energy source has been coal which, until 1973-1974, remained very stable in cost. However, other operating expenses were escalating. The company was able to avoid rate increased by building larger thermal units with greater efficiency, higher steam temperatures, higher steam pressures, and more automation in operation. The size of the system permitted the installation of these larger units to gain the economies of scale. Figure 5 shows how the load is carried on a typical weekly cycle, and the mix of generation to meet the customer demand. The base load is carried by the Cook Nuclear 1100 MW, Gavin, 1 & 2, 1300 MW, and Amos 3, 1300 MW. These are the most efficient and largest units on line. It is planned to operate them at nearly full load 24 hours per day. The next series is the 800 MW and 600 MW units which carry a portion of the base load, but are cut back during off-peak as necessary. The intermediate load is carried by the 225 MW to 480 MW units and is cut to minimum during off-peak periods. The peaking units are those which are taken off-line each day during off-peak hours and are the older, smaller, and less efficient units along with hydro units and pump storage units. With this combination of generation, the system is incrementally loaded to optimize fuel costs, unit efficiency, and line losses. This is carried out by on-line digital computer, which drives an analogue system to control generation. This is pointed out so we can evaluate our operation if effective load-management is used to control our customer demands.

The art of transmitting power from the generating plant to the customer has also experienced great changes in the last few years such as higher transmission voltages of 765 Kv, high voltage circuit breakers to clear faults quicker and better protecting equipment, interconnection operations with diversity power exchanges, pooling to reduce reserves, electronic monitoring systems for power restoration. In distribution we have increased voltages, better voltage regulation, underground systems and better insulation.

I would like to review energy source briefly to point out coal will be with us for many years in the future. The principal energy sources are coal, oil, gas, water and nuclear. Coal is in abundant supply or enough to last several hundred years, but certain grades are not so plentiful, such as low ash and low sulphur coals. The oil supply is largely from foreign sources with increasing costs. Gas is a very limited resource and continues to escalate in cost. Water power is limited by potential sites and environmental restrictions. Nuclear holds a bright future; however, uranium ore has a limited life unless the breeder reactor is developed. The technology for nuclear plants is new; however, since 1956 breeder reactor offers promise of low cost energy, but is at least 10 to 15 years in the future. This means coal will be our principal resource for generation of electric power for the next decade.

AMERICAN ELECTRIC POWER SYSTEM
ANNUAL PEAK LOAD AND GENERATING CAPABILITIES

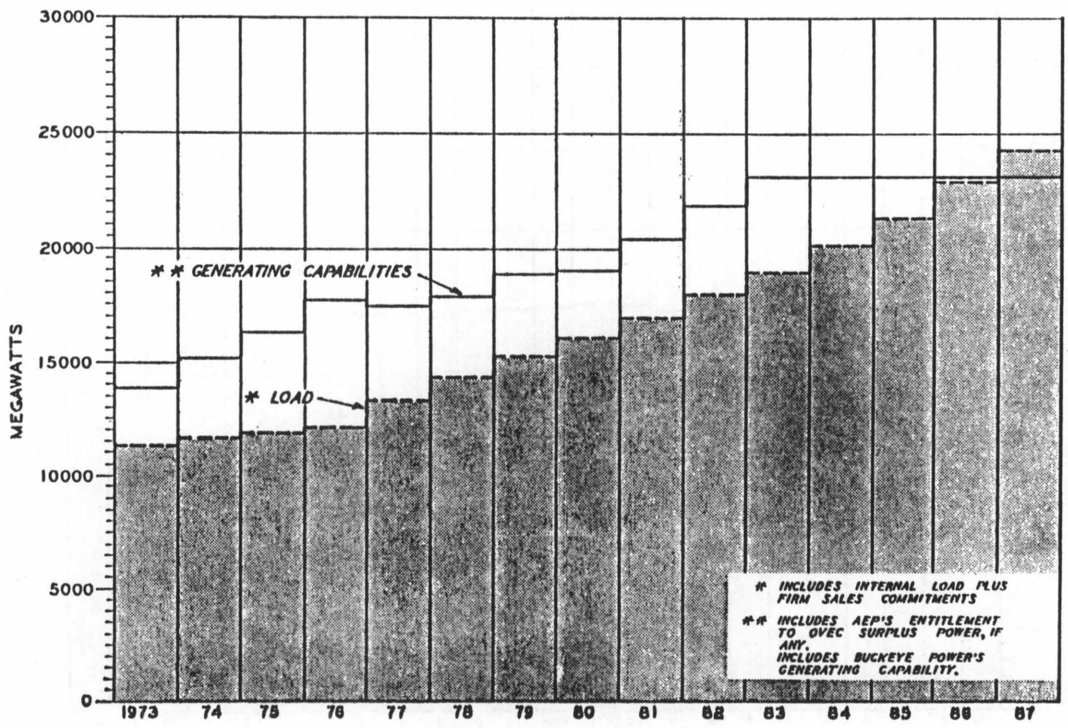


FIGURE 4

TYPICAL WEEKLY LOAD CURVE

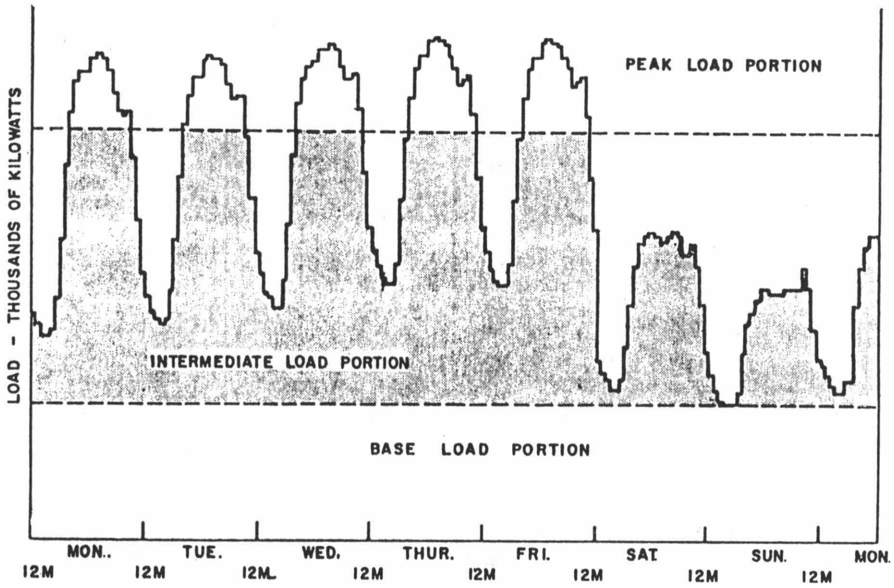


FIGURE 5

In the early 1970's, inflation bringing about higher costs, it became necessary for utilities to begin seeking rate increases. The resulting higher costs of electricity have brought on questions about peak load pricing, life time rates, inverted rates, flat rates, and many other ideas for changing the rate making process. The electric utility has been subjected to pressures to change rates and to improve load factors. The company would be very happy to increase the load factor, and reduce the need for greater capital investment in generating plants. What are the tradeoffs? Will the housewife be willing to wash and dry clothes between 11 pm and 7 am? Will commercial and industrial customers change their operations to off-peak hours? Are people willing to change their present living habits? (Then, the next question, what are the benefits?) AEPCo. system has recognized these questions. Two years ago the company initiated a load research program to determine the power use patterns of our customers as they are affected by the time of day, day of week and season of year, as well as weather conditions. Analysis of this data will help us to plan better for future electric needs, to evaluate better the cost of service for rate making, to advise customers on more efficient use of energy, and to evaluate the potential of any possible load management programs. Inherent in this concept of load management is the potential of a better and more efficient utilization of existing facilities, production plants, transmission and distribution with an associated improvement in overall system load factor. The traditional rate making factors will be examined with present and new data. We will be knowledgeable of the electric use patterns to see the influence on time of day, seasonal loads, life-line, flatten block and other restrictions. This load research program consists of installing special meters with three magnetic tape tracks to record load demand and energy, time and reactive power. A total of 600 meters will be used, including those customers with electric heat and non-heating customers. The program will also be extended to commercial and industrial customers. This part of the survey will require some 750 installations due to the diversity of load characteristics. The program will be considered in the future for all major industrial customers. These tapes will all be processed through a translator and computerized so all data can be analyzed over a time period to be available for study purposes.

