FINAL REPORT

EDA GRANT # 99-6-09359-1

"A PROJECT TO REDUCE THE IMPACT OF ENERGY SHORTAGES AND COST INCREASES ON INDUSTRIAL PRODUCTION IN THE SOUTHEAST"

VOLUME I
PROJECT OVERVIEW

by

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Abstract

The purpose of EDA Grant # 99-6-09359-1 was to assist industry develop energy conservation programs and to assemble training materials from information developed in those activities for use in other states. Under the project ten plants were selected for in-depth case study work. Twenty-nine others were selected as technical assistance firms. In the case study companies detailed conservation programs were developed and monitored. In the technical assistance companies specific projects were recommended. A training program for energy conservation field agents was developed and used to train area office representatives. Five workshops and seminars were held during the project. Direct energy savings due to this project were estimated to exceed $1.8 million in the first year and capital investment stimulated by the project is estimated to exceed $900,000. Auxiliary benefits from the project included development of several industry specific energy research projects, development of resources for conservation programs in schools, hospitals, and local governments, and development of several legislative initiatives.

This report is divided into three volumes. Volume I gives an overview of the project with major conclusions and recommendations. Volumes II and III are designed as training materials and resources to organizations in other states that wish to implement similar programs.
Section II

Introduction and Background

General Background

In the years preceding the Arab Oil Embargo of 1973, the United States enjoyed periods of vigorous economic growth. Energy of all forms, including natural gas, was not thought of as a precious commodity or a limiting factor to growth. This age of profligate energy use has ended but systems and designs dependent on unlimited resources remain a constant threat to the nation's economic health. In 1977, four years after the first winter of a national energy crisis, the general public still questions the existence of a state of emergency and many industries are as little acquainted with alternative energy sources or energy conserving methods as in 1973.

The warning signals for a 1976 winter of hardship were clearly posted. Henry Kissinger, (then) Secretary of State, stated the embargo cost the United States 500,000 jobs, more than $10 billion in national production and rampant inflation. The Bureau of Labor Statistics in December of 1975, a year later, reported a similarly bleak record:

"The private sector of the economy, which employs over 80 percent of nonagricultural payroll workers, bore the brunt of the 1974-75 cutbacks in nonagricultural payroll employment. From the September 1974 peak to April 1975, private payroll jobs decreased by 2.8 million, while the public sector had a gain of 400,000." 1

In March of 1976 a "revised" BLS employment projection was made assuming higher priced energy would be available, but scarce. Full employment in years to come will be increasingly difficult to attain:

"The earlier set of projections to 1985 incorporated an assumption that unemployment would reach 4.0% in 1975 and would remain at that level to 1985. In the current set of projections the unemployment rates moves from 8.5% in 1975 steadily downward to 4.0% in 1985." 2

Prior to 1973, economic projections were formulated under the assumption that the gap between oil consumption and domestic oil supplies would be met by imports. Oil imports in 1973 were about 33% of total consumption and by 1976 this figure had risen to 42%, almost half of all petroleum and related products used.

Manufacturing industries are extremely important to the national economy as well as for Georgia. The Manufacturing sector of the United States in 1972 employed close to 20 million people who contributed to a value added of over $450 billion. The shipment value of the products was over $1,000 billion. In Georgia alone the manufacturing industries of durable and non-durable goods employed over 450,000 people in 1972 who contributed to a value added of close to 7.5 billion dollars and had a shipment value of over $18 billion.

Tremendous quantities of energy are consumed by the manufacturing sector in the United States. In 1974 the manufacturing sector consumed an equivalent of 3.92 trillion kilowatt hours or 13,000 trillion BTU's. The cost of this energy was around $19.5 billion. Based on energy consumption the breakdown of the various energy sources is natural gas 54%, electricity 16%, fuel oil 14%, coal 10%, coke and breeze 3% and other fuels 3%. In Georgia the manufacturing sector consumed an equivalent of over 75 billion kilowatt hours at a cost of over $15.6 million. Among the states Georgia ranks fifteenth in energy consumption. The breakdown of energy consumption by the manufacturing sector is Georgia is electricity 17%, natural gas 45%, fuel oil 20%, coal 6% and other fuels 12%.

The above figures show that there is a tremendous dependence on natural gas, the supply of which is dwindling at an alarming rate. Since Georgia is not a major supplier of energy the rising costs of energy could affect its economic performance in the future. Since alternate energy sources cannot be found to boost the energy
supply in the near future, the solution to this problem is vigorous energy conservation.

This general energy situation has had considerable impact on manufacturing industries in the southeast. Many of the firms in the southeast are smaller industries that do not have technical resources or technical staffs to develop, implement and monitor energy conservation programs. Consequently, these firms are harder hit in periods of shortages and cannot develop the longer range strategies that will be necessary for meeting future energy shortages.

Because of the lack of skills and finances in smaller businesses and industries and because of a general lack of expertise of public agencies for working with these types of firms the Economic Development Administration (EDA) granted the Engineering Experiment Station at Georgia Tech funds to develop and conduct a program of technical assistance to smaller manufacturing industry. This assistance, limited to energy conservation work, was to be used as the basis for achieving the goals and objectives described in the next section.
Section III

Goals and Objectives

Goal

"The goal of Grant # EDA-99-6-09359-1 is to reduce the impact of energy shortages and increased energy costs on employment and industrial expansion by creation and stimulation of industrial energy conservation programs."

Objectives

(1) Develop training materials for use by appropriate state agencies in encouraging industrial energy conservation,

(2) Develop in-depth case studies showing the economic benefit to be derived from company energy conservation programs,

(3) Provide technical assistance to industry in Georgia in energy conservation,

(4) Evaluate the impact of industrial energy conservation activities.

Organization of Report

This report describes project activities and major end items that were produced during the 12-month period of work under this grant. Volume I summarizes project methodology, other benefits of the project, and includes recommendations for future work of this type.

Volume II is a compilation of case study and technical assistance information catalogued by industry. The Volume II Table of Contents is given on page 3. This volume also includes a compilation by industry of specific energy conservation ideas showing estimated costs and savings. This volume is designed as a working reference for individuals who would provide technical assistance to industry. It describes the make-up of industries, the technical energy conserving opportunities within the industries and specific projects undertaken.
The material in the volumes was derived from actual firms participating in this work program.

Volume III is designed to provide a basis for conducting a similar program in other states. Program methodology is described in detail as are methods for selecting participating firms. In addition, training materials for technical workshops are included. The volume III Table of Contents is given on page 6. A key component of Volume III is an 18 minute slide-tape package constructed from interviews of plant engineers and plant managers. This package is designed to motivate energy conservation activity in plants by having plant personnel communicate their experiences and cost savings in energy conservation.
Section IV
Overview of Project

This section of the report presents an overview of the project and briefly describes the various tasks and activities performed and the results accomplished.

Selection of Companies

The first task in the project was to select the industrial sectors in which efforts would be concentrated. Based on a number of criteria including: energy usage, value added, employment and potential savings, the Standard Industrial Classification (SIC) sectors of Textile Mill Products (SIC 22), Food and Kindred Products (SIC 20), Primary Metal Industries (SIC 33), Stone, Clay, Glass and Concrete Products (SIC 32), Apparel (SIC 23), Paper and Allied Products (SIC 26), Lumber and Wood Products (SIC 24), Chemicals and Allied Products (SIC 28) and Fabricated Metal Products (SIC 34) were selected.

After the industrial sectors were selected the individual plants were selected based on a number of criteria including energy consumption, employment, management interest, sophistication related to energy conservation and potential savings. The case study companies were selected based on management interest, their willingness to invest in energy saving methods and in-house engineering capability.

Case Study and Technical Assistance Methodology

After the companies had been selected and the project explained to the plant executives an appointment was made for a plant visit by a team of specialists from Georgia Tech. The purpose of this visit was to conduct an energy audit and to identify potential energy saving methods, processes and equipment. In a number of cases, the energy conservation data sheet that was
prepared by the project staff was filled out to document the energy usage, the status of energy conservation in the plant and the major energy consuming equipment or processes. The procedure for identifying potential energy saving methods can be broken into the following categories:

1) Finding methods of improving the energy efficiency of the process by minor changes in operating procedures, without major capital investment.

2) Defining methods of improving energy efficiency by recovering waste heat or resources for use in the same process.

3) Identifying heat and resource recovery from a systems viewpoint and trying to match the wastes from one process to the needs of another within the same plant.

4) Finding alternate energy sources that could replace those in short supply.

5) Identifying new technology and process modifications that are more energy efficient and can replace existing methods.

The technical assistance companies were given a list of these concepts and in some cases a rough estimate of the potential energy savings for the case study companies. A more detailed analysis of the energy savings, the approximate cost of the modifications and the approximate return on investment was presented to the plant executives. This effort was followed up by continued contact with the companies and by providing assistance in evaluating the proposals submitted by vendors or equipment manufacturers and by providing advice in actual installation of equipment. In the case of technical assistance plants the project staff responded to specific requests of assistance in energy conservation but did not provide continued in-depth assistance.

Training Programs and Seminars

A training program for the field office personnel of the Engineering Experiment Station was conducted on May 5, 6, and 7, 1976. This program involved
lectures on various topics such as: fuels, combustion, electrical distributors, heat recovery, steam, refrigeration, space heating and air conditioning, combustion analysis and testing. It also involved tours through the Georgia Tech power plant facilities and buildings.

Five industrial energy conservation workshops were held for local industries at different locations in Georgia on the dates and locations given below:

1. October 19, 1976 - Dalton
2. January 31, 1977 - Savannah
3. February 3, 1977 - Atlanta
4. March 22, 1977 - Rome
5. March 24, 1977 - Athens

The workshops were attended by plant engineers and managers who were directly involved in the implementation of energy conservation measures at the plants. The workshop included lectures on fundamentals of energy conservation, insulation, heat recovery, boilers, steam distribution, utilities and fuels. A number of handouts supplementing the lecture materials were distributed. Also, the findings of the project staff and the energy conservation methods identified in case studies and technical assistance activities were presented and discussed. The slide/tape show developed under this project was also shown. As a means of feedback an evaluation form was filled out by all participants which helped improve and modify succeeding workshops. The evaluation of the workshops are discussed in great detail in Section VI.

Audio Visual Presentation

As part of the transfer package an 18 minute slide/tape presentation was developed to provide other agencies or states with the methodology for carrying out an energy conservation program. This presentation was developed
by interviewing a number of industry personnel and by taking a number of photographs of relevant subjects and compiling them in a meaningful way to impress the need for energy conservation.

Advisory Council

An advisory council consisting of members of private business, industry, trade associations, chambers of commerce, state and local governments and the legislature was formed to advise and guide the project staff in the methodology and activities of the project. The council also served as a means of dissemination of the energy conservation methods to accelerate implementation.
Section V

Additional Project Benefits

In addition to meeting the objectives outlined above in Section II the project had several other ancillary benefits to the Georgia energy situation and to the situation in several other states. The project increased awareness of the need for industrial energy conservation extension and research work in several industry groups. This increased awareness led subsequently to the formulation of active programs in the industries. From information developed during this project several industrial energy conservation research projects have been initiated. The project also provided the ability to develop resources at Georgia Tech to help non-industrial energy consumers in developing conservation programs. From the project activities several legislative initiatives were forthcoming and these are expected to have direct impact on industrial energy conservation in the very near future. These initiatives can serve as the basis for activity in other states in the nation.

Increased Awareness

Through this project awareness of the need for and the benefits of energy conservation in several industry groups and trade associations has been developed. Specifically in the carpet, textile and food processing industries the project has had direct impact. In the carpet industry, which is the third most energy intensive Georgia industry, the Carpet and Rug Institute is now developing an active Energy Committee. This committee is under the general oversight of the CRI's technical director who has served on the project advisory committee and who has worked directly with the project team. Members of the Georgia Tech project team are serving as adjunct members to the CRI energy committee and are helping that committee formulate its agenda of activities.
In the textile industry the project has had several spin-off benefits. Principally, the project provided data and contact to allow formulation and definition of a major research effort funded by the Energy Research and Development Administration. This $356,000, 30-month effort is designed to identify and demonstrate wet process modifications to save approximately 30% of the energy currently used in the textile industry.

Activities in the food processing industry have also been impacted by this project. Through this project several energy conserving process modifications have been identified and implemented. The success of these efforts has resulted in state funding for additional energy conservation work through the Georgia Poultry Federation.

Additional Research and Extension

Through interaction with industry groups and specific industrial firms the project has allowed development of resources and research programs that will significantly impact energy use in the near future. As mentioned above the project provided the basis for development of a $356,000, 30-month textile research project.