We are now installing 30 residential electric thermal storage devices on APCo. lines in Virginia. The device is a brick-like refractor core material contained in a heavily insulated metal cabinet. The hours selected to heat will be 11 pm to 7 am. The heat will be released as required. Over 5 million of these devices are used in France, Great Britian and Germany today. These units we are testing were made in England by Creda, a division of Tube Investment; an American company, Tennessee Plastics, Inc., Johnson City, Tennessee, has a joint working agreement with the English company. Special metering will be installed to collect data performance, and the State Corporation Commission has approved special rates for those customers.

We have also initiated a residential insulation financing plan in Virginia. This plan permits loans up to $750 for 3 years for customers who want to insulate their homes.

There are four homes under construction in our area which are being designed for solar heat with different systems, we have permission to install special metering to study the effects of interfacing of solar collectors, storage and standby heater equipment.

The Carrier Corporation has recently developed a storage cooling unit with 330,000 BTU of cooling. The device will freeze ice during off peak hours to be used for total cooling. One of these units will be installed on the APCo. system and we will observe this operation for future reference.

In conclusion, the electric industry is vitally concerned in future load characteristics which will be reflected in rates, reduce capital expenditures and give us better operating conditions. We thank you for giving us a part in the program and it is workshops like these which will influence the future in better utilization of our energy resources.

"ABOUT NTIS"

Roy Stamm
National Technical Information Services
5825 Port Royal Road
Springfield, Virginia 22161

The United States has no national scientific and technical information system; it has a plurality of products and services offered by government and private sources. But, of all the sources NTIS -- the National Technical Information Service -- offers the broadest range and in-depth coverage by products and services across the entire spectrum of science and technology.

The organization originated in 1946 as the U. S. Government's mechanism for channeling captured German and Japanese research and technology to U. S. Business. As U. S. Government-funded R&D grew in the 1950's and 60's, NTIS became the central public access for the resultant technical reports.

Today NTIS operates the central information system for technical reports, computer software, data files on magnetic tape, and Government-owned patents.

New reports and some journal articles are processed into the central information system daily. Bibliographic citations are created for each report by information specialists. Report flow into the system is controlled by traditional procedures for cataloging, subject classification, subject indexing, and abstracting. Each citation is keyboarded through a mini-computer system which provides "on-line" data entry and data edit for input processing and data selection for its various announcement media.

Reports are added to the system at increasing annual rates, with growth progressing from 46,000 reports in 1971 to over 60,000 in 1975. The total data base now includes some 1 million items -- with over 500,000 in machine readable form.

The reports describe the results of the U. S. Government's entire research, development, testing and evaluation program or over 50% of the total research and development expenditures for both the public and private sector. This is twice the number of new books produced by all U. S. publishers.

From the 270 new reports collected daily and the record we make of them, we create a number of current awareness periodicals. The newsletters called Weekly Government Abstracts, are created in 26 different subject areas such as Chemistry, Physics, Energy, Behavior and Society, and the Environment. A comprehensive journal called Government Reports Announcements & Index, is published bi-weekly for librarians, technical information specialists and those requiring all the summaries in a single volume. A cumulative index is also produced each year. Also, there is available a published search -- a subject search or bibliography of our total file containing a collection of abstracts and corresponding citations for every document and other specialized packages of information we have in the system that pertains to that subject search. We have over 1000 published searches on subjects that are of topical interest.

Federal agencies and non-profit organizations utilize NTIS as the public promoter and sales agent for many of their periodicals. More than 20,000 subscribers buy copies of over 30 different periodicals sold by NTIS. These subscriptions range in subject matter from Solar Energy Bibliographies to monthly energy statistics to the Environmental Protection Agency's Quarterly Bibliography.

NTIS fills orders for about 12,000 reports daily in addition to 7,000 standing orders for its' periodicals. It supplies customers with about four-million research reports each year. The reports are generally available in both paper copy and microfiche. Microfiche are 4 x 6 inch film sheets with spaces for 98 pages, each one-twenty fourth the size of the original paper copy. Your professional library can be portable thanks to microfiche. One hundred and fifty sheets of film are about one-inch thick so that you may easily carry the equivalent of fifty 300 - page books in one pocket. An average file cabinet can hold ten thousand reports or the equivalent of a small technical information center.

NTIS has a specialized service called Selected Research in Microfiche (SRIM) which automatically provides subscribers with microfiche copies of research reports in subject areas they select.

NTIS analysts help subscribers choose from among some 500 different subject categories and 200,000 unique descriptive terms. For example, if a subscriber's area of interest is Energy or Energy Use, Supply and Demand, he would receive about 140 complete report texts over a 12 - month period at a cost within the reach of a modest information budget. The reports are sorted and distributed to subscribers every two weeks as a standing order service.

For retrospective information retrieval, several large information processing systems supply the NTIS bibliographic search file, and some 20 others to a computer network serving 3,000 - 4,000 subscribers who make over 200 searches of the NTIS file daily. The data base is leased by 30 additional information organizations who perform more than 7,000 SDI and awareness searches each day. NTIS also provides on-line search services of its own and of several closely related bibliographic files. The on-line interactive bibliographic retrieval service, called NTISearch provides librarians, technical information specialists, researchers, and those who have a need to know with instant access to over 500,000 document records. A customized strategy is developed in collaboration with an information specialist at NTIS. Using controlled language thesauri, frequency counts for subject terms in the NTIS data base, and the Boolean logical connectors (and, or, but not) the subject specialists develop search strategies to comb the entire collection of documents to find the specific information needed. The research summaries retrieved on-line are thorough and usually not otherwise available. Many times published searches have already been developed and prepared by analysts in anticipation of users' needs. Search strategies have already been developed on topics such as Solar Electric Power Generation, Nuclear Power Plants (Site Selection), Oil Spills or Oil Pollution Removal, and the Biological Effects of Mercury Pollution. The obvious advantage is that Published Searches are ready and waiting to be sent to you just as soon as you need it.

Licensable technology is also made available by NTIS. It is the U. S. Government's central agency for announcing new Government-owned inventions and for promoting their commercialization. NTIS obtains foreign patent protection on selected government inventions, and negotiates directly for licenses utilizing these inventions. The availability of licensable government technology is brought to world attention by NTIS-arranged exhibits and seminars, as well as by a special newsletter, mail promotion and through other licensing organizations.

Another major developmental area for NTIS is: Computer-based data files produced by Federal agencies and the computer programs for manipulating the files. These files which are listed in a directory -- represent a large part of the nation's computer-based data inventory available for public use. Special reports from some of these files are produced to meet individual user demands. In addition, under contract to the General Services Administration, NTIS operates the Federal Software Exchange Center for computer programs produced or owned by Federal agencies. These programs cover the full range of computer applications, and are sold to the public by NTIS.

I have highlighted the major NTIS products and services available for your use. And in the Information Services Catalog, these services are described in detail. Should you wish to have further information, please feel free to contact NTIS.

FEDERAL INVOLVEMENT IN STANDARDS AND CODES

James F. Shivar
Program Manager
Energy Research and Development Administration
20 Massachusetts Avenue
Washington, D. C. 20545

IS THERE AN OIL CRISIS?

Washington Post, July 9, 1977: "The U. S. economy is now balanced precariously on the Saudi's willingness to keep production high and to keep it rising . . . Does this constitute a crisis? . . . What are the chances that the Saudi's will change direction?

"No one knows, but for every barrel of oil the U. S. requires from them, the risk rises."

The U. S. imports about 50% of the total domestic consumption.

OIL PROBLEM

World supply of oil is estimated to be two trillion barrels. More than 360 billion barrels have been consumed. Current proved crude will produce 600 billion barrels. Annual growth rate of consumption since 1960 is 8%. If 5% -- oil resources would be exhausted by 2010. We may not actually run out; the remaining oil resources will become more difficult and too expensive to extract.

PRESIDENT CARTER'S NATIONAL ENERGY ACT

20 APRIL, 1977

Provides To:

- Reduce rate of growth to 2%
- Reduce gasoline consumption by 10%
- Reduce oil imports to less than 6 million BBS/day
- Establish a strategic reserve
- Increase coal production
- Insulate 90% of all homes
- Use solar in 2½ million homes

Major Features:

- Conservation and increased fuel efficiency
- Rational pricing and production prices
- Substitution of coal for oil
- Develop new technologies for the future

CONSUMPTION

20% used for heating and cooling of buildings
74 million residents
1.5 million non-residential buildings (29 billion SF)
200,000 schools and hospitals

PROPOSED ENERGY CONSERVATION PROGRAM FOR SCHOOLS AND HEALTH CARE FACILITIES

$900 million; 3 years; 50-50 grant
State plan
Energy audits: Sydney Berwager. FEA (202)566-7472
Energy measures: Tom Gross, (202)566-7916

FEA ENERGY CONSERVATION PROGRAM OBJECTIVES

Reduce energy demand growth rate
Develop and implement programs that increase the efficient use of energy
Ensure environmental concerns are balanced with national energy goals
P. L. 94-163, Title III,
- Part A -- Automotive fuel economy
- Part B -- Energy conservation program -- other than automobiles
- Part C -- State energy conservation program
- Part D -- Industrial energy conservation
- Part E -- Other federal energy conservation measures

Goal: 5 percent reduction of total energy consumption for 1980 -- 350,000 BPD
Promote (not promulgate) conservation of energy
- Establish guidelines
- Provide overall coordination
- Provide technical assistance
- Provide financial support to states

PART C, STATE ENERGY CONSERVATION PROGRAM GUIDELINES

Lighting efficiency standards (ASHRAE 90-75, Section 9)
Carpool
Energy efficiency for procurement practices
Thermal efficiency standards (ASHRAE 90-75, Section 4-9)
Turn right on red
State plans due in by March 28, 1977
State plans implemented nationally January 1, 1978

PART E, OTHER FEDERAL ENERGY CONSERVATION MEASURES GUIDELINES

Develop mandatory standards for procurement programs
Implement 10-year plan for energy conservation with federal buildings - owned and leased
- Lighting
- Thermal
- Insulation
- Hours of operation
- Thermostat

Public education program
- Energy conservation
- Carpool

10 STATE COOPERATIVE AGREEMENTS

(DUE JUNE 1977)

Equate ASHRAE 90-75 to local climates
Develop programs for building officials
Education and training of program requirements
Compare NCSBCS model code to 90-75
Evaluate roles of code enforcement processed
Investigate legislative problems
Recommended approach to development and implementation
Provide framework for information transfer appropriate to P. L. 94-163 and P. L. 94-385

CONTRACTS

NBS Survey -- 20 stated (NBSIR 77 - 1259)
LOC-COM -- city impact analysis
NACo -- county impact analysis
Provide framework for information transfer appropriate to PL 94-163 & PL 94-385
  Establish monitoring, evaluation and reporting systems

ENERGY CONSERVATION WORKSHOP PROGRAM

February to September 1977 - over 600 workshops planned (FEA: 202-566-9950)

LOW-INCOME WEATHERIZATION PROGRAM (PL94-385)

Authorization in Congress for $200 million, FY-77 thru FY-79
The FEA provides $585 million thru FY-80

FEA - AN IMPACT ASSESSMENT OF ASHRAE STANDARD 90-75 BY ADL

"ASHRAE 90 generally increases the cost of the exterior wall, floors, roof, and domestic hot water system. Glazing costs may be higher or lower depending upon building type. Unit costs for lighting, and particularly HVA/C equipment and distribution system, were significantly lower and tended to offset the increase in other costs."

Average changes related to 1973 construction and operation practices are as follows:

	Unit Cost Dollars Per Square Foot	Energy Savings
Single-Family Residence	-0.02¢	-11.3%
Multi-Family Residence	-0.42¢	-42.7%
Office Building	-0.63¢	-59.7%
Retail Store	-0.18¢	-40.1%
School Building	-0.44¢	-48.1%

ASHRAE 90-75 VS. HUD MPS

REDUCTION IN ANNUAL ENERGY CONSUMPTION RELATED TO 1976 CONSTRUCTION

	NE	N. Central	South	West	Mps Avg.	ASHRAE 90-75
Single-Family	-30%	-30	- 6	- 5	-18%	+11%
Low-Rise Apartments	-50%	-48	-49	-48	-48%	-43%

CHANGE IN INITIAL CONSTRUCTION COST/SQ. FT.

	NE	N. Central	South	West	Mps Avg.	ASHRAE 90-75
Single-Family	+32¢*	+32¢*	- 3¢	0	+15¢	- 2¢
Multi-Family (*double glazing)	+ 4¢	+15¢	-15¢	-16¢	-12¢	--

IMPACT ON BUILDING MATERIALS

		INCREASE
Storm Windows	+ $162M/YR	18-20%
Insulation	+ 62M/YR	13%
HVAC	- 136M/YR	- 6%
Average	+ $100M/YR	

INSIGNIFICANT IMPACT ON RESIDENTIAL HOME BUILDERS

PART E, FEDERAL ENERGY MANAGEMENT PROGRAM (FEMP)

GSA, FEA, HUD, ERDA, DOD, USPS, have reduced almost 25 percent of the energy since 1973. 1974 federal government held title to over 400,000(±) buildings.

"Identifying Retorfit Projects For Federal Buildings" - GPO 041-018-00129-8, $2.20.

Process Standard For Design of Energy Efficient Federal Buildings

ERDA STANDARDS PROGRAM

Objectives:

- Provide R&D required for developing and upgrading standards for energy conservation in buildings
- Track experiences in adoption and administration of thermal efficiency standards
- Identify institutional impediments to use of thermal efficiency standards
- Provide RD&D support for improving implementation of thermal efficiency standards

History Illuminates The Need For Energy-Related Standards:

Pre-embargo era
  Most standards related to health and safety: not energy
  HUD, VA. FHA used energy-related standards for housing for particular materials, such as insulation

Post-embargo period
  New awareness by legislators, public agencies by professionals and by code groups
  Federal actions
    PL 93-577 "Non-nuclear Energy R&D Act" - December, 1974
    President Ford's message to congress - January, 1975

PL-94-163, "Energy Policy and Conservation Act" December, 1975
PL-94-385, "Energy Conservation & Production Act" August, 1976
State Action: New Legal Authority Through State Law

Historical Problems With Building Codes and Standards

Absence of scientific supporting data
Multiplicity of technical authorities
Lack of uniformity
Impact of building costs

Thrust 1 - Update Current Energy-Related Standards

Internal spaces
- Ventilation requirements
- Lighting standards

Exterior envelope
- Wall components
- Windows
- Attics

Thrust 2 - Develop Performance Standards

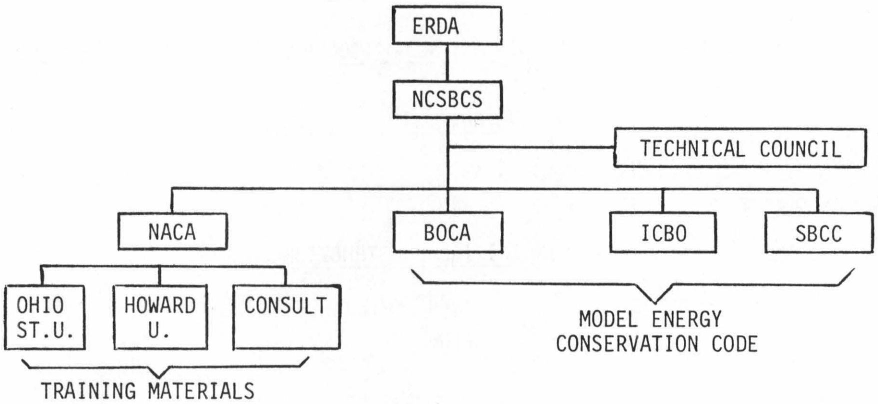
Standards research, development and demonstration in support of HUD - new buildings
RD&D for existing buildings

Thrust 3 - Implementation

Assisting HUD/FEA
Training to assist in implementing standards
Track existing and BEPS standards
Institutional improvements

State and Local Building Officials

Three Major Goals:
- Develop model energy conservation code based on ASHRAE 90-75
- Develop training material and conduct courses to train building code officials
- Recommend and demonstrate new systems to update codes and accept construction innovations



NCSBCS: National Conference of States on Building Codes and Standards
NACA: National Academy of Code Administration
BOCA: Building Officials and Code Administrators International, Inc.
ICBO: International Conference of Building Officials
SBCC: Southern Building Code Congress International, Inc.