In addition the project has also resulted in a $270,000 2-year project in the poultry processing industry. This project will reclaim reject heat from cooling equipment to supply all energy now derived from natural gas fired boilers. This project is cooperative with a company which is contributing $50,000 to the effort in addition to use of a plant.

In another case the project provided a base of liaison with a paper company manufacturing molded paper products. This liaison has resulted in a proposal to ERDA to develop improved energy efficient paper drying technology. The firm has agreed to commit approximately $200,000 cash and in-kind support to this research. Negotiations are currently underway with the same firm to
develop and demonstrate use of wood as an alternate to natural gas fuel in product dryers. If successful, this research could lead to development of a significant wood based supply industry in the southeast.

Another major conservation proposal effort is underway with a leading primary metals producer. This project will be completely funded by private sources.

Non-Industrial Energy Conservation Spin-Offs

Due to publicity generated through this project, several other energy conservation projects have been initiated. These have been with local governments, school systems, and hospitals within the state. This project allowed development of resources at Georgia Tech to conduct this type of work and resulted in contact that led to other research. To date, programs have been conducted, without EDA funding, with three school systems, a major hospital, and an Area Planning and Development Commission (through which work with local governments were conducted). In addition to these projects, several other projects are being negotiated.

Legislative Initiatives

As a result of interaction on the project advisory committee by a key state legislator who serves on the House Industry Committee, several legislative initiatives have been formulated. These were introduced during the 1977 legislative session and were carried forward for interim study. Included were:

(a) a bill to provide tax relief on purchase of energy conserving plant modification equipment,

(b) a bill to stimulate use of wastes as fuels in industry,

(c) a bill to stimulate use of wood and biomass as fuels in industry.
These will be considered and refined by the House Industry Committee during the interim period and will be re-introduced in the 1978 legislative session.

In addition to these bills, and as a partial result of this project, a joint resolution was passed by the legislature directing the Office of Energy Resources (State Energy Office) to establish an energy extension service. This program is currently under planning in the OER.

Summary

In total, this project has had significant spin-off benefits. It has provided a technical basis at Georgia Tech to provide technical assistance to smaller business and industry; it has provided important liaison capability with industry and local and state governments; it has provided input to the legislative process and has allowed important energy policy inputs to that process.
Project Evaluation

A project evaluation form developed by the project staff was mailed or delivered to the primary contact in each company, both case study and technical assistance. The purpose of this form was to determine the effectiveness of the program as perceived by the company involved. The company contacts were asked to fill out and return the forms to Georgia Tech.

To date 27 evaluation forms have been returned and a compilation of the responses is shown in the form below. From the evaluation sheets it was found that a very large percentage of the respondents thought that the project was successful and that Georgia Tech had provided adequate assistance that energy savings in the range of 5% to 25% would result in their plants from this assistance. They also expressed the need for an office to provide technical assistance and they feel that the University System would be best suited to do the job.

Workshop Evaluations and Feedback

There was a general consensus that the workshops were very helpful and informative. The participants also indicated that there should be more workshops held and more often. They expressed the feeling that the information presented was very educative and thought provoking and indicated new possibilities that had not been thought of. From the feedback received it was found that the plants were at a very low level of sophistication in their energy conservation programs. The extent of their contribution in a majority of cases was turning off lights or other equipment when not in use, conversion to high pressure sodium lights and insulation. They also indicated that they were interested in specific project descriptions rather than general discussions of research and concepts.
Estimation of Savings

This project has created an awareness of the needs and benefits of energy conservation throughout industries in Georgia. A number of recommendations were given to industry both short range and long range, those involving major capital investments and those not involving major capital investments. These various recommended projects are in different stages of implementation. A few projects have been implemented while some are being implemented and others would be implemented in the future when capital availability or other factors make them more attractive. It was difficult to estimate the savings of the technical assistance companies. Based on the indications on the returned evaluation sheets, the estimated saving based on today's fuel cost is approximately $1,800,000 per year.

It was possible to break down the savings and capital expenditures for the case study companies as shown below:

Money committed to Projects that:

1) Were Implemented $65,000
2) Are being Implemented $106,000
3) Will be Implemented $540,000
**TOTAL** $711,000

Estimated annual dollar savings based on 1976 fuel prices that result from projects that:

1) Were Implemented $130,000
2) Are being Implemented $233,000
3) Will be implemented $540,000
**TOTAL** $903,000

Estimated annual dollar savings based on 1976 fuel prices from the technical assistance projects is approximately $900,000. This is the total of all projects that were implemented and will be implemented.
EVALUATION SUMMARY

A. Site Visit

1. Was the objective of the site visit clear?
   
   Yes 27  No

2. At the site visit did the Tech team answer your questions sufficiently?
   
   Yes 27  No

B. Recommendations

3. Were the recommendations for energy conservation relevant to your company?
   
   Yes 27  No

4. Were the techniques for conservation sufficiently described by the Tech team?
   
   Yes 24  No 2

5. What total percentage of energy do you feel you could save through energy conservation measures?

   
   0%  1  30%
   7 5%  35%
   3 10%  40%
   5 15%  45%
   4 20%  50%
   4 25%

C. Assessment of Need

6. Is an office needed to provide technical assistance to companies similar to the assistance provided by Georgia Tech?

   Yes 20  No 4
7. If you answered YES to the previous question, this office should be

_14_ within the University System

_3_ a new agency of state government

_2_ a newly formed agency of government or private organization

D. Overall

8. Would you rate the Tech Project successful:

_25_ Yes _1_ No

Worth your investment in time

_25_ Yes _1_ No
Several key results have been obtained from work under this program. First, there is considerable potential for conservation in smaller manufacturing industries. Typically non-capital intensive techniques can be expected to yield savings of 5-15% over what is currently used. With capital expenditures greater savings, from 10-40% depending on the industry, may be technically feasible. Economic feasibility of many techniques is dependent on plant energy use. Smaller plants, with correspondingly less energy use and cost, cannot justify many modifications on economic grounds. Many of these firms are constrained to finance improvements with cash-flow and cannot make large capital expenditures with even 3-5 year payback rate. Consequently, it is recommended that methods for financing (or guaranteeing financing) energy conservation modifications in small business be studied and developed.

Closely linked with this recommendation is the need for serious consideration of ways to stimulate investment for energy conservation equipment by smaller firms. Since management in these firms is cognizant of factors such as rapid depreciation and/or more direct tax reduction incentives these should be considered as a primary tool for stimulating small business investment to conserve energy.

Increased energy conservation activity in firms can only take place if firm information is available to management. Since industrial energy conservation is a highly technical subject and since smaller business and industries do not have technical staffs to develop plans a continued need for on-site technical assistance is seen. This technical assistance should be limited, in most cases, to development of plans and requests for proposals to equipment.
manufacturers and consultants. (Such requests will stimulate further economic activity.) The direct technical assistance to industry is needed since each plant has unique requirements and because of the highly technical nature of energy saving programs.

Another key recommendation is that a body of appropriate technical assistance and case study information should be developed and disseminated through a central organization in each state. This information should, when possible, reflect actual case history experiences of small business and industry.

A final conclusion is that the linkage between existing industry and the national technological base needs to be strengthened. The level of technology in most smaller industries can be increased significantly with concomitant increases in productivity. It is recommended that development of a comprehensive program of technical and management assistance be developed. This program should not be limited to energy and should focus on development, through projects, and dissemination of case study information. The program should function as a cooperative effort between state government, federal government, and private industry.
FINAL REPORT
EDA GRANT # 99-6-09359-1

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CASE STUDY AND TECHNICAL ASSISTANCE

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Introduction

This major group includes establishments engaged in the manufacture of a variety of textile mill products. The establishments included in this broad classification can be further broken into the following categories:

1) Broad Woven Fabric Mills, Cotton
2) Broad Woven Fabric Mills, Man-Made Fiber and Silk
3) Broad Woven Fabric Mills, Wool
4) Narrow Fabrics and other Small wares Mills
5) Knitting Mills
6) Dyeing and Finishing of Textiles
7) Floor Covering Mills
8) Yarn and Thread Mills
9) Miscellaneous Textile Goods

The textile industry is one of the larger manufacturing industries in the United States. In 1974 the industry employed over one million people who contributed to a value added of over $13 billion. The value of industry shipments in the same year approached $33 billion. A large section of the textile industry is concentrated in the Southeastern part of the United States. In Georgia the textile industry is the largest employer among the manufacturing industries employing over 111,000 people—almost one quarter of the labor force involved in the manufacturing sector. The value added by this industrial sector in 1972 exceeded $1.5 billion which represents over 20% of the value added by the manufacturing sector. The value of industry shipments for the same year exceeded $4 billion.

The industry consumed over 75 million barrels of oil equivalent energy in 1973 and is ranked in the top ten in industrial energy use. The approximate
distribution of this energy is electricity 31%, natural gas 33%, fuel oil 19%, coal 7%, and other fuels not specified 10%.

In Georgia the total energy consumed by the textile industry in 1976 was approximately equivalent to 47,800 billion BTU's of which 47.7% was natural gas, 26.5% electricity, 9.6% fuel oil and 4.2% coal. This industry is highly dependent on natural gas as the major source of thermal energy.

Discussion

Plant visits indicated that engineering capabilities were considerably better at larger facilities than at smaller establishments. The small plants in general are dependent upon natural gas and have not experienced significant difficulty in obtaining necessary quantities until recently. When combined with the economies of scale and the declining price of natural gas with volume, energy conservation engineering and implementation has been difficult to economically justify at small installations.

The medium to large installations have started comprehensive energy conservation programs. All of the companies were interested in any assistance Georgia Tech could provide. Some of the more attractive concepts have been implemented by various plants and the technology made available for others to consider. The approach taken by Georgia Tech to address both the equipment and its application by industry was well accepted. However, energy use data by process was generally unavailable or in a form such that different processes could not be accurately compared. Sufficient data was obtained by working closely with individual mills to identify relative energy consumption of major wet processes and estimate their conservation potential.

The major energy consuming equipment in the industry includes boilers, dryers, climate control systems, and product construction machinery. Climate
control and product construction equipment are utilized in dry processing (spinning, knitting, weaving, tufting, etc.) and have benetted from extensive engineering. Most of the energy required in dry processing or the manufacture of textile structures is in the form of electricity.

Wet processing (dyeing, drying, finishing, etc.) on the other hand utilizes energy predominately in its thermal form. Energy in fuel is either transformed and utilized as steam (heating dye liquors) or directly combusted (drying operations). The thermal uses of energy, influenced by low cost, has not yet developed comparable engineering sophistication to the electrical uses found in dry processing.

It was found that approximately 41 million barrels of oil equivalent energy (BOE) is consumed by the wet processing segment. Of that, an estimated 12.5 million barrels can be eliminated by conservation via procedural and engineering modifications which is approximately 31% of the wet processing segment and 19% of the total industry consumption.

There are two major areas where conservation should be most productive. Drying and heat setting operations waste the largest amount of energy due to the weight processed and the required repetition. It should be noted that drying operations account for most of the energy consumption shown for continuous dye ranges, finishing ranges and printing ranges. Atmospheric dye bacs and related atmospheric equipment consume an inordinate amount of energy due to their design and, therefore, also appear especially suited for conservation efforts.
TEXTILE INDUSTRY
CASE STUDY 1.1

Description

The company is a medium sized carpet mill producing tufted rugs and carpets. The company is a fully integrated plant with all its manufacturing facilities in one location. Average employment is 1650. The plant spins raw fiber into yarn and tufts the yarn into carpet. The carpet is dyed, bound and shipped. The products have an international market but the actual sales volume was unavailable. The annual energy cost is approximately two million dollars.

Selection of Company

The textile industry represents a major segment of Georgia industrial employment. Textiles are concentrated in the northern section of Georgia almost totally dominating employment in Dalton, Rome, LaFayette and Rabun Gap. Other textile plants are scattered throughout the state. The plant selected is representative of one of the larger segments of the textile industry in Georgia carpet.

The plant is representative of the industry in several ways. It has nearly all the processes that would be associated with carpet production including raw fiber and processing of the fiber into finished products. The detailed process flow charts are attached.

Initial Contact

The initial contact was made by a Georgia Tech field office person who set up the initial appointment for a plant visit. During the initial plant visit Georgia Tech engineers met with the plant manager and plant engineer.
When the project was explained to plant personnel there was some initial skepticism as to whether Georgia Tech could help them. During the visit, the plant was toured completely and a number of potential energy saving modifications noted. (These are described later in the section.) There were a number of follow-up visits to the plant to gather data and to assist in modifications being made.

Process Description

The basic raw materials are filament pretextruzed polyester fibers and cotton fibers. The raw fiber is twisted and heat set in equipment that is heated by natural gas. The set yarn is then wound into skeins and is ready for tufting. The yarn is then tufted into carpet in large complex tufting machines. The tufted carpet is then dyed or printed. The dying is done in dye becks, which are similar to large vats. These dye becks are filled with water and the required dye is added. The dye solution is then heated to boil by introducing live steam into the becks. The carpet is then introduced and agitated for a specified period in the solution which causes it to be dyed. The solution is then drained and the carpet is rinsed with clean water. The carpet is then transported to the dryers that are direct fired with natural gas. The dry carpet is then given a backing of foam or jute and sent to the curing ovens that are also fired with natural gas. The carpet is then trimmed and finished ready for packing and shipping.

The major energy consuming equipment in the industry include boilers, dryers, climate control systems and product construction machinery. Most of the wet processes (dying, drying, and finishing) use energy in the thermal form. This thermal energy is used either directly or as steam (to heat dye liquor).
Observations Made in Plant

It was observed during the tour of the plant that the major energy sources--electricity and natural gas--were metered only at one location for the entire plant. There was an absence of monitoring of energy usage for the individual processes.

It was found that there was a visible excess of steam used in the dye becks. There were no temperature controls for the steam input to the dye beck and hence the steam valves were kept constantly open to heat the water to as high a temperature as possible. However, since the water temperature cannot rise above about 209° at the altitude of the plant, large volumes of steam flowed out of the dye becks directly into the stacks and into the atmosphere.

It was observed during the visit that a pipe connecting the makeup water to the deaerator was undersized, resulting in excessive pressure loss and higher energy consumption than necessary. It was suggested that an additional pipe be installed to run parallel to the existing pipe to reduce the pressure drop.

During the initial meeting plant management informed us that they had a budget allotted for heat recovery from the dryers and that they planned to pursue the project in the near future. It was our experience in dealing with other carpet industries that the heat recovery systems on dryers were experimental at best and most of them were being discarded because of high maintenance and low efficiency. It was suggested that they invest in heat recovery from boiler stack gases rather than from the drier.

It was noted that a heat exchanger was being used on spent dye liquor. This waste drain averages in temperature from 120-140° F. The heat exchanger had no instrumentation to indicate its effectiveness. The plant personnel were advised to check the performance of the heat exchanger.
Although a sizeable quantity of electricity is used by this plant, an observation of the electric load characteristics indicated a very flat load, which in turn means low demand changes.

Recommendation

Based upon in-plant observation and the analysis of data collected, recommendations were submitted to plant management. The major recommendations are described in detail later in this case study.

Stage of Implementation and Company Interaction

The company was extremely enthusiastic in its energy conservation efforts and has given its fullest cooperation to Georgia Tech personnel. One of the first impacts of this project was the creation of a new position, Manager of Utilities in the plant. The responsibilities of this manager include initiating new energy conservation ideas and projects, and coordinating the requirements and wastes of energy in all divisions of the plant. This has created the possibility of approaching the energy conservation problem from a systems point of view, rather than from a process or division level.

The first project that was implemented was the installation of a new pipe for boiler makeup water parallel to the existing line. The actual cost of installation came to less than $600 and the pay back period was 6 months before taxes or 12 months after taxes.

The company has budgeted the cost of a heat recovery system for the dryer. The company was advised to use the money for heat recovery from the boiler stacks. After several months of talking and demonstrating the feasibility and economic returns on this project, the firm did elect to use this money to recover heat from the boiler stack. This project was approved by them during the last quarter of 1976, and complete installation was not
accomplished until the first quarter of 1977. No test data is now available on this system.

The company has also insulated their boiler system and instrumented a dye beck in order to measure waste streams and steam consumption to determine how much energy is actually required in the dyeing process. It was demonstrated that in excess of 60-70% of the energy consumed is going down the drain or up the exhaust stacks. The Georgia Tech team presented some programs suggesting operational procedures in the dye house that should be able to reduce the current energy consumption by 50%. This program has reached the state of being approved by both the production manager and the engineering manager. During February of 1977 the company is initiating modifications to one full size dye beck, in which they will attempt to make major changes in the energy consumption pattern.

A heat exchanger that was installed for recovering heat from the spent dye liquor had no instrumentation to determine whether it was performing satisfactorily. The manufacturer's statement on the heat exchanger indicated that it was sized to operate at a U value of 360. Plant personnel made measurements of flow and temperature in the streams going through the machine to determine the amount of heat recovered. Initial U values ranged from 16-18, indicating roughly 1/20 of the specified performance was being obtained. The exchanger was taken out of service and cleaned with inhibited hydrochloric acid. Initial U values of 170 were measured but fouling rapidly reduced the heat transfer efficiency, reducing the U value to 100-120. Cleaning thus improved the performance, but fouling will continue to be a problem.
Figure 1. Process diagram of a fully integrated carpet mill.
Recommendations

Dye Beck Exhaust Reduction

A common method of dyeing carpet is the use of the atmospheric dye beck. The dye beck by necessity exhausts steam to the atmosphere. Approximately 50% to 60% of the steam used in dyeing is exhausted through the roof. This loss can be reduced by dampering the exhaust fan and opening the damper to the point where steam is no longer entering the room. We believe that at least 50% of the exhaust steam can be eliminated by dampers which would save 25% of the steam used in dyeing. At this plant the following evaluation was made:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam for dyeing</td>
<td>60,000 lb/hr.</td>
</tr>
<tr>
<td>Exhaust</td>
<td>30,000 lb/hr.</td>
</tr>
<tr>
<td>Exhaust Savings</td>
<td>15,000 lb/hr.</td>
</tr>
</tbody>
</table>

$30 per hr.
$210,000 per yr.

This system needs to be coupled with the proper steam controls to the dye beck. The accomplishment of exhaust reduction may be obtained by one or more of the following methods:

- Stack dampers
- Fan modifications
- Sparge modifications
- Dye beck doors
- Steam controls
Spent Dye Liquor Heat Recovery

One of the largest requirements for thermal energy in the textile industry is the boiling of the dye liquor during the drying process. Since the liquid should be at 210°F for dyeing and a considerable amount of water is used, the costs are high. These energy requirements can be reduced if the heat in the spent dye liquor can be reclaimed.

Although standard heat exchangers are generally used for this service, their performance in dye liquor has proven poor since coefficient of heat transfer values range from 20 to 100 BTU/hr°F ft°. There are systems used in other industries that can be used to reclaim this heat. One such system would be flash evaporation. This would eliminate the fouling problem present with heat exchangers.

The following evaluation was made on your dyeing operation:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dye Liquor Quantity</td>
<td>350,000 gal/day</td>
</tr>
<tr>
<td>Dump Temperature</td>
<td>190°F</td>
</tr>
<tr>
<td>Available Heat</td>
<td>80 BTU/lb</td>
</tr>
<tr>
<td></td>
<td>233 M BTU/day</td>
</tr>
<tr>
<td>Savings</td>
<td>$120,000 per yr.</td>
</tr>
<tr>
<td>Cost</td>
<td>$100,000</td>
</tr>
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</table>
Boiler Stack Gas Heat Recovery

Considerable savings can be realized by preheating the boiler make-up before it is admitted to the deaerator as shown in the attached graph. This can be accomplished with a heat exchanger in the boiler stack as shown below.

Boilers number 2 and 3 connected to a common stack.

<table>
<thead>
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<th>Boilers number 2 and 3 connected to a common stack.</th>
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<tr>
<td>Combined capacity of boilers</td>
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<tr>
<td>Make-up percentage</td>
</tr>
<tr>
<td>Approximate deaerator inlet water temperature</td>
</tr>
<tr>
<td>Deaerator outlet temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack gas</td>
<td>485°F</td>
</tr>
<tr>
<td>Make-up</td>
<td>60°F</td>
</tr>
</tbody>
</table>

-12-
Assumptions

Fuel--30% #6 oil, 70% gas

Average cost of fuel--$1.71/mm Btu.

Operation--7,000 hr./yr.

Average Load--62,000 lb./yr.

Approximate Cost of Heat Recovery System $45,000
Annual Fuel Savings $67,000
After tax savings $35,000
After tax payback period 15 months
Enthalpy of water at 215° water = 183.2 Btu/lb.

Enthalpy of saturated steam at 125 psi = 1191.6 Btu/lb.

Enthalpy difference = 1008.4 Btu/lb.

Assuming a boiler efficiency of 80%

Heat input to the boiler = \frac{1008.4}{0.80} = 1260.5 \text{ Btu/lb. of steam}

Heating Value of Natural Gas

= 1000 \text{ Btu/cu.ft.}

Theoretical air requirements for combustion

= 10.0 \text{ cu.ft./cu.ft. of gas}

Assuming 20% excess air in combustion

Air requirements

= 12.0 \text{ cu.ft./cu.ft. of gas}

Fuel requirement/lb. of steam

= \frac{1260.6}{1000} \text{ Btu/lb. steam} \text{ cu.ft.}

= 1.2605 \text{ cu.ft./lb. of steam}

Hence air requirement

= 1.2605 \times 12 \text{ cu.ft./lb. of steam}

= 15.126 \text{ cu.ft./lb. of steam} \times 0.075 \text{ lbs./cu.ft.}

= 1.1345 \text{ lbs. air/lb. of steam}

If the exhaust temperature was 600°F and was reduced to 225°F in a heat exchanger

Energy Recoverable

= 1.1345 \text{ lbs. air/lb. steam} \times 0.2455 \text{ Btu/lb. air°F} \times 375°F

= 104.44 \text{ Btu/lb. of steam}
Actual Savings in energy assuming a boiler efficiency of 80% 

\[ = \frac{104.44}{0.8} = 130.55 \text{ Btu/lb. of steam} \]

For a 100,000 lbs. steam/hr boiler capacity

Energy Savings 

\[ = 13.055 \times 10^6 \text{ Btu/hr.} \]
Assumptions

1) Water enters boiler from deaerator at 215°F
2) Steam pressure 125 psi
3) Fuel combustion with 20% excess air
4) Boiler efficiency 80%
5) Exhaust air dropped to 225 in heat exchanger
6) Energy saved = Energy recoverable / Boiler efficiency
Savings from the Use of Available Preheated Air

Direct savings in fuel could be achieved by using available preheated air for combustion in the boiler. The attached graph shows the energy savings that could be achieved by using various quantities of air preheated by different amounts. In your plant, large volumes of hot air is available from the exhaust of the driers.

Technical Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Boiler capacity</td>
<td>86,000 lb./hr.</td>
</tr>
<tr>
<td>Average load</td>
<td>62,000 lb./hr.</td>
</tr>
<tr>
<td>Temperature of outside air</td>
<td>75°F</td>
</tr>
<tr>
<td>Temperature of drier exhaust air</td>
<td>250°F</td>
</tr>
<tr>
<td>Preheat available</td>
<td>175°F</td>
</tr>
<tr>
<td>Air requirement of boiler</td>
<td>15,630 cfm</td>
</tr>
</tbody>
</table>

Economic Calculations

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy savings</td>
<td>2.954 mm Btu/hr.</td>
</tr>
<tr>
<td>Annual energy savings (7000 hr./yr.)</td>
<td>20,678 mm Btu/yr.</td>
</tr>
<tr>
<td>Dollar savings @ $1.71/mm Btu</td>
<td>$35,360</td>
</tr>
<tr>
<td>Dollar savings after taxes</td>
<td>$18,390</td>
</tr>
<tr>
<td>Estimated cost of modification</td>
<td></td>
</tr>
<tr>
<td>(a) If present burners could be used</td>
<td>$9,000</td>
</tr>
<tr>
<td>(b) If new burners have to be installed</td>
<td>$21,000</td>
</tr>
<tr>
<td>Approximate payback period even in worst case</td>
<td>1 yr. 2 mos.</td>
</tr>
</tbody>
</table>

An added advantage of this system is that particulate matter in the drier air would be combusted and with tighter environmental restrictions this may be the best way to dispose of these particles.
Savins From the Use of Pre-Heated Air

Specific Heat of standard air = 0.24 Btu/lbm\(^\circ\)F

Density of standard air = 0.075 lbm/cu.ft.

Sample Calculation

Energy Saved by using 100,000 cfm of air preheated by 100°F

\[ \text{Energy Saved} = 100,000 \text{ cfm} \times 100 \text{°F} \times 0.24 \text{ Btu/lbm°F} \times 0.075 \text{ lbm/cu.ft.} \]

\[ = 180,000 \text{ Btu/min} = 10.8 \text{ MM Btu/hr.} \]
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.2

Description

This Company custom-dyes carpet for Georgia manufacturers in its 130,000 square foot facility. There are 105 employees at the plant. With an annual sales volume of about $4.8 million, energy costs for the year are as follows: electricity - $108,000; natural gas - $240,000; number 6 fuel oil - $100,000.