Building Standards

NCSBCS RD&D Contract
- New model code
- Training material for building officials
- Improvements for accepting innovations

ASHRAE R&D Contracts
- Manual of accepted practices
- Develop rifs and rufs
- Support writing of Standard 100-P

State Contracts
- California Energy Agency
- Minnesota Energy Agency
  - Tracking experiences

SUMMARY

Energy Crisis?
Uniform, acceptable energy conservation codes for new and existing buildings
Education programs for public awareness to energy conservation
Better communication - local/state/federal
Feedback
Technical assistance to state/local governments
RD&D to develop new, economical, hands-on methods for energy conservation in buildings

COMMERCIAL BUILDING STANDARDS

James A. Grinnan, P.E.
Van Wagenen & Searcy, Inc.
Consulting Engineers
337 West Forsyth Street
Jacksonville, Florida 32202

I would like to cover three areas to familiarize you with the ways that the HVAC and refrigeration industry is working to conserve energy and how you can obtain information to assist you in conserving energy in your new or existing building. These areas that we will cover are:

- What is ASHRAE?
- ASHRAE Standard 90-75
- Proposed ASHRAE Standard 100.

ASHRAE is an international Engineering and Technical Society composed of some 32,000 members in 120 counties. Most of ASHRAE's members are Engineers in the HVAC and Refrigeration field and in one manner or another working as Consultants, Utilities Engineers, Manufacturers, Contractors, or Sales Engineers. As such, ASHRAE is the driving force in one of the high energy using sectors of this country. Over one-third of the total energy consumption in the United States and Canada is in residential and commercial buildings and over 60% of that energy is consumed in space heating and cooling. Therefore, we have a real opportunity to conserve energy in both new and existing buildings.

Energy has been considered as expendable in this country due to artificial prices and tax structures; however, now energy must be considered as a resource. As with any resource, we must use it wisely and ASHRAE is working toward that goal.

The main objectives of ASHRAE are to provide an exchange of information between members in the industry, and where information is lacking, sponsor research projects to confirm or develop information.

Research projects sponsored and paid for by ASHRAE are carried out by colleges, universities, manufacturers, Professional Engineers, or others having the necessary facilities and expertise required to provide accurate and timely data. Research funds are contributed by the members and their firms and totaled over $350,000 last year, we expect this figure to continue to increase each year.

Dissimination of information by ASHRAE is through semi-annual national meetings with forums, symposiums, and seminars, publication of technical papers, The ASHRAE Journal, and the ASHRAE Guide and Data books. The Guide and Data books are published one each year on a rotating basis. These books are written and re-written by the members of ASHRAE serving on technical committees on a volunteer basis. Having been written by many of the best Engineers in the field, these books are accepted world wide as the latest and best design guides and are even accepted by courts of law.

The objectives of ASHRAE can be stated as:

1. Conservation of people energy through control of their living and working environments; and

2. Minimization of energy used in production and processing.

In 1974, ASHRAE was asked by the National Bureau of Standards (NBS) and by the National Conference of States and Building Codes and Standards (NCS-BCS) to develop a reference guide on energy conservation. ASHRAE Standard 90-75, "Energy Conservation in New Buildings" was the result of that request. Standard 90-75 was coordinated by over 5000 Engineers, Architects, Manufacturers and Construction experts throughout the United States and Canada. The final standard is a consensus of these experts. Standard 90-75 is a prescriptive standard which gives the designers wide latitude in their final designs but maintains a low energy budget. Performance and budget type standards were not used due to restrictions on the designers and the difficulty of administration in code form. ASHRAE Standard 90-75 consists of the following eleven chapters:

ASHRAE Standard 90-75:

1. Purpose
2. Scope
3. Definitions
4. Exterior Envelope
5. HVAC Systems
6. HVAC Equipment
7. Service Water Heating
8. Electrical Distribution Systems
9. Lighting Power Budget Determination Procedures
10. Energy Requirements for Building Designs Based on System Analysis
11. Requirements for Building Utilizing Solar, Wind, or Non-Depleting Energy Sources

Chapters 1 through 3 are self explanatory. Briefly, Chapters 4 through 9 cover the following topics:

Chapter 4, Exterior Envelope, deals with building insulation, configuration, orientation, infiltration, glass heat transfer and glass shading for the particular design selected and establishes areas and "u" factors that should be used for each.

Chapter 5, HVAC Systems, establishes parameters for design conditions, zoning, system types, system efficiencies, system control, ventilation rates, and pipe and system insulation.

Chapter 6, HVAC Equipment, establishes minimum efficiencies for all mechanical equipment and a period of time for the manufacturers to meet or exceed these efficiencies.

Chapter 7, Service Water Heating, establishes minimum efficiencies similar to Chapter 6, but adds insulation and control standards and limits flow of water through the various types of fixtures.

Chapter 8, Electrical Distribution Systems, provides for power factor correction, selection of service voltage, limits voltage drop through the distribution system, light switching and metering.

Chapter 9, Lighting Power Budget Determination Procedures, establishes a lighting power budget that will produce adequate lighting with an emphasis on task lighting.

By use of the above chapters and forms provided, the designer can determine whether or not his proposed building will, in fact, "pass" or "fail" the standard. Should the particular building pass on both heating and cooling by the principles shown in Chapters 4 through 9, then the designer can safely proceed with the completion of the design documents. If the building should "fail" then the designer has the option of adjusting wall "U" values, glass areas, shading factors, lighting levels or other factors as required to comply with Chapters 4 through 9. If this isn't feasible, then the designer has the option of doing an energy study that proves his building and its design is better then the requirements of Chapters 4 through 9. This energy study is provided for and detailed in Chapter 10 entitled "Energy Requirements for Building Designs based on System Analysis".

Chapter 11, Non-Depleting Energy Sources, provides for the use of alternate sources of energy that are of the non-depleting type.

Chapter 12, Annual Fuel and Energy Resource Determination, is now in the final review phase and will be published at the next revision of Standard 90. Chapter 12 provides a methodology for the designers of HVAC systems to determine the quantities and types of energy resources consumed by buildings, evaluating the relative efficiency of oil, gas and coal from their points of orgin.

The impact of Standard 90-75 on the construction industry and energy conservation was studied by the Arthur D. Little Company. Their study indicated the following impact:

Cost of Average Building would remain the same.
Equipment Manufacturers costs will increase substantially to re-design equipment to increase EER.
Standard 90 will improve wall and roof "U" factors and thereby the Insulation Industry sales will more than double.
Standard 90 will improve glass "U" factors and shading coefficients. This improvement will cut down the area of glass but increase the market by 80% due to retrofit and better quality.
Standard 90 substantially reduces lighting levels by providing task lighting. The net effect is that the energy consumption of new buildings will be reduced by 25% over what would be required by last year's design.

Proposed ASHRAE Standard 100

The members of ASHRAE have Standard 100 in final draft at this time and out for public review. We expect Standard 100 to be available to the public within one year. Standard 100 entitled "Energy Conservation in Existing Buildings" consists of the following six booklets:

100.1 Low Rise Residentials

100.2 High Rise Residential

100.3 Commercial

100.4 Industrial

100.5 Institutional

100.6 Public Assembly

Since the buildings and systems dealt with in Standard 100 are existing, a different approach has been taken. The general theory is that you would like for the existing building to conform to ASHRAE Standard 90-75; therefore, calculate an energy budget for the existing building in accordance with Standard 90-75; and then, proceed to determine the items that can be changed to make the building conform to that budget. Establish a cost benefit for each item that should be changed to conform to Standard 90. If the return on investment is adequate, the change in the building or the systems must be made.