Analysis

The facilities, including building and equipment, were found to be adequately maintained. The combustion efficiencies of the number 1 and 2 boilers were checked on two different occasions and found satisfactory while burning fuel oil and natural gas. It was recommended that an automatic control system be installed on the office's heating and air conditioning system to save as much as 50 percent of the energy needed for heating and cooling the offices.

Since the energy loss of the 10 dye becks amounts to about 35 to 50 percent of the energy required to operate the becks, it was recommended that the company investigate the feasibility of modifying the becks and installing heat recovery systems on the boilers.
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.3

Description

This company manufactures area, bath, and scatter rugs in its 105,000 square foot facility for a national and international market. There are 130 employees at the plant. Energy costs for 1975 were as follows: electricity - $47,926; natural gas - $94,392.

Analysis

Based on a survey of the plant, the following analyses and/or recommendations were made:

1. Recommended that accounting procedures be established for each of the energy sources and the procedures should include accounting for unit quantities as well as dollar costs.

2. Recommended that a timer with a manually timed override switch be installed on the office's heating and air conditioning system to reduce thermostat settings at night and on the weekends to save up to 50 percent of the energy used in the offices.

3. Since large volumes of warm air inside the building were escaping through large summer vents and exhaust fans during the winter months, it was recommended that these openings be closed and better sealed during cold weather.

4. Recommended that a CO₂ flue gas analyzer be purchased to check the boiler's combustion efficiency once a week to assure its operating at peak performance. The boiler was measured at 74.6 percent efficient and found to be exhausting $100 a day in unburned fuel. It was costing the company an additional $.30 per 1,000 pounds of generated steam. They have since corrected this problem.
5. Recommended that insulation be replaced where missing on the steam mains.

6. There were two air compressors operating at the same time. It was recommended that the mechanical hook-up be investigated, and if one compressor could handle the load, the second compressor should be shut off or the pressure settings changed on the supply tanks. The electrical operating cost of both compressors cycling simultaneously is more than one compressor operating for longer periods.

7. Recommended that an evaluation of the proper location of the space heaters be performed. Several heaters were found to be heating unoccupied areas of the plant while employees were working in other areas with no heat.

8. Plant lighting levels were found to be adequate and measured 15 footcandles.
Description

This company dyes carpet for northwest Georgia manufacturers in its 40,000 square foot facility. Forty-eight employees work at the plant. With an annual sales volume of about $1,300,000, energy usage and costs for the year are as follows: electricity - 2,025,000 KWH - $49,000; natural gas - 6,700,000 CF - $65,200; fuel oil - 565,000 gallons - $121,000.

Analysis

A summary of the major analyses and/or recommendations made as a result of a survey is as follows:

1. Recommended that accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.

2. Recommend that a timer with a manually, timed override switch be installed on the office's heating and air conditioning system to decrease the energy consumption of the offices by as much as 50 percent.

3. Lighting levels in the manufacturing areas were found to be adequate and measured 20+ 10 footcandles. It was found that the office and hall light levels were as high as 200 footcandles. It was recommended that they purchase a light meter and reduce the levels in all areas except in the laboratory to a maximum of 50 footcandles.
4. The combustion efficiency of the natural gas or fuel oil fired boiler was measured at 81.9 percent while operating on gas. That is adequate, because it should be maintained at a minimum of 80 percent. It was recommended that a CO₂ flue gas analyzer be purchased to check the boiler's efficiency once a week to assure it is operating at peak performance.

5. Recommended that insulation missing on the steam lines be replaced including the immediate repair of broken control valves.

6. Recommended that the side walls of the 12 dye becks be insulated.

7. Holes through the walls of the building and around dock doors should be repaired, because large amounts of cold air were entering into the building. Air curtains or individually controlled heaters over the dock doors were needed to minimize the heat exchange loss from the building.

8. Ways to decrease the energy consumption on the wet goods dryer were recommended. Such as, replacing missing insulation and decreasing exhaust fans.
Description

This company makes flocked bedspreads and drapes for its international market in its 274,000 square foot facility. Five hundred persons are employed at the plant. With an annual sales volume of about $12,000,000, energy costs for the year are as follows: electricity - $85,000; natural gas - $85,000; fuel oil - $6,500.

Analysis

As a result of a survey of the company, analyses and recommendations were as follows:

1. Plant was well maintained from an energy point of view.
   a. Additional insulation had been added to ceiling.
   b. Installed air curtains over doorways.
   c. Installed automatic control system for manufacturing area's HVAC system.
   d. Installed heat recovery system for dye waters.

2. Recommended that accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.

3. Recommended that a timer with a manually timed override switch be installed on the office's heating and air conditioning system to decrease the energy consumption of these offices by as much as 50 percent.

4. Lighting levels in the manufacturing plant were found to be adequate and measured 20-10 footcandles. Office and hall light levels
were measured as high as 200 footcandles. It was recommended to purchase a light meter and reduce these levels to a maximum of 50 footcandles in the offices.

5. Recommended closing and sealing off of nonfunctional vent pipes in the building.

6. Boilers were found to be operating efficiently.
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.6

Description

This company dyes yarn for northwest Georgia manufacturers in its 25,000 square foot facility. Seventy persons are employed at the plant. Annual energy costs are as follows: electricity - $43,200; natural gas - $71,518; Number 2 fuel oil - $200,000 (based on three-month average).

Analysis

As a result of a survey of the company, analyses and recommendations were as follows:

1. Recommended that accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.

2. Recommended that all roof areas be insulated with the equivalent of 6 inches of glass-fiber batt insulation, whenever possible.

3. Recommended that a timer with a manually, timed override switch be installed on the office's heating and air conditioning system to decrease the energy consumption of these offices by as much as 50 percent.

4. Lighting levels in the manufacturing plant were found to be adequate. They measured an average 15 footcandles.

5. The combustion efficiency of the natural gas-fuel oil fired boiler was measured at 78.5 percent while operating on natural gas. It costs an additional $1.96 per hour in fuel costs to operate the boiler at the low efficiency.
Recommended that a CO\textsubscript{2} flue gas analyzer be purchased and be used by the boiler maintenance personnel to check the boiler's efficiency once a week to assure it is operating at peak performance.

6. Recommended that the side walls of the five dye becks be insulated.

7. Recommended that company investigate the feasibility of installing a heat recovery system for the dye water to recover heat from the hot wastewater.
Description

This company makes knit cloth and men's and boys' knit underwear in its 258,000 square foot facility for its national market. It has approximate annual energy usage as follows: electricity - 5,472,244 KWH; natural gas - 54,818 therms; fuel oil - 90,298 gallons.

Analysis

The following verbal and/or written recommendations were made:

1. Operations be consolidated in as small an area as possible to decrease energy consumption of HVAC systems. Shut off air conditioning ducts to the knit material storage area so that the cooled air can be used in the cutting room.

2. Have electric utility company determine power factor and install power factor corrector equipment.

3. Insulate ceiling and roof to an equivalent of 6 inches.

4. Install doors or curtains to minimize hot air flowing into cooled areas.

5. Cut off steam flow to those areas not needing steam during hot weather.

6. That the air conditioning systems be placed on timers with manual override timer switches.

7. Lighting could be reduced in the T shirt sewing room and in the packaging materials storage area. Every other row of fluorescent lights could be disconnected in the T shirt sewing room and the remaining row of lights be relocated directly above the conveyor belts between
each two rows of machines. The lint on the bulbs in the sewing 
rooms should be wiped off once per month. Also, the lighting level 
in the storage areas for packaging materials should be decreased. 
Taking these steps would eliminate 12.3 kilowatts of electrical con-
sumption each operating hour and also reduce the overloaded condition 
of the air conditioning system.
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.8

Description

This company makes bath sets, bathroom carpet, and scatter rugs for its international market. It has 125 employees. Based on an annual sales volume of about $3,000,000, energy usage and costs for the year are as follows:
electricity - 587,038 KWH - $24,277; natural gas - 20,549 cf - $17,106; Number 2 fuel oil - 13,591 gallons - $4,730; LPG - 95,615 gallons - $30,148.

Analysis

As a result of a survey of the plant, it was estimated that an energy savings of 25 to 30 percent could be achieved if recommendations were implemented as follows:

1. That accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.
2. Serious consideration should be given to acceptance of any firm gas offers.
3. All roof areas be insulated with the equivalent of 6 inches of glass-fiber batt insulation.
4. All steam leaks should be repaired.
5. Where insulation is missing on the steam mains, it should be replaced.
6. Reduce thermostat settings at night and on the weekend.
7. Install doors or curtains to close off unheated storage areas and loss from around dock doors.
8. Move thermostats from 8 to 10 foot levels to lower levels which would permit easy adjustment.
Description

This company makes carpet in its 237,000 square foot facility for a national market. It has 350 employees. Based on an annual sales volume of about $41 million, energy costs for the year are as follows: electricity - $216,000; coal - 15,000 tons - $555,000.

Analysis

As a result of a survey of the plant, recommendations were as follows:

1. Lighting levels in the manufacturing areas were found to be adequate and measured an average of 15 footcandles.

2. Recommended that accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.

3. Recommended all roof areas be insulated with the equivalent of 6 inches of glass-fiber batt insulation.

4. Recommended that a timer with a manually, timed override switch be installed on the office's heating and air conditioning system to decrease the energy consumption by as much as 50 percent.

5. Recommended that a CO$_2$ flue gas analyzer be purchased to be used to check the boiler's efficiency once a week to assure it is operating at peak performance.

6. Recommended that missing insulation on steam mains be replaced.

7. Recommended that the feasibility of installing a dye water heat recovery system to improve efficiency of becks be determined and to consider insulating the side walls of the dye vats.
Description

This company makes artificial grass carpet for its national market in its 166,000 square foot plant. It has 40 employees. Based on an annual sales volume of about $12,000,000, approximate energy costs for the year are as follows: gas and electricity - $96,000.

Analysis

The following recommendations were made:

1. Seal off the existing openings and holes in the exterior areas of the plant to decrease heat losses and to minimize heating load on gas fired space heaters.

2. Relocate the space heaters that are around the perimeter of the building to areas where the heat is needed and have the air discharge directed towards these areas rather than parallel to the sides of the building.

3. Relocate the rows of lights that are directly under the skylights.

4. Close off drafts around doors and check on the feasibility of using air curtains over dock doors that are frequently used.

5. Lower the hoods on the infrared preheaters closer to the carpet and use the hot exhaust of one unit to preheat the makeup of the other.

6. Determine the feasibility of using the exhaust heat from the coater to help heat the plant.

7. Install a timer with a manual, timed override switch on the office's heating and cooling system to decrease the energy consumption in the offices by as much as 50 percent.
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.11

Description

This company dyes yarn for national manufacturers in its 43,000 square foot facility with 48 employees. Based on an annual sales volume of about $2,500,000, energy costs for the year are as follows: electricity - 879,320 KWH - $27,000; gas - 144,112 ccf - $9,000; fuel oil - 3,700 gallons - $1,394.

Analysis

It was estimated that energy savings of approximately 25 to 30 percent could be achieved if recommendations were implemented as follows:

1. Insulate the side walls of the dye vats. One suggestion is to consider foam glass covered with stainless steel.

2. That additional study be given to required humidity levels and to humidity level control. It would appear that the excess humidity in the dye area could be used in the main plant at times which would reduce the load on the steam boiler. It also appears that when humidifying in the summertime the air conditioner may be removing moisture from the air while moisture is reintroduced by the humidifier.

3. That a dye water heat recovery system be implemented.

4. That a study of load profile be made relative to the applicable electrical rate schedule.

5. An economizer air cycle on the air conditioning units could contribute to increased operating costs and might need modifying.

6. The air intake inlet pipe for the air compressor should be extended to take air supply from outside the boiler room to help it operate more efficiently.
7. Combustion air for the steam boiler should be taken directly from the outside rather than from inside the building so as to minimize varying air volumes consumed by the boiler adversely affecting combustion efficiency.

8. Accounting procedures should be established for each of the energy sources and the procedure should include accounting for unit quantities as well as dollar costs.

9. That a General Electric No. 214 Light Meter be purchased to properly adjust the lighting levels in the plant and to assist in decreasing the levels in the offices to an adequate 50 footcandles.
TEXTILE INDUSTRY

TECHNICAL ASSISTANCE CASE 1.12

Description

This company manufactures carpet for an international market in a 230,000 square foot facility. It has 250 employees. Based on an annual sales volume of about $30 million, energy costs for the year are as follows: electricity - $78,000; natural gas - $40,958; propane - $53,560.

Analysis

As a result of a survey of the plant, findings and recommendations were as follows:

1. Accounting procedures be established for each of the energy sources and that the procedures should include accounting for unit quantities as well as dollar costs.
2. All roof areas should be insulated the equivalent of 6 inches of glass-fiber batt wherever possible.
3. A timer with a manually-timed override switch be installed on the office's heating and air conditioning system to decrease the energy consumption of the offices by as much as 50 percent.
4. Reduce light levels in the hallways and the offices from a measured 175 footcandles to a maximum 50 to 20 footcandles. Lighting levels in the manufacturing plant were found to be adequate and measured an average 17 footcandles.
5. Purchase a CO₂ flue gas analyzer to be used to check the boiler's efficiency once a week to assure it is operating at peak performance. The boiler's combustion efficiency was measured at 83 percent.
6. The new steam lines from the boiler to the old steam lines needed insulating and would have less than a twelve-month payback.
Description

This is a textile operation that produces polyester and nylon carpet yarns and polypropylene carpet backing. They have 350 employees and operate a 3-shift work schedule. Their annual sales volume is approximately $10 million and they primarily serve the southeastern market with some export business. The firm's annual energy costs are: electricity - $200,000; natural gas - $20,000; fuel oil - $60,000.

Analysis

We conducted a plant tour and identified areas of potential energy savings. The firm was already engaged in energy conservation projects in many of these areas (returning condensate to boiler, electrical distribution improvements, heat recovery for boiler feedwater, and dryer exhaust heat recovery). We were requested specifically to investigate the potential energy savings related to an enthalpy control system for the plant's air conditioning system.

An engineering and economic analysis was conducted on enthalpy control. The results indicated a conservative savings estimate of $5,000 annually with an approximate $3,000 equipment installation cost. It was also recommended that the system's economizer be upgraded.
Introduction

This major group includes establishments engaged in the manufacturing and processing of foods and beverages for human consumption.

This group is divided into the following categories:

1) Meat Products
2) Dairy Products
3) Preserved Fruits & Vegetables
4) Gain Mill Products
5) Bakery Products
6) Sugar, Confectionary Products
7) Fats and Oils
8) Beverages
9) Miscellaneous Foods, Kindred Products

This industry employed more than 1.5 million persons in 1974 and the value added was approximately $44.9 billion with a sales volume of $1.62 billion placing this industry among the top five in the United States in all three categories. In Georgia the food and kindred products industry employs more than 47,000 persons who contribute to a value added of more than $1 billion and a sales volume of more than $3.5 billion.

In 1974, this industry consumed about 7.1% of the energy used by all manufacturing industries. This energy consumed was equal to $9.56 \times 10^5$ billion Btu's.

In Georgia, the Food and Kindred Products Industry used about 6.7% of all energy consumed in 1974. Of this total, electricity accounted for 20.3%, Coal 0.04%, Fuel Oil 8.2%, Natural Gas 55.9%, and other fuels 15.6%. From those figures it can be seen that the industry is heavily dependent upon natural gas and would be drastically affected by anything reducing the supply of natural gas.
The food and kindred product industry is a significant contributor to the Georgia economy. The main products produced are livestock, poultry, vegetable, fruits and nuts. The largest segment of the above is the poultry industry. Georgia leads all other states in income from poultry and poultry products and is recognized as the Poultry Capital of the world. Georgia is second in broiler and egg production (outranking all other states except California for eggs and Arkansas for broiler production). The Georgia poultry industry is now producing and processing approximately 4-1/2 million pounds of chicken and more than 1 million dozen eggs each day. Due to this important role and the large energy consumed the project staff concentrated on the poultry processing plants.

**Discussion**

As mentioned above the project staff concentrated their activity on poultry processing plants. Four case studies were done in poultry processing plants and one in a vegetable processing plant. As in most other plants visited in-house engineering capability was very limited. In the past, energy has been of the order of 2-3% of the cost of processing which provided little incentive for energy conservation. With the supply of natural gas dwindling at an alarming rate and with heavy curtailments the plant executives have started seeing the need for conservation. Even though it is a small fraction of the processing cost it still is a sizable quantity in the state of Georgia which amounted to 1.3 trillion Btu's in 1974.

There are a number of areas in which energy conservation is possible. The major energy consuming processes are the scalder, the chiller, the boiler and refrigeration system. The scalder wastes large amounts of heat due to the USDA requirement of an overflow of 1/2 quart of the 130°F water of the scalder tank per bird. This water has traditionally been dumped down the drain. There
exists a possibility of recovering heat from this overflow water to preheat makeup water. It would also reduce the steam necessary to heat the tanks. The chiller also has a similar possibility of prechilling the makeup water there by reducing the refrigeration or ice load required. A typical example of the need for coordinated research in energy conservation can be found in this industry. The refrigerating units reject large quantities of heat to the atmosphere at the condensors. This heat could be used to heat boiler makeup water or scalder makeup water and reduce energy consumption.
Description

The plant markets ready-to-cook broilers, primarily in the southeastern region. The plant processes approximately 80 thousand birds per day operating on an 8-hour shift, 5 days per week. Employment ranges from 250 to 300 people. Sales volume is approximately $20 million, of which $250,000 constitutes energy expenditure.

Selection of Company

Previous mechanical equipment design work at Georgia Tech had been done at this plant. Future energy projects were discussed at that time and the management seemed particularly interested in participating in a project with Georgia Tech.

The plant, one of the largest in the State of Georgia, is ranked quite large on a nation-wide scale. Because its process production is typical for the industry, recommended modifications could easily be transferred to other broiler processing plants.

Four plants in this industry were chosen as case studies for the project. Out of the four this particular plant was selected to be the base with an in-depth analysis to be performed. The results of this analysis were used as guidelines in analyzing the remaining three plants.

Initial Contact

In obtaining the approval of management and the cooperation of the plant manager, Georgia Tech personnel stressed their previous involvement in the poultry industry, and displaying an in-depth knowledge of the
industry and its processes. It was pointed out that their main function at the plant was to find ways to conserve energy rather than to learn about the industry.

In discussing the project and energy conservation with the plant personnel, they expressed a noncommittal feeling toward most of the ideas. They were willing to see what Georgia Tech's expertise could offer them but, as expected, would not immediately commit themselves to the implementation of any of the suggestions. This type of attitude prevailed in those plants visited within the poultry industry.

Energy Inventory - fuel costs

The primary source of energy in the poultry processing plant is electricity. At this plant, electricity costs were $180,000 in 1975. The primary consumers of electricity were the ammonia refrigeration compressors (used for cold storage), blast freezing, and ice making. Secondary consumers were the motors used in conveying systems, ventilation systems, and pumps.

Natural gas and fuel oil—billed at approximately $50,000 a year (1975)—were used to fire steam boilers which provide steam for space heat and for maintaining temperature in hot water scalding tanks.

Energy Inventory - process description

The process consists of delivery by truck of live poultry, grown on numerous farms, to the processing plant where they are unloaded in coops at the hanging room. The coops are placed on a conveyor from which the employees remove the birds and hang them by their feet on an overhead conveyor. The overhead conveyor then moves them such that their heads go through an electrically charged water tank which stuns the birds and renders them unconscious. The birds now enter into the part of the processing
plant known as the picker room. They are moved into a killing mechanism which cuts their throats and moves them toward the scald tank. As the birds move to the scald tank (still on the overhead conveyor) they are bled.

Each bird stays in the scald tank (a hot water tank maintained at 127 to 130 degrees) approximately a minute and a half in order to facilitate picking their feathers. The feathers are picked off the birds and the remaining fine hair left on the skin is removed by moving the birds through an open flame. After completion of this step the birds are moved from the picking room into the processing room where their feet are severed and the birds are removed from the overhead conveyor. The portions of the birds remaining on the overhead conveyor are transported back to the hanging room where they are removed.

The birds in the processing room are rehung onto another conveyor called the eviscerating line. As the birds move down the eviscerating line the oil gland at the tail of each bird is automatically cut off. Next a vent cut is made in each bird and the cloaca is cut off. Each bird is then moved to a machine where the entire insides, known as the viscera, are drawn out and left attached to the bird. At this point, the bird passes through inspection performed by U.S.D.A. inspectors. If the bird is down-graded, it is moved to a separate process line where the acceptable pieces are removed, prepared and frozen. Those birds that are accepted pass on down the line where the giblets (gizzard, liver and neck) are removed from the viscera and separately processed. The giblets are put through a chill tank (an ice bath maintained at approximately 35 degrees) where they remain for 30 minutes. They are later packaged and stuffed into the outgoing birds.

The remaining viscera is cut loose from each bird and washed away to go through an offal tank. The offal tank transports the substance to a rendering plant where it is rendered down to be used as feed. The feathers
are also recycled in the rendering plant and rendered down as feed supplement.

The birds go through a final washing and are then dumped into a chilled water tank where the temperature of each bird is reduced to approximately 35° F. As the birds leave the chill tank they are again graded and the grade A birds are packaged whole and shipped out in iced boxes. The downgraded birds are cut up, packaged, and are taken to blast freezers where they are frozen. The complete process diagram is shown in Figure 2.

Plant Observations

On subsequent visits to the plant, data were collected during the operating hours and clean up periods, and plant personnel supplied additional data regarding current and historical energy usage. Interviews were also conducted with poultry processing equipment manufacturers and service representatives for major items of equipment in plant, i.e., boilers, ice makers, chillers and refrigeration units. This information was then evaluated to determine the most economically feasible energy conservation measures. In reviewing the data and from observations made in the plant it was determined that the two major energy consuming systems were the refrigeration units and the steam heating systems.

Refrigeration units - The primary refrigerant in the plant is ammonia with a number of small air conditioning units and the existing water chillers using Freon. The largest units are the icemaker and the cold storage unit with 425 compressor horsepower and 650 compressor horsepower respectively. Condensers in these two units are evaporative condensers which operate at a pressure of 186 psig and a compressor discharge temperature of approximately 280°F. The cold storage unit operates at a condenser pressure of 150 psig and
FIGURE 2. PROCESS DIAGRAM OF A POULTRY PROCESSING PLANT
a compressor discharge temperature of approximately 265°F. Normally, the icemaker operates continuously with a constant load. However, the load on the cold storage and freezer refrigeration unit varies, dependent on the product refrigeration requirements.

Steam heating systems - The scald tanks are maintained at approximately 128°-130°F by injection of live steam through a temperature regulated control valve. Steam is also used to heat high pressure water for plant cleanup operations, and for plant space heating.

Fuel usage data collected during plant operation and cleanup indicates that plant cleanup requires approximately 60% of the fuel burned in the boilers. Maintenance of the scald tank temperature requires approximately 37.5% of the fuel, and the remaining 2.5% represents standby losses during the time between cessation of bird scalding and commencing clean up operations.

Upon establishing the nature and overall pattern of energy consumption in the processing plant, certain processes were rejected as possible areas for energy conservation. These included the overhead conveying system and numerous other processes which employ fractional horsepower electric motors. While this equipment could be addressed with respect to motor replacement with more efficient motors and better control systems, the economics are not attractive. Energy consumption of process equipment with relatively small electric motors should be considered when evaluating replacement equipment. An example of this at this particular plant was the purchase of a number of new feather picking machines. The replacement machines required only 1/3 the horsepower of the old picking machines.
The following recommendations were communicated to the management of the plant.

A. **System Modifications:**

1) **Insulation:** Insulation in high and low temperature applications is standard practice in industry, and the current and projected high cost of fuel and electric power makes insulation an investment which will pay for itself many times over. At the plant, insulation of bare steam lines and the chill tanks would yield a payback period of less than a year.

2) **Heat Recovery:** Rising fuel costs have mandated an evaluation of systems for recovering process heat which have not proved to be reasonable investments in the past when energy was relatively inexpensive. Broiler processing plants are particularly adaptable to heat recovery, due to the requirements for large quantities of relatively low grade hot water in the scalding operation.