Standard 100 is directed toward:

1. Up-grading the thermal performance of the building envelope.

2. Increasing the efficiency of the energy using systems and components.

3. Providing maintenance and operating procedures, recommendations, and guide lines that will achieve conservation of energy.

The Chapter entitled "Procedure" in Standard 100 provides for a method of determining compliance with the Standard. Compliance can be determined by one of four methods as follows:

1. Performance in accordance with Standard 90 with no changes required.

2. Component performance method - the building shall be tested to conform to Sections 4-9 of Standard 90 and retorfits made to meet or exceed Standard 90.

3. Performance Standard Method - an actual annual energy use for the existing building shall be calculated and this result compared to the building as modified to meet Standard 90 in accordance with Chapter 10. If the building meets or exceeds this Standard, then the building will comply. If it does not meet the Standard then retorfit will be required.

4. Economic Payback Method - all retrofit items possible for the particular building should be studied and an economic payback computed. If the payback is less than 10 years then retrofits should be made in accordance with the greatest economic return until Standard 90 and Standard 100 are complied with.

Chart No. 1 shows a suggested flow for determination of the best directions to take for energy conservation.

ASHRAE Standards 90 and 100 are only standards that are suggested for use by Architects, Engineers and Building Owners. Although there are many good reasons for using the Standard, there is no force of law for their use.

The real force is, of course, the cost of energy. In time, we may slowly react to this, but, as long as prices are regulated we will not react as fast as we should in order to conserve the fossil fuel energy sources. The Federal Government through FEA and ERDA are making things happen and slowly the states are reacting. As of now, 26 states have enacted some form of energy legislation for new construction and much of this legislation has used ASHRAE 90-75 as a basis.

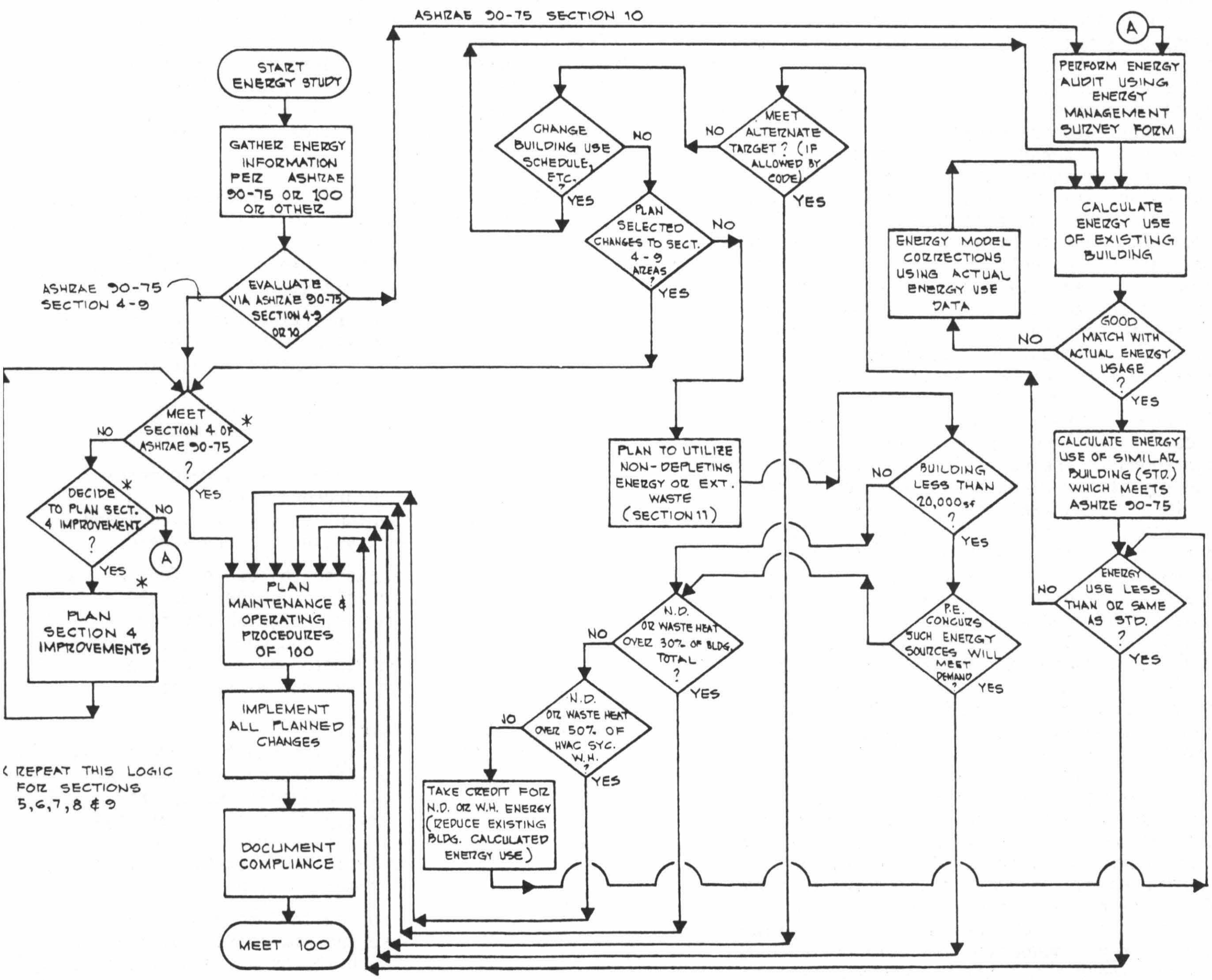
HUD is responsible for the development, promulgation and enforcement of energy standards for all new construction. HUD has worked with ERDA, NCS-BCS and other code bodies to produce a model code for the use of states and localities. This model code which was scheduled for issue on June 1, 1977 was based on ASHRAE Standard 90-75. Soon we'll see Standard 100 taking the same route as Standard 90; however, the only control on existing buildings at this time is the cost of energy.

In closing, we've discussed the vehicles that are being used by Architects and Engineers to produce new energy conscious designs or to retrofit existing buildings. I suggest that you work with your consultants to set up an energy conservation program on your new or existing building to obtain cost savings and thereby conserve energy implementing the following:

1. Obtain total management committment
2. Obtain employee understanding and cooperation
3. Make complete energy surveys
4. Analyze survey results
5. Set conservation goals
6. Develop reporting format
7. Implement engineering changes
8. Monitor results

Do not fall into the trap of thinking your new building is "energy conscious" and will stay that way over the years. I urge you to obtain these standards and work with them. Just the practice of going through the standards will make you more energy conscious and you'll see ways of improving your buildings as you walk through them.

CHART NO. 1



UNIVERSITY INTERFACES WITH STATE-LOCAL GOVERNMENTS AND INDUSTRIES ON ENERGY PROBLEMS AND ISSUES

Robert C. Stephenson
Professor of Management
Texas A&M University and Associate for University Programs
Energy Research and Development Administration under
provisions of the Intergovernmental Personnel Act

INTRODUCTION

Never in the history of man have we been confronted with an issue so complex and pervasive as the current energy problem. It is a problem that reaches down to touch everyone of use. It impacts on our communities, states and regions in a variety of ways. The energy problem is broadly defined as a national issue, to be dealt with through national policies, plans, programs and regulation. But, we are rapidly coming to realize that energy is truly a global issue that will be a strong factor in the shaping of future international relations among nations. When we talk of energy management, whether it be in the context of industry, state-local governments or our homes, we must recognize that our efforts are being concentrated on mere subsets of a much larger and complex management exercise. Mankind is faced with an unprecedented need to critically assess, wisely allocate and frugally manage energy as a scarce resource. We must orchestrate the management of alternative energy resources and the development and testing of alternative energy use strategies to assure the availability of energy to drive our economy and to preserve essential aspects of our life style. Energy management will require the concerted efforts of both the public and private sectors. Universities constitute a major intellectual resource that to date has been underutilized in seeking answers to energy problems. Industry, government and the universities are challenged to create an effective working triad to address the development of energy options and a capability for managing them. Universities are challenged particularly to analyze and respond to the education-training elements of energy manpower and energy management needs.