   Areas for consideration of heat recovery include the following:

   a. Recovery of heat of condensation from refrigeration units - for every ton (12000 BTU/hr) of refrigeration effect, approximately 1.25 tons (15000 BTU/hr) of heat must be rejected from the refrigerant in the condenser. Typical large ammonia refrigeration units, such as the icemaker and cold storage refrigeration units, employ evaporative condensers to reject this heat to the atmosphere. Thus, in addition to throwing away the heat of condensation, electric power must be consumed to reject the heat. Recovery of a portion of this heat to heat water would represent a reduction in the steam required from the boilers, as well as a reduction in electric power cost for evaporative condenser operation.

   b. Recovery of waste water, heat and refrigeration - the USDA requirements of minimum overflows from the scald tanks and chillers constitutes
wasted energy, if these overflows are simply discharged to the plant drainage systems. The largest cost for energy to maintain desired temperatures in the scald tanks and chillers is the cost to heat makeup water to the scald tank, and to chill makeup water to the chillers. A "regenerator" system can be used to recover a substantial portion of the heat from the scald tank overflow and the refrigeration from the chiller overflow. However, due to the water quality (grease, suspended solids, etc.) of the overflows, regenerator systems have been costly and hard to justify in the past. But today's higher fuel and electric costs have reduced the payback for regenerator systems to under three years.

c. Recovery of refrigeration compressor heat - the plant uses over 800 horsepower in water cooled refrigeration compressors. The cooling water from the compressor water jackets may be reused as a source of hot water, provided the water is certified as potable. If the potability of the water is questionable, a heat exchanger could be employed to transfer heat from the compressor cooling water to scald tank makeup water.

3) Lighting System: Lighting systems can represent a source of energy savings in most cases, due to the fact that past designs of lighting systems have been based on relatively low energy cost. In the plant, the lighting system in the processing area consumes approximately 25 kilowatts of power, and approximately 13,200 kilowatt-hours of energy every month, if the lights are left on for 24 hours every working day. If lighting levels were reduced during cleanup periods and lights switched off whenever possible, energy savings would be significant. These savings are available with essentially no capital investment, so that the payback in decreased energy costs would be realized immediately.
4) Equipment Control Systems: Operation of broiler processing equipment is often dependent on automatic controls. Thus, these control systems determine the efficiency at which the equipment operates. Energy conservation with such equipment operation is possible through installation of several control systems.

a. Temperature regulation on high pressure pumps - the high pressure hot water used for cleanup of the plant is steam heated. Water at the suction of the high pressure pump is heated by steam in a shell and tube heat exchanger, with steam from the heat exchanger condensed in a steam trap, from which condensate is mixed with the hot water or returned to the boiler. At present, steam flow to the heat exchanger is constant. If the steam were regulated to control the temperature of the hot water, fuel cost for firing the boiler could be decreased.

b. Metering ice flow into chillers - the USDA will allow credit for ice added to the chillers to be applied to the amount of chill water added to result in a 2 quart/bird overflow. Common practice in processing plants is to meter the makeup chill water but not the ice added. For example, if 40 tons/day of ice is used for maintaining chiller temperature, weighing the ice on a metered basis could reduce chill water requirements by 9,500 gallons/day. This would represent more than 20% of the total chill water requirements at a processing rate of 10,500 birds/hour. Thus, the energy cost required to chill 9,500 gallons/day would be saved, in addition to water cost and treatment cost of the water conserved.

B. Operations:

A major factor in realizing energy savings is accurate control of equipment operations, to maintain the maximum possible efficiency.

a. Boiler operation - the maximum efficiency which is guaranteed by package boiler manufacturers is typically 80%. Thus, at least 20% of the heat
value of the fuel firing the boiler is lost up the stack. A number of factors in boiler operation can further decrease the efficiency, including excess combustion air, erratic fuel control, and deterioration of boiler internal components. Each operating boiler should be checked daily with respect to combustion efficiency. This is a relatively simple test and the fuel savings realized will more than pay for the man hours expended in the test procedure. When firing only one boiler, the idle boilers should be isolated by closing valves to conserve steam. Steam heating systems should be isolated by positive shut off line valves, when steam is not required. This will prevent steam loss through leaking control valves, heating coils, etc. Finally, condensate return lines to the boilers should be routed such that any operating boiler can receive the returned condensate.

b. Peak demand control - although control of peak electric demand will not result in any energy savings, the net effect will be a reduction in energy costs due to the nature of the electric demand billing. Control of peak demand can be implemented through elimination or reduction of electric load during a period when electric load is high throughout the plant. For example, during process operation in summer months, when load on the refrigeration units is maximum, nonessential electric loads may be reduced or eliminated to limit the peak kilowatt load. Peak load control requires constant monitoring of electric demand and rapid switching of loads to be reduced. Packaged peak control units are available which will monitor electric demand and automatically reduce loads when the demand approaches a predetermined peak value. However, these units are expensive and cost savings are difficult to evaluate.

c. Cleanup operations - cleanup operations in processing plants have been addressed from the standpoint of water conservation. Due to the fact that much of the water used is heated with steam, conserving water will also
result in reduced fuel cost. Wherever possible, cold water should be used for cleanup operation.

DEMONSTRATION PROGRAMS

In order to demonstrate the cost effectiveness of energy conservation in the poultry processing industry, certain installations of equipment and/or insulation will be made in processing plants. These installations will be examples of some of the above energy conservation measures. These installations will be monitored and the data compiled will be evaluated to determine return on investment for the installed equipment. The demonstration programs proposed and the attendant economic justification, based on installation of the plant, are as follows:

I. Insulation of Bare Steam Pipe

Bare pipe to be insulated:

- 2" pipe - 300 lin feet = 157 ft\(^2\)
- 2 1/2" pipe - 75 lin ft = 49 ft\(^2\)
- 3" pipe - 350 lin feet = 275 ft\(^2\)
- 4" pipe - 150 lin feet = 157 ft\(^2\)

TOTAL 638 ft\(^2\)

Insulation cost: Cost included 1-inch thick fiberglass pipe insulation and aluminum jacketing around insulation.

<table>
<thead>
<tr>
<th>Insulation $/ft.</th>
<th>Jacketing $/ft.</th>
<th>Total Material Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; pipe</td>
<td>$0.80</td>
<td>$0.46</td>
</tr>
<tr>
<td>2 1/2&quot; pipe</td>
<td>$0.90</td>
<td>$0.57</td>
</tr>
<tr>
<td>3&quot; pipe</td>
<td>$0.99</td>
<td>$0.64</td>
</tr>
<tr>
<td>4&quot; pipe</td>
<td>$1.29</td>
<td>$0.90</td>
</tr>
</tbody>
</table>

(Does not include labor to install) TOTAL $1388
STRAIG PIPE INSULATION

---

TEMP. AMBIENT = 80°F

1" Fiberglass Insulation

Q=608 BTU/hr. FOR EVERY FOOT OF UNINSULATED 3" STEAM PIPE

Q= 73 BTU/hr. FOR EVERY FOOT OF UNINSULATED 3" STEAM PIPE

COST OF INSULATION (3" PIPE)

ALUMINUM JACKETING $0.99/ft.

$0.50/ft.

TOTAL $1.49/ft. + INSTALLATION COST

ANNUAL FUEL SAVINGS -- (608-73)BTU/hr. X 242 WORKING DAYS = 3.1 \times 10^6 BTU/yr/ft

(3.1MBTU) ($1.50/MBTU) = $4.65/yr/ft
Energy savings: Assume boiler is fired on natural gas with a cost of $.12/therm with an efficiency of 75%.

Energy Cost - $\frac{.12}{0.75} / \text{therm} = $ .16/100,000 \text{ BTU}

Heat loss through bare pipe - 387,904 \text{ BTU/hr.}

Heat loss through insulated pipe 46,574 \text{ BTU/hr.}

Energy Saved 341,330 \text{ BTU/hr.}

Annual Savings:

(341,330 \text{ BTU/hr.}) ($0.16/100,000 \text{ BTU}) (24 \text{ hr/day}) (242 \text{ days/yr.}) = $ 3172/yr.

Payback period: $ 1388 = 0.44 \text{ yr.} - \text{Approx. 5 1/4 months.}

$ 3172

II. Insulation of Chillers

Surface area of chillers to be insulated is approximately 800 \text{ ft}^2

Insulation Cost:

1-inch thick "Armaflex" insulation - $ 1.35/\text{ft}^2

Adhesive - .05/\text{ft}^2

Protection insulation jacket - 1.50/\text{ft}^2

TOTAL $ 2.90/\text{ft}^2

Insulation cost:

(2.90/\text{ft}^2) (800 \text{ ft}^2) = $2320 (Does not include labor to install)

Uninsulated chiller heat gain: 111 \text{ BTU/ft}^2\text{-hr.}

Insulated chiller heat gain: 94 \text{ BTU/ft}^2\text{-hr.}

101.6 \text{ BTU/ft}^2\text{-hr.}

Annual savings - Assume ice must be added to maintain chiller temperature.

(101.6 \text{ BTU/hr-ft}^2) (800 \text{ ft}^2) \div (288,000 \text{ BTU/ton ice}) = 0.282 \text{ tons/hr.}

($ 4/\text{ton ice}) (0.282 \text{ tons/hour}) (815 \text{ hr, shift}) (242 \text{ working days/yr.}) = $2320/\text{hr.}

saved.

Return on investment: $\frac{2320}{2320} = \text{1 year.}
CHILL TANK INSULATION

Q\text{IN} = 111 \text{ BTU/ft}^2\text{-hr.}

Temp. Ambient = 70^\circ\text{F}

Ice & Water
@ 33^\circ\text{F}

Q\text{IN} = 9.4 \text{ BTU/ft}^2\text{-hr.}

Temp. Ambient = 70^\circ\text{F}

1" THICK
ARMAFLEX
INSULATION

COST OF INSULATION = $1.35/\text{ft}^2$
ADHESIVE = $0.05/\text{ft}^2$
OUTER JACKETING = $1.50/\text{ft}^2$
TOTAL = $2.90/\text{ft}^2$

ENERGY SAVINGS - (111 - 9.4 BTU/\text{ft}^2\text{-hr.}) \times \text{Hr/Shift} \times 242 \text{ Working Days/yr} = 200,000 \text{ BTU/ft}^2\text{-yr}

\frac{(200,000 \text{ BTU/ft}^2\text{-yr.})}{(144 \text{ BTU/lb.})(2000\text{lb/ton})} = 0.69 \text{ Tons Ice/hr-ft}^2$

SAVINGS - (0.69 Ton Ice/yr-ft$^2$) ($4.00$/ton/ice) = $2.76$/yr-ft$^2$
Ammonia Compressor Heat Recovery

Assume the compressor cooling water required for the ammonia compressors to be approximately 0.075 gpm/ton refrigeration.

Assume 300 tons refrigeration on ice-maker.

Cooling water required = 22.5 gallons per minute

Heat recovery system cost:

Heat exchangers (2 shell tube heat exchangers in series) $1000
Piping 200
Valves 200

Total (does not include labor to install) $1400

Energy Savings:

Assume cooling water is cooled from 100°F to 80°F

\[(225,000 \text{ Btu/hr}) \times ($1,000,000 \text{ Btu}) \times (29 \text{ hr/day}) \times (242 \text{ workdays/yr}) = $2090/\text{year}\]

Return on investment = \$1,400 = 0.67 \text{ years} = 8 \text{ months}
\[
\frac{\$2090/\text{yr.}}{}
\]
AMMONIA COMPRESSOR HEAT RECOVERY

Jacket Cooling Water

Makeup Water 65 GPM @ 70°F

Cooling Water Return to Evaporative Condenser 30GPM @ 80°F

Cooling Water From Compressors 30GPM @ 100°F

Makeup Water 65 GPM @ 86°F

COST OF HEAT RECOVERY SYSTEM:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Exchangers</td>
<td>$1000</td>
</tr>
<tr>
<td>Piping</td>
<td>200</td>
</tr>
<tr>
<td>Valves</td>
<td>200</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$1400</td>
</tr>
</tbody>
</table>

ANNUAL SAVINGS = (225,000 BTU/hr) X 24 hr/day X 242 days/yr = 1.307 X 10⁹ BTU/yr.

(1.307 X 10⁹ BTU/yr) X $0.16/100,000 BTU = $2090/yr
Stage of Implementation

The following recommendations have already been implemented:

- Insulated 100 psig steam lines--cost of $3200--Measured resulting reduction of fuel consumption in boiler is 3%. Payback time is less than a year.

- Insulated chill water tank--cost $3000--Estimated payback of 1 year.

- Installed new water chilling system with 90,000 gallons storage tank to reduce ice requirements and reduce electrical peak demand.

- Installed plastic door strips to reduce heat flow from cold storage area.

- Implemented boiler maintenance program to maintain boiler efficiency.

The heat recovery system has not been implemented at this time but is being considered.
Description

The primary product of the plant is the ready-to-cook broilers which are marketed primarily in the Southeastern region. In addition to the broiler processing, the plant also includes a feed mill, broiler grow out house and a hatchery. Approximately 7,000 birds per hour are processed with the plant operating on a two shift, 5 days per week basis. The plant employs approximately 300 people, and sales volume exceeds $30 million per year.

Selection of Company

The selection of this plant resulted from a contact to Georgia Tech by the plant's general manager who served with Georgia Tech on a Poultry Advisory Committee. Georgia Tech was asked to review the plant processes and determine whether any help could be given to them on the topic of energy conservation.

Initial Contact

Experiences during the initial contact with the company are essentially identical to those of Case Study 2.1.

Energy Inventory - fuel costs

The primary source of energy in the plant is electricity. At this particular plant electricity costs of over $300,000 in 1975 were billed. The primary consumers of electricity were the ammonia refrigeration compressors used for cold storage, the blast freezing, and the ice making.
Secondary consumers were the motors used in conveying systems, ventilation systems and pumps, and the plant lighting. Figure 3 shows the flow of energy to the various processes.

Natural gas and fuel oil, which are billed at approximately $100,000 a year (1975), were used to fire steam boilers, which provide steam for maintaining temperature in hot water scalding tanks and steam for space heating.

**Energy Inventory - Process Description**

The process description for the company is very similar to the description for Case Study 2.1. The process diagram is found in Figure 2. The process consists of delivery of the live poultry, which have been grown on a number of farms, by truck to the processing plant where they are unloaded at the hanging room in coops. The coops are placed on a conveyor from which the employees remove the birds and hang them by their feet on an overhead conveyor. The overhead conveyor then moves them such that their heads go through an electrically charged water tank which stuns the birds and makes them unconscious. The birds now enter into the picker room. They are fed into a killing mechanism which cuts their throats and moves them toward the scald tank. As the birds move to the scald tank, they are bled.

Each bird stays in the scald tank approximately a minute and a half. The feathers are picked off and the remaining fine hair left on the skin is removed by singeing with an open flame. After completion of this step the birds are moved from the picking room into the processing room where their feet are severed and the birds are removed from the overhead conveyor. The remaining portion of each bird left on the overhead conveyor is transported back to the hanging room where it is removed.

The birds in the processing room are rehung onto the eviscerating line. As the birds move down the eviscerating line, the oil gland at the tail of
FIGURE 3

ENERGY FLOW DIAGRAM
POULTRY PROCESSING PLANT

-59-
the bird is automatically cut off. Next a vent cut is made in the bird and the cloaca is cut off. Each bird is then moved to a machine where the viscera are drawn out and left attached to the bird. At this point the bird passes through inspection performed by U.S.D.A. inspectors. If the bird is downgraded it is moved to a different process line where the acceptable pieces are removed, prepared and frozen. Those birds that are accepted pass on down the line where the giblets are removed from the viscera and they are separately maintained at approximately 35° where they remain for 30 minutes. They are later packaged and stuffed into the outgoing birds.

The remaining viscera is cut loose from the bird and washed away to go through an offal tank. The offal tank transports the substance to a rendering plant where it is rendered down to be used as feed. The feathers are also recycled in the rendering plant and rendered down as feed supplement.

The birds go through a final washing and are then dumped into a chilled water tank where the temperature of the bird is reduced to approximately 35° F. As the birds leave the chill tank they are again graded and the grade A birds are packaged whole and shipped out in iced boxes. The downgraded birds are cut up, packaged, and are taken to blast freezers where they are frozen.

Plant Observations

The survey made of this plant primarily addressed available energy savings which could be implemented without altering present process operations, but rather by modifying existing equipment to increase the energy utilization of the equipment. This approach would minimize capital expenditure and represents a logical first step in realizing energy savings. Further energy savings are available by replacing existing equipment with
new, more energy efficient equipment, i.e. replacing existing ice chillers with jacketed refrigerated chillers.

In visiting the plant, data were collected during the operating hours and clean up periods, and plant personnel supplied additional data regarding current and historical energy usage. Interviews were also conducted with poultry processing equipment manufacturers and service representatives for major items of equipment in plant. The information was then evaluated to determine the most economically feasible energy conservation measures. In reviewing the data and from observations made in the plant it was determined that the two major energy consuming systems were the refrigeration units and the steam heating systems.

Refrigeration units - The primary refrigerant in the plant is ammonia, with a number of small air conditioning units and the existing water chillers using Freon. The largest units are the icemaker and the cold storage units. Normally, the icemaker operates continuously with a constant load. However, the load on the cold storage and freezer refrigeration unit varies, dependent on the product refrigeration requirements.

Steam heating systems - The scald tanks are maintained at approximately 128°-130° F by injection of live steam through a temperature regulated control valve. Steam is also used to heat high pressure water for plant cleanup operations, and for plant space heating.

Fuel usage data collected during plant operation and cleanup indicates that plant cleanup requires approximately 60% of the fuel burned in the boilers. Maintenance of the scald tank temperature requires approximately 37.5% of the fuel, and the remaining 2.5% represents standby losses during the time between completion of bird scalding and commencing clean up operations.
Energy forms used in feed mill operation include electricity and fuel used to fire the boilers. Steam generated in the boilers is used for maintaining stored fat temperature, for heating and moisturizing feed to be pelletized and for space heating. Electricity is used for electric motors and for lighting.

Upon establishing the nature and overall pattern of energy consumption in the processing plant, certain processes were rejected as possible area for energy conservation. These included the overhead conveying system and numerous other processes which employ fractional horsepower electric motors. While this equipment could be addressed with respect to motor replacement with more efficient motors and better control systems, the economics are not attractive. Energy consumption of process equipment with relatively small electric motors should be considered when evaluating replacement equipment. An example of this at this particular plant was the purchase of a number of new feather picking machines. The replacement machines required only 1/3 the horsepower of the old picking machines.

Analysis

The steam generating and distribution system can be made more energy efficient by use of insulation and by maintaining the boilers in proper tune. Tuning the boilers for maximum combustion efficiency is a fairly simple procedure which should be performed daily. A combustion efficiency test on the feed mill boilers indicated one boiler operating at approximately 81%
efficiency and the other boiler operating at approximately 70% efficiency. The efficiency should be maintained at 80-85%. Lower efficiencies indicate excessive fuel losses up the stack, due either to too much combustion air or to deterioration of boiler internals.

Steam used to heat the fat tank is supplied at 100 psig and 338°F. To most efficiently utilize the steam as a heating medium, steam temperature should be maintained as high as possible. Bare steam pipes represent a significant heat loss and should, therefore, be insulated. Heat loss through the fat tank can also be reduced by additional insulation of the tank, although the payback period for insulating the fat tank would be considerably longer than of insulating bare steam pipes.

Hot steam condensate should be routed back to the boiler feedwater system and these lines should be insulated. Steam traps should be maintained in good condition to minimize the loss of steam.

Finally, the air which is used to cool the feed pellets is presently exhausted to the atmosphere and represents wasted heat. Recovery and use of this wasted heat would effectively reduce fuel requirements. The recovered heat could be used for space heating or heating boiler feedwater.

Hatchery

The principal source of energy used in hatchery operation is electricity, with steam being used for cleaning operations and for space heating. As in the feed mill, it is recommended that all steam lines and condensate return lines be insulated and that the insulation be maintained in good condition.

The areas in the hatchery comprising the egg storage area, the setter area and the hatcher area are all environmentally controlled. Therefore,
the walls and ceilings in these areas should be well insulated to minimize heat gain or loss. Ventilating fans in these areas should have louvered outlets to minimize conditioned air losses through the openings when ventilation is not required.

The fuel used for space heating could be reduced by utilizing heat recovered from the exhaust air from the hatchers and setters.

**Processing Plant**

The processing plant is by far the largest energy user in the complex. Electrical energy is used to power processing air conditioning equipment and for lighting. Fuel, either fuel oil or natural gas, is used to fire the boilers, to heat spaces and to heat water. Due to the complexity and variety of energy consuming processes in the processing plant, substantial energy savings are available by improving the energy utilization of individual processes and interrelating these processes to improve the overall energy utilization of the plant.

Scalding Operation: The scalding operation is generally the largest single consumer of fuel, because of the use of live steam for maintaining scald tank temperature. Heat losses from the scald tanks include loss of heat from the tank walls and water surface to the surrounding air space, loss of heat due to the required water overflow, and loss of heat involved in heating the birds. Only 10% or less of the heat added to the scalders in the form of steam is needed to heat the birds from an assumed incoming temperature of 105°F to 130°F at the exit of the scalder. Thus, approximately 90% of the steam added to the scalders is lost to the surrounding air space.
and down the drain with the overflow. Reduction of this heat loss will result in reduction of fuel costs. Possible methods of reducing the scalder heat loss are listed below.

1. Recovery of heat from scald tank overflow--The overflow from the scald tank is assumed to be 1 quart/bird as required by USDA. Unheated makeup water must be added to replace the overflow and the water lost with the bird. This makeup water must be heated to the desired temperature, and this requires over 50% of the total steam added to the scald tank. Preheating the makeup water would reduce the steam required in the scalding process. One method of preheating the makeup water would be to transfer the heat from the heated water overflow to the makeup water through use of a heat exchanger. A complete system for recovering the heat from the scald tank overflow to preheat the makeup water is currently available, and the system is claimed to recover 80% of the heat from the overflow. At a processing rate of 7000 birds/hour and a city water temperature of 65°F, this system will save energy at the rate of approximately 1,000,000 BTU/hours, which is equivalent to 7-14 gallons of fuel oil per hour.

2. Reducing heat flow from scald tank water surface--At present, warm water vapor escapes from the surface of the water in the scald tanks at a high rate, due to the agitation and mixing of the water and the forced air flow from the ventilating fans in the scald room. A great deal of heat and water are removed from the scald tank as a result. If a sheet metal cover were fabricated to enclose the water surface in the scald tank, the net effort would be one of creating a dead air space for insulation of the tank. In addition, water vapor escaping the water surface would condense on the
enclosure and run back into the scald tank. This cover would have to be easily removable for cleaning and inspection purposes. For this reason, an overhead hoist system might be used.

3. Insulating the scald room—Although complete insulation of the scald room walls and ceilings would not be recommended, due to the continuous ventilation of the room, the room should have only the air flow required for ventilation leaving the room. During the plant survey, it was noted that one wall opening from the scald room to the outside of the plant was not provided with doors. During a cold day, this opening accounts for a great deal of heat loss. All accessways to the scald room should have tight fitting doors or air curtains, and the doors should be closed as much of the time as possible.

4. Use of waste heat—A great deal of heat is presently wasted in the processing plant through refrigeration operation. The ammonia which is used in the plant refrigeration systems will reach a temperature of 250°F or higher at the discharge of the reciprocating compressors. This superheated gas must be cooled to a lower temperature (typically 85-90°F) and condensed. At present, this heated ammonia is cooled and condensed in the evaporative condenser by rejecting the heat to the atmosphere. This heat which is presently wasted to the atmosphere could be utilized to heat makeup water and reduce the amount of steam required to raise the makeup water temperature to the temperature in the scald tank. Recovery of the wasted heat would involve installing a shell and tube heat exchanger in the ammonia discharge line from the compressors. Water would flow through the tubes and be heated by the hot ammonia in the shell. When hot water was not needed, the evaporative condensor would continue to provide the cooling effect required.
Whole Bird and Giblet Chilling: The bird and giblet chillers in the processing plant can be made more energy efficient by insulating the walls of the chillers. Insulating the bird chillers would result in a savings of approximately 5 tons ice/day (2 shifts/day). Proportionate savings are available with the giblet chiller. Insulation of the chillers would involve a recommended 1-1/2 inches of polyurethane insulation with an aluminum or vinyl jacket installed over the insulation.

Another means of saving on ice and chilled water cost is to meter the ice added to the chillers and apply the amount of ice added towards the total chilled water required by USDA for chiller operation (2 quarts/bird).

Additional savings on cost of refrigeration could be realized by installing a recovery system on the chiller overflows and using this chilled water to cool makeup water to the water chiller. However, this system would be ineffective during times when city water is as cold or colder than the overflow from the chillers.

Electrical Load Control: Although control of peak electric demand will not actually conserve electric power, such control will result in reduced electric power costs due to the nature of the electric demand. Scheduling of large electric loads, such as the icemaker, for times other than peak load periods may be feasible. Control systems for monitoring peak electric demand and reducing plant loads at a predetermined demand value are available, but their applicability to processing plants has not been evaluated.

Lighting System: USDA requirements for illumination levels are 50 foot-candles for inspection stations and 30 foot-candles in all other working areas. Illumination readings taken in the plant during the survey showed
over 100 foot-candles at inspection stations and approximately 60 foot-candles at working stations. Thus, lighting levels could be significantly reduced while remaining within required illumination levels. Even if reduced lighting is not desired, lighting system power consumption could be reduced by turning off lights whenever possible, such as during clean up shift in areas already cleaned.

**Maintenance of Energy Consuming Systems**

A great deal of energy can be wasted due simply to neglect of various components of the systems in the complex which consume energy. Listed below are suggested maintenance measures for assuring peak energy efficiency.