There is a great deal of confusion and uncertainty over the true nature and extent of the energy problem. Experts disagree on world reserves of fossil fuels and forecasts of use patterns. The press is writing of the impending oil glut that supposedly will result from new North Slope and North Sea oil. Some are making optimistic projections of large natural gas supplies from tight Devonian shales and geopressured Gulf Coast sediments. The future of nuclear energy is subject to a range of serious environmental and socioeconomic problems. There are serious questions as to whether we can achieve a large-scale conversion to coal as a major source of energy in an environmentally acceptible manner. The successful development of fusion and large-scale solar energy as unlimited energy sources, if they are to materialize are not near term solutions. Many think that the energy problem is a fabrication of our energy producers or politicians or both.

Experience since the oil embargo of 1973 has clearly shown that in the future we can expect to pay substantially higher prices for energy in all forms. Furthermore, the winter of 1976-77 confronted us with the grave realities of interrupted supplies. We can see today more clearly then ever that energy management must entail not only the conservation of energy as a cost-saving function, but the development of alternative energy sources to insure uninterrupted supplies.

INDUSTRIAL ENERGY CONSERVATION

There are those who have a blind faith in the ability of American science and technology to keep gasoline flowing at our service stations, natural gas in the pipe lines and a limitless flow of electricity. Indeed, the National Energy RD&D Plan and Program developed by the Energy Research and Development Administration (ERDA 76-1) sets forth an ambitious program of research, development and demonstration activities which are calculated to provide energy technologies to meet needs in near-term, mid-term and long-term time frames. The goals of the ERDA program are:

NEAR TERM (Now to 1985 and beyond)	- Increase the efficiency of energy used in all sectors of the economy and extract more usable energy from waste materials.
	- Preserve and expand major domestic energy systems: coal, light water reactors, and gas and oil from new sources and by enhanced recovery techniques.
MID TERM (1985 to 2000 and beyond)	- Accelerate the development of new process for producing synthetic fuels from coal and extracting oil from shale.
	- Increase the use of fuel forms such as geothermal energy, solar energy for heating and cooling, and extraction of more usable energy from waste heat.
LONG TERM (Beyond 2000)	- Permit the use of the essentially inexhaustible resources: nuclear breeders; fusion; and solar electric energy from a variety of options including wind power, thermal and photovoltaic approaches, and ocean thermal gradients.
	- Provide the technologies to use the new sources of energy, which may be distributed as electricity, hydrogen, or other forms throughout all sectors of the economy.

In the ERDA program a major portion of the total effort is devoted to large-scale, high technology approaches to the development of new energy sources and the conversion of energy into usable forms. In the short-term, however, energy conservation has been singled out as an important national goal. The ERDA conservation R&D program is organized under six programmatic divisions. These are:

1. Buildings and Community Systems
2. Industrial Energy Conservation
3. Transportation Energy Conservation
4. Electric Energy Systems
5. Energy Storage Systems
6. Conservation Research and Technology

The conservation program of ERDA is focused primarily on the engineering development and demonstration of existing conservation technologies. Basic research on conservation is very limited, but applied research on supporting technologies includes heat transfer, combustion, fuels, aerodynamics, materials and tribology. In Industrial Energy Conservation, the objectives are to reduce the energy consumed per unit of production throughout the industrial/agricultural sectors by:

- Developing economically viable technologies for reducing energy consumption.
- Accelerating industrial initiatives in the demonstration and adoption of energy conservation technologies.
- Stimulating adoption of techniques for improving the overall efficiency of industrial/agricultural processes and materials usage.

ERDA does not normally undertake industrial energy conservation projects that industry might be expected to do on its own. Most projects involve industry cost sharing. The projects focus on six major industrial sectors which consume about 70 percent of the energy used by industry (chemicals, petroleum refining, primary metals, pulp and paper, cement and food processing). Projects are solicited in accordance with program goals and objectives. The potential level of energy savings to be demonstrated by a project is important among the criteria in the proposal evaluation process. The ERDA Industrial Energy Conservation program also includes a technology transfer activity, the purpose of which will be to aid in the moving of ERDA-developed technologies into commercial applications. It is significant to note, however, that the ERDA program does not include the development of energy management concepts nor the training of energy managers.

The ERDA program in industrial energy conservation may be expected to make significant contributions to the near- and mid-term saving of energy in industry, but the program is no panacea for the range of energy problems facing industries today. Requirements established by FEA for energy conservation goals must be met by applying existing technologies. Furthermore, the winter of 1976-1977 convinced many industries as to the urgency in developing supply alternatives to natural gas, at least in periods of emergency. A number of state governments have been moving to develop comprehensive energy resource policies and management plans to safeguard against serious energy disruptions and economic chaos. In developing these management plans, the states are recognizing needs for energy technology assistance to their industries, and particularly the small industries, which are not being adequately addressed by current Federal programs. States, working together with industries and marshalling the technological capabilities in their universities, should be able to develop effective cooperative team efforts to address energy conservation needs and to increase both public and private sector capabilities for the effective management of available energy resources in order to maintain a balanced and stable economy.

ROLE OF UNIVERSITIES IN ENERGY MANAGEMENT

Traditionally, there has been continuous interaction between industry and the universities, in particular those institutions with professional programs in engineering and business administration. These relationships have typically involved a range of activities including continuing education, professional development, research, engineering development, special studies, problem assessment, problem solving, field advisory services, etc.

Energy problems and needs are so broad and complex that it is often difficult to assemble within the professional staff of a business or industry specialists from the various disciplines required to address all of these problems and needs. Specific energy problems may require inputs of a variety of science and engineering disciplines, systems management, finance, accounting, environmental scientists, and other disciplines knowledgeable with respect to socio-economic, legal and regulatory aspects of energy. Industries, individually or collectively through trade associations, can complement their own energy technology and management capabilities through the development of cooperative energy programs with universities. State and local governments can utilize the capabilities available in universities to explore and evaluate energy policy alternatives. Universities also can serve as a valuable contributing partner to government and industry in seeking mutually acceptable balances in regulations and controls contained in government energy management programs.

Universities, to be responsive to the problems and needs of industry in the energy field, must be prepared for and committed to providing energy assistance. If the providing of energy services to industry is to be a recognized part of the public service mission of the university, there should be institutional recognition and support of this objective. Energy capabilities of the faculty and staff should be critically assessed and organized into appropriate teams. The institution should organize efforts to assure that its energy specialists are knowledgeable about current energy policies and programs of Federal, state and local governments. Assistance to specific industries should be based on a careful assessment of the perspectives which the industry has of its problems. When the university enters into a contractual agreement to deliver an energy service to an industry, care should be exercised to be certain that the performers of the service and the industry representatives have a common understanding of what is to be delivered.

The university might offer a range of energy-related programs and services that would fall within the fundamental missions of the institution: education/training, research and public service. These activities might include the following:

Energy Management - An interdisciplinary energy management option could be offered to students enrolled in engineering, business administration or public programs which would concentrate on energy problems and issues and the management of energy as a scarce resource. The option could include a seminar in which visiting lecturers from industry and government could present actual case histories in energy management.

Career Development - The university could offer a special energy management degree program for mid-career executives from industry and government who are seeking to expand or redirect their career efforts in energy management. Participants in the career development program in turn might be utilized as adjunct faculty in both undergraduate and graduate level programs.

Continuing Education - The university could develop and offer conferences, workshops and short courses on energy management or a wide variety of topics focusing on specific energy problems or issues of industry or the public sector.

Internship - The university could develop an internship program through which students pursuing an energy management option could gain on-the-job energy management experience by serving in industry or government.

Research - Industry or state-local government might support problem-oriented energy research in the university. Team relations between industry and university researchers might be developed. The research might focus on specific aspects of energy conservation or it might undertake to explore the optimization of energy efficiency through alternative industrial processes. State sponsorship might focus on environmental, socio-economic, legal or institutional aspects of energy management policies. Universities might team with industry and/or state-local government to conduct energy research or demonstration projects with support from Federal programs.

Problem Assessment Services - Industry or state-local governments might seek the assistance of university energy specialists to define and assess specific energy problems or to consider alternative strategies for the allocation and management of energy resources.