**Steam System**

1. Boiler efficiency should be checked daily and combustion air adjusted to maintain peak boiler efficiency (80-85%).

2. Insulate all steam distribution piping and periodically inspect insulation, repairing where needed.

3. Periodically inspect all steam valves, coils, traps, etc. for steam leaks and repair when necessary. A leak 1/8 inch in diameter in a 100 psig steam line can represent a loss of $650/year with firing boilers on natural gas, and $1400/year firing on fuel oil.

**Electrical Systems**

1. Maintain ventilation rates at minimum required values to minimize loss of conditioned air. Make certain that all openings to conditioned spaces are closed whenever possible.

2. Maintain insulation on walls of refrigerated spaces, on refrigerant lines, on chilled water and glycol lines, and on ice storage and conveying equipment.
3. Make periodic amperage checks of large capacity electrical equipment to identify possible current leaks or equipment faults.

Stage of Implementation

The corporate offices for this particular plant are in the process of instituting a corporate-wide energy conservation program. When the program is complete and energy funding has been received the recommendations presented will be applied.
Description

This plant is part of a large corporation which operates seven poultry processing plants, three of them in Georgia. The plant operation formerly consisted of an older processing plant, but has been replaced by a new processing facility.

The plant processes 7000 birds per hour operating on two eight hour shifts, five days per week. A $31 million dollar sales volume is anticipated for the year. Because the plant has been operating only a few months, energy consumption data are not available.

Selection of Company

The selection of the facility was made in conjunction with previous work in energy conservation performed at another plant within the corporation. At the time of the initial contact a new processing facility was under construction, this plant would take over the operations of the old plant. The opportunity to provide engineering assistance with energy consuming systems being installed represented a unique case study.

Initial Contact

Georgia Tech personnel met with the lead design engineer on the new plant. Through this engineer, we were provided access to the plans and construction site of the new processing facility. The lead engineer and equipment service representatives provided pertinent information on all of the large energy consuming systems being installed in the new plant.
Energy Inventory - fuel costs

Although the plant has been in operation for only a few months, it is estimated that electrical energy consumption will be billed at approximately $300,000 a year. The electricity will be used primarily in the ammonia refrigeration compressors used for cold storage and ice making. Motors, conveying systems, ventilation systems and pumps, and plant lighting will also consume a portion of the electrical energy.

While natural gas is not used at this facility, it is estimated that approximately $140,000 of fuel oil per year will be used, mainly to fire the steam boilers.

Plant Observations

The initial and subsequent visits to the new facility provided an understanding of the design rationale for the various processing operations. This plant is much better engineered than other processing facilities visited. A number of energy considerations had already been instituted in the plant design. The new processing equipment, including feather pickers, automatic eviscerators, jacketed chillers, etc., was state-of-the-art with respect to energy efficiency. However, a number of operations, such as scalding, were performed in the same manner as in much older plants. For the most part, the equipment installed in the new plant was new and efficient, but the overall process was essentially the same as in other, older processing plants. (See Case Study 2.1 - Process Description.)

Recommendations and Implementations

It is difficult to recommend a major change in equipment or process in a facility in which the equipment was just purchased. For the most part,
engineering assistance for the plant was provided in the form of suggestions for add-on equipment, or possible modes of operation which would minimize energy costs. One unique aspect of the processing plant was the provision made for heat recovery in the design of the chill water and heated water systems. USDA requires that one quart of warm (130°F) water per bird be overflowed at the scalder to maintain sanitary conditions. Another USDA requirement calls for two quarts of cold water per bird overflowed at the chiller. Historically, these flows have been discharged directly to the plant drain system. At the facility, heat exchangers and collection tanks have been installed at the overflow points of the scalder and the chiller. Since water is being constantly overflowed from these tanks, makeup water must be constantly added. The counter-flow heat exchangers transfer heat to the makeup water in the scalder system, and transfer heat from the makeup water in the chiller system. As previously indicated, these heat exchangers were provided in the original new plant design. However, in order to evaluate the effectiveness of the heat exchangers, water flow meters and temperature indicators were purchased and installed to monitor system performance.

Stage of Implementation

The primary measures for energy conservation in this facility were the inclusion of heat recovery systems. These systems have been instrumented by project personnel and are being monitored for effectiveness in conserving energy. Other recommendations are under consideration by the corporate engineering staff at present, and continuing engineering assistance is being supplied to the plant personnel.
Description

This plant is part of a corporation which operates other processing plants in the state of Georgia, processing broilers. The plant operates two eight hour shifts, 5 days per week, processing 7000 birds per hour. They serve a regional market. With an annual sales volume of approximately $30 million, energy costs for the year are approximately $400,000.

Selection of Company

The selection of this plant resulted from a contact to Georgia Tech by the plant's general manager who served with Georgia Tech on a Poultry Advisory Committee. Georgia Tech was asked to review the plant's processes and determine if any help could be given to them in the area of energy conservation.

Initial Contact

Experiences during the initial contact paralleled those of other poultry operations. See Case Study 2.1 - Initial Contact.

Energy Inventory - fuel costs

The primary source of energy in processing plant is electricity. At this particular plant electricity costs of over $300,000 in 1975 were billed. The primary consumers of electricity were electric motors used in conveying systems, ventilation systems and pumps, and the plant lighting.

Fuel oil which was billed at approximately $100,000 a year (1975) was used to fire steam boilers, which provide steam for maintaining
temperature in hot water scalding tanks and steam for space heating.
(See Figure 3.)

**Energy Inventory - process description**

The process description is essentially identical to that of Case Study 2.1.

**Plant Observations**

In reviewing the data and from observations made in the processing plant, it was determined that the two major energy consuming systems were the refrigeration unit and the steam heating system.

Refrigeration units - The primary refrigerant in the plant is ammonia, with a number of small air conditioning units and the existing water chillers using Freon. The largest units are the icemaker and the cold storage unit. Normally, the icemaker operates continuously with a constant load. However, the load on the cold storage and freezer refrigeration unit varies, dependent on the product refrigeration requirements.

Steam heating systems - The scald tanks are maintained at approximately 128°-130° F by injection of live steam through a temperature regulated control valve. Steam is also used to heat high pressure water for plant cleanup operations and for plant space heating.

Fuel usage data collected during plant operation and cleanup indicates that plant cleanup requires approximately 60% of the fuel burned in the boilers. Maintenance of the scald tank temperature requires approximately 37.5% of the fuel, and the remaining 2.5% represents standby losses during the time between cessation of bird scalding and commencing clean up operations.
The energy forms utilized in the rendering plant are electricity to power equipment and fuel oil or natural gas to fire the plant boilers. The fuel used to fire the boilers represented the largest energy consumption in the plant and was, therefore, the target for potential energy savings.

Upon establishing the nature and overall pattern of energy consumption in the processing plant and rendering plant, certain processes were rejected as possible areas for energy conservation. These included the overhead conveying system and numerous other processes which employ fractional horsepower electric motors. While this equipment could be addressed with respect to motor replacement with more efficient motors and better control systems, the economics are not attractive. Energy consumption of process equipment with relatively small electric motors should be considered when evaluating replacement equipment. An example of this at this particular plant was the purchase of a number of new feather picking machines. The replacement machines required only 1/3 the horsepower of the old picking machines.

Recommendations

Recommendations as submitted to the company are shown in the following paragraphs.

Boiler and steam distribution system - The boiler is a critical element in efficient utilization of energy from fuel oil, due to the fact that the boiler efficiency is the largest single factor affecting the quantity of fuel oil used. For this reason, it is recommended that the boiler be maintained at maximum efficiency to give the most economical conversion of fuel oil to steam. The boilers in the poultry processing plant should be maintaining an overall efficiency of at least 80%. An analysis of the carbon dioxide content in the boiler fuel gas indicated
the two boilers were actually operating at 78% and 74% combustion efficiency. Thus, approximately 5% of the total fuel oil burned was lost up the stack because the boilers were not in good tune. The analysis of the fuel gas is a simple operation, taking no more than five minutes, which should be performed daily. A daily testing will indicate when the boiler needs attention and the manhours expended on this procedure will easily be paid back in reduced fuel costs. In addition to checking boiler combustion efficiency, regular preventive maintenance should be carried out on the boiler feed water system, blowdown system and chemical feed system.

Once steam has been generated as efficiently as possible in the boiler, transporting the steam to the point of use involves a system of steam pipes and valves. Since steam is used in the processing plant primarily as a source of heat, any heat loss in the steam piping system will represent additional boiler operating cost. For example, every foot of uninsulated 3-inch steam pipe carrying steam at 100 psig will represent a cost of approximately $12/year in lost energy if the boiler is operating at 80% efficiency, 24 hours/day, 250 days/year. If the same pipe were insulated with 1 1/2-inches of fiberglass insulation, the heat loss is reduced by approximately 93%, to save over $11/year per foot of 3-inch pipe. Insulation of presently uninsulated steam lines is an investment which will pay back in less than six months if fuel oil cost $0.35/gallon.

Additional energy savings are available by:

1) Regular inspection of steam pipes, valves and traps to detect and repair any steam leaks;

2) Returning all steam condensate which can be recovered to boiler feedwater system through insulated pipes;

3) Turning off all steam supply valves to systems not in use.
The economics of maintaining an efficient steam system cannot be over-emphasized. In addition to saving energy by reducing steam requirements, (steam presently costs over $3/1000 pounds), the life of the equipment will be increased.

Energy recovery systems - A number of processes in the processing plant result in the production of waste energy. These processes include the bird scalder, the evaporative condensers for the refrigeration units, and the whole bird and giblet chillers. Each process is presented below and the nature of the wasted energy is identified.

1) Scalder - Steam is used to maintain the scalder temperature. Energy is wasted in this process through hot water overflow and heat loss from water surface and tank walls to the surrounding air.

2) Evaporative condensers - In order to condense the hot ammonia gas from the refrigeration compressors, energy is used in the evaporative condensers to remove heat from the ammonia. This heat is wasted into the atmosphere.

3) Bird and giblet chillers - The water in the chillers is chilled through use of energy in the water chiller and the icemaker. The chiller overflows represent wasted energy if the chilled water flows directly to the drain system.

If the waste energy from these processes can be used at some other point in the plant, energy costs will be reduced. The following suggestions are measures for utilizing the waste energy.

Scalder operation: The bird scalder hot water overflow represents a loss of approximately 36% of the heat added to the scalder as steam, if 1 quart/bird is overflowed. The unheated makeup water to the scalder must be heated to the desired temperature by addition of steam. If the hot overflow was used to preheat the makeup water, steam requirements could be substantially reduced. Several heat recovery systems are commercially available, which will transfer heat from scalder overflow to makeup. At a processing rate of 7000 birds/hour and a makeup water temperature of 65°F,
a heat recovery system will save energy at the rate of approximately 1,000,000 BTU/hour, which is equivalent to 7-14 gallons of fuel oil per hour, depending on steam system efficiency.

Heat is also lost from the scalder water surface and tank walls. This heat loss can be reduced by insulation of the scalder walls and by constructing a suitable cover over the scalder water surface. If possible, a cover over the scalder would create an insulating dead air space above the water surface. In addition, a cover would reduce evaporation of water from the scalder by allowing water vapor to condense and run back into the scalder. A cover could be fabricated from sheet metal, with an overhead hoist arrangement to allow easy removal for cleaning and inspection.

Recovery of refrigeration condenser heat: The ammonia refrigeration units are a source of a great deal of wasted heat, since all the heat removed in the refrigeration process is given off at a higher temperature in the evaporative condenser. Ammonia temperature at the discharge of the reciprocating compressors is typically 250°F or higher. Energy is presently used for fans and pumps in the evaporative condenser to cool the ammonia to 85-90°F. This heat is recoverable and can be used to heat scalder makeup water or cleaning water by installing a shell and tube heat exchanger in the ammonia discharge line. When hot water is not needed, the evaporative condenser would continue to provide the cooling needed. This system would save energy by reducing steam requirements for the scalder and the high pressure pumps and by reducing the load on the evaporative condenser.

Whole bird and giblet chilling: The bird and giblet chillers in the processing plant can be made more energy efficient by insulating the walls of the chillers. Insulating the bird chillers would result in a savings of approximately 5 tons ice/day (2 shifts/day). Proportionate savings are available with the giblet chiller. Insulation of the chillers would involve
a recommended 1-1/2 inches of polyurethane or polystyrene insulation with a vinyl jacket installed over the insulation.

Another means of saving on ice and chilled water cost is to meter the ice added to the chillers and apply the amount of ice added towards the total chilled water required by USDA for chiller operation