Field Advisory Services - Industry or state-local governments might seek on-site visits of university energy specialists for walk-through energy audits, energy management studies or to address specific energy problems.

The ultimate success of the coupling of universities with industry and/or state-local governments to address energy management problems and issues will depend to a significant extent on the care devoted by all concerned parties in the definition of problems to be studied and the expectations for performance.

SUMMARY

Universities have capabilities to assist industry and state-local governments in addressing energy management problems and issues of common concern. A commitment to energy public service must be made by the university. Activities should be tailored to identified needs and priorities. Care should be exercised in defining problems to be studied and expectations for performance. Universities can join with industry and state-local governments to develop cooperative partnerships for increasing the effectiveness of energy management in both the private and public sectors.

LIST OF SPEAKERS

William Axtman
Assistant Executive Director
American Boiler Manufacture Association
1500 Wilson Boulevard
Suite 317 A. M. Building
Arlington, Virginia 22209
(703) 522-7298

Charles E. Dorgan
Program Director
Dept. of Engineering and Applied Science
University of Wisconsin
Madison, Wisconsin 53706
(608) 262-2061

Robert T. Dorsey
Manager
Lighting Technology Department
General Electric Company
Nela Park
Cleveland, Ohio 44112
(216) 266-2363

James A. Grinnan
Vice President
Van Wagnenen and Searcy, Inc.
337 West Forsyth Street
Jacksonville, Florida 32202
(904) 358-2105

John Hart
Industrial Extension Service
North Carolina State University
Raleigh, North Carolina 27607
(919) 737-3262

Michael Shehadi
Regional Engineer
Johnson Controls, Inc.
10601 Decatur Road
Philadelphia, Pennsylvania 19154
(215) 637-1700

Donald E. Hillier
Vice President and General Manager
Quality Assurance - Environmental and
  Corporate Industrial Engineering
Johns Manville Sales Corporation
Ken-Caryl Ranch
Denver, Colorado 80217
(303) 979-1000

Jack Kepner
Executive Assistant to the Vice President
  and General Manager
Appalachian Power Company
P. O. Box 2021
Roanoke, Virginia 24022
(703) 344-1411

Clarence H. Long
Professor
Mechanical Engineering Department
123 Randolph Hall
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061
(703) 951-6803

Robert G. Massey
Program Officer
Industry/Association Programs
Office of Energy Programs
U. S. Department of Commerce
Washington, D. C. 20230
(202) 377-5762

Neil Patterson
Manager
Application Engineering
The Trane Company
La Crosse, Wisconsin 54601
(608) 782-8000

Jim Shivar
Energy Research and Development Administration
20 Massachusetts Avenue
Room 2252-C
Washington, D. C. 20545
(202) 376-4818

Patricia L. Spencer
Director
Industry/Association Programs
Office of Energy Programs
U. S. Department of Commerce
Washington, D. C. 20230
(202) 377-3535

Roy Stamm
National Technical Information Services
5825 Port Royal Road
Springfield, Virginia 22161
(703) 557-4640

Robert G. Stephenson
Office of University Programs
Energy Research and Development Administration
400 1st Street, N. W., Room 308
Washington, D. C. 20545
(202) 376-9184

Goodwin H. Taylor
Goodwin H. Taylor, Ltd.
Consulting Engineers
6121 Lincolnia Road
Alexandria, Virginia 22312
(703) 941-7600

LIST OF PARTICIPANTS

Danny T. Anderson
P. O. Box 2867
United Va. Bankshares, Inc.
Roanoke, VA 24001

K. W. Baker
331 Burruss Hall
Bldgs. & Grounds
VPI&SU
Blacksburg, VA 24061

Bennie Barham
Physical Plant Dept.
UNC Greensboro
Greensboro, NC 27412

Charles A. Barron
P. O. Box 1551
Carolina Power & Light Co.
Raleigh, NC 27602

E. W. Biederman
501 Keller Bldg.
Penn State University
University Park, PA 16802

Gary Blanchard
4100 Chain Bridge Road
Purchasing & Supplying
Management Agency
Fairfax, VA 22030

R. Gill Blandford
Pembroke Off. Park
Pembroke One Bldg.
Pembroke Developers, Inc.
Va. Beach, VA 24362

Wilbert T. Borum
Box 6122 Hampton Inst.
Hampton, VA 23668

John Bouldin
U.S. Army Eng. Support Agcy.
Attention F E S A-ED-FE
Ft. Belvoir, VA 22060

Samuel P. Bowen
Dept. of Physics
Robeson Hall
VPI&SU
Blacksburg, VA 24061

E. R. Bowery
2000 Electric Way
Harvey Hubbell, Inc.
Lighting Division
Christiansburg, VA 24073

Jack Brocksmith
5225 Troost Avenue
Rockhurst College
Kansas City, MO 64110

Richard J. Bronski
Acme Visible Records, Inc.
Industrial Engr.
Crozet, VA 22932

Conrad M. Browe
419 Rotary Street
Project Engineer
Engineering Inc.
Hampton, VA 23661

Mitchell R. Brown
NASA Building F-10
Wallops Island, VA 23337

L. R. Bryant
Wiley & Wilson
2310 Langhorne Road
Lynchburg, VA 24501

Floyd A. Burkel, Jr.
Capitol Annex Bldg., Rm. 16
Dept. for Local Gov.
Frankfort, KY 40601

Jack Burns
Solite Corp.
P. O. Box 2015
Arlington, VA 22202

Thomas A. Caldwell
Newport News Shipbuilding
204 Ridgeland Drive
Smithfield, VA 23430

H. Norvel Camden, Jr.
3600 W. Broad Street
Suite 380
Technical Resources
VPI&SU Extension
Richmond, VA 23230

Robert M. Campbell
South Main Street
James Madison University
Harrisonburg, VA 22801

Frank J. Capek
Rm. 203 Engr. Research Lab.
Univ. of Miss. - Rolla
Rolla, MO 65401

Robert Chaing
Cowgill Hall
VPI&SU
Blacksburg, VA 24061

Vincent J. Cilimberg, Jr.
2312 Terra Bella St., N.W.
Building Const. - VPI&SU
Blacksburg, VA 24060

Dave Clark
Concrete Pipe & Prod., Inc.
P. O. Box 1223
Richmond, VA 23801

J. R. Clemens
331 Burruss Hall
Bldgs. & Grounds
VPI&SU
Blacksburg, VA 24061

Edmond B. Collins
206 Coliseum
Cooperative Ext. Service
W. Virginia University
Morgantown, WV 26506

O. D. Cumbia
Southside Va. Community College
Alberta, VA 23821

Mr. Glen Dalton
Farmbest Foods, Inc.
P. O. Box 860
Bristol, VA 24201

Perry L. Dannelley
P. O. Box 2784
Center for Indus. Services
University of Tennessee
Jackson, TN 39301

C. F. Debusk
331 Burruss Hall
Bldgs. & Grounds
VPI&SU
Blacksburg, VA 24061

Thomas Doran
U. S. Army Facilities Engr.
Support Agency
Attention: F E S A-ED-FE
Ft. Belvoir, VA 22060

Brad Doss
Georgia State University
University Plaza
Atlanta, GA 30303

V. E. Doss
Boiler Safety Division
Labor & Industry
Richmond, VA 23211

Kevin Dunne
Div. of Motor Vehicles
2220 W. Broad Street
Richmond, VA 23220

Paul L. Early, Jr.
WESTVACO Corp.
320 Hull Street
Richmond, VA 23224

Gary W. Estes
Div. of Consumer Counsel
Office of Attorney General
11 S. 12th St., Suite 308
Richmond, VA 23219

Robert J. "Doodle" Faulk
Fitzgerald Water, Light & Bond
Comm.
Rt. #3, Box 275 N.
Fitzgerald, GA 31750

Thomas Michael Ferrall
Farnsworth Heating & Plumbing
P. O. Box 865
Bristol, VA 24201

Lawrence A. Floro, Jr.
109 Kinkead Hall
University of Kentucky
Lexington, KY 40506

Donald Fournier
U. S. Army Facilities
Engr. Support Agency
Attention: F E S A-ED-FE
Fort Belvoir, VA 22060

Norman L. Fuqua
Southside Va. Comm. College
Alberta, VA 23821

Edward S. Gant
Presbyterian School of
Christian Education
1205 Palmyra Ave.
Richmond, VA 23227

S. Douglas Gant
Utilities Project Engr.
PPG Industries, Inc.
P. O. Box 949
Lexington, KY 27292

Homer C. Gough, Sr.
N. C. School of the Arts
200 Waughtown St.
Winston-Salem, NC 27107

Mel Hachhalter
12200 Henderson Rd.
Clifton, VA 22024

James Hales
Fairmont State College
Fairmont, WV 26554

Frank E. Hall
Rubatex Corp.
Railroad Ave.
Bedford, VA 24523

Verns Hegler
Univ. of Missouri
Rolla, MO 65401

W. D. Henshaw
Div. of Motor Vehicles
2220 W. Broad St.
Richmond, VA 23220

John W. Higgins, III
Sav-A-Stop, Inc.
2001 Apperson Dr.
Salem, VA 24153

R. L. Highers
Univ. of Tenn
Center for Indus. Serv.
146 Capitol Hill Bldg.
Nashville, TN 37219

Richard L. Hill
Area Extension Office
150 West Main Street
Technical Resources
VPI&SU Extension
Abingdon, VA 24210

John Hoffman
Bethany College
Bethany, WV 26032

Fred L. Huckstep
James Madison Univ.
S. Main St.
Harrisonburg, VA 22801

Bryant Ingram
Defence General Supply Center
Richmond, VA 23297

Carl Lee Johnson
Ladybird Apparel
1255 Williamson Rd., S.E.
Roanoke, VA 24013

Ted L. Jones
Room 3, Agri. Admn. Bldg.
2120 Fiffe Rd.
Columbus, OH 43210

J. K. Jordan
Bldgs. & Grounds
VPI&SU
331 Burruss Hall
Blacksburg, VA 24061

Thomas E. Loxley
218 Page Street
Technical Resources
VPI&SU Extension
Luray, VA 22835

C. Lee Lintecum
West Piedmont Planning Dist.
Committee
P. O. Box 1191
Martinsville, VA 24112

R. P. Lortie
R. J. Reynolds Tobacco Co.
Suite 900 N.C.N.B. Plaza
Winston-Salem, NC 27101

T. R. McAnge, Jr.
Suite 230, Peters Creek Plaza
1314 Peters Creek Rd. N. W.
Technical Resources
VPI&SU Extension
Roanoke, VA 24017

Hugh K. McGavock
Smithey and Boynton
P. O. Box 8335
Roanoke, VA 24014

Bill McMichens
KEW-NEER Co.
Country Club Rd.
Harrisonburg, VA 22801

Virginia D. McWhorter
VPI&SU
Rt. 1, Box 14
Newport, VA 24128

Emerson Mann
Carter Machinery
P. O. Box 1096
Salem, VA 24153

Boyd Marcus
Office of Energy Serv.
7700 Midlothian Tnpk.
Richmond, VA 23235

Leonard Martin
Rappahannock Comm. College
P. O. Box 318 Bldg. & Grounds
Warsaw, VA 22572

Robert M. Martin
P. O. Box 60
City Hall
Lynchburg, VA 24505

William Mascenik
Public Tech., Inc.
1140 Conn. Ave., N. W.
Washington, DC 20036

Barbara Mears
1150 Grand Ave.
Kansas City, MO 64106

Henry C. Moore, Jr.
P. O. Box 158
Technical Resources
VPI&SU Extension
Appomattox, VA 24522

Michael J. Moore
City of Richmond
Dept. of Public Utilities
900 East Broad St.
Richmond, VA 23219

Howard G. Morris
Acme Visible Records, Inc.
Crozet, VA 22932

Marshall Moser
Physical Plant Dept.
U N C - Greensboro
Greensboro, NC 27412

Robert Naismith
Applied Physics Dept.
Atlantic Research Corp.
5390 Cherokee Ave.
Alexandria, VA 22314

James Neavill
Univ. of Kentucky
College of Business & Econ.
Room 415 Commerce Bldg.
Lexington, KY 40506

Byron Nelson
U M R
Rt. #4, Box 111
Rolla, MO 65401

Lester D. Olson
Northern Va. Comm. College
8333 Little River Tnpk.
Annandale, VA 22003

Lawrence E. Perry
P. O. Box 12365
Lawrence Perry & Assoc.
Roanoke, VA 24025

Paul V. Phibbs
Bridgewater College
Supt. Bldg. & Grounds
Bridgewater, VA 22812

Frank L. Plotts
Leggett Store
P. O. Box 1689
Danville, VA 24541

Tom Rienerth
Delmarva Advisory Council
P. O. Box 711
Salisbury, MD 21801

James R. Ross
Univ. of Tenn.
Center for Ind. Serv.
124 S. Madison St.
Cookeville, TN 38501

John Ryba
Coast Guard Research &
Devp. Center
Groton, CT 06340

Louis C. Saksen
Va. Commonwealth Univ.
Manager of Planning Const.
910 W. Franklin St.
Richmond, VA 23284

J. Fred Saverance
Div. of Gen. Services
Engin. Operations
921 Main St.
Columbia, SC 29201

Dr. Harald Schutz
Maryland Academy of Sciences
Dept. of Science & Engr.
601 Light St.
Baltimore, MD 21230

John Scott
1150 Grand Ave.
Kansas City, MO 64106

Thomas M. Shea
Burroughs Wellcome Co.
Box 1887
Greenville, NC 27834

F. M. Shelor
United Va. Bankshares, Inc.
P. O. Box 2867
Roanoke, VA 24001

Alton Smith
Physical Plant Dept.
U N C - Greensboro
Greensboro, NC 27412

Phillip E. Smith
Dan River Inc.,
Woodside Div.
P. O. Box 6126
Greenville, SC 29606

Boyd Spencer
Va. Energy Office
Richmond, VA 23219

Ron Spitler
5110 Greenfield St.
Roanoke, VA 24108

John B. Staley
Balloy & Justice Arch. & Engr.
1843 Blakemore Rd.
Richmond, VA 23225

Lee Stallard
Carter Machinery
P. O. Box 1096
Salem, VA 24153

Delmer Stanger
Montgomery Co. School Bd.
200 Junkin St., Box 29
Christiansburg, VA 24073

R. H. Staten
Catawba Hospital
Supt. of Build. & Grounds
Catawba, VA 24070

John W. Sumner
Montgomery Co. School Bd.
200 Junkin St., Box 29
Christiansburg, VA 24073

Jerry A. Thompson
Thalhimers Engr. Manager
Rt. #1, Box 365
Manakin-Sabot, VA 23103

William Torkington
Reynolds Metals Co.
6601 W. Broad St.
Richmond, VA 23261

Avtar K. Trehan
Dept. of Studies in Engr.
Hampton Institute
Hampton, VA 23668

Wayne C. Turner
School of Industrial Engr.
and Management
Oklahoma State Univ.
Stillwater, OK 74074

N. R. Waldrop, Jr.
State Dept. of Education
P. O. Box 62
Richmond, VA 23216

Lynn R. Ward
West Piedmont Plan. Dist. Comm.
P. O. Box 1191
Martinsville, VA 24112

Mike Wasell
Wasell Engr. Service
903 Westend Blvd.
Winston-Salem, NC 27101

Helen Wells
VPI&SU
228 Wallace Hall
Ext. Specialist, MHFD
Blacksburg, VA 24061

Douglas J. Wilson
Lynchburg Gas Company
600 Main St.
Lynchburg, VA 24505

James H. Wilson
VPI&SU
Engr. Tech. Dept.
Blacksburg, VA 24061

Richard Wilson
Rockhurst College
5225 Troost Ave.
Kansas City, MO 64110

Janice Woodard
VPI&SU
228 Wallace Hall
Ext. Specialist, MHFD
Blacksburg, VA 24061

M. F. Woodlin
Co. of Hanover
Director of General Serv.
Hanover Court House
Hanover, VA 23069

Richard A. Yocius
Koppers Co., Inc.
Forest Prod. Division
P. O. Box 792
Salem, VA 24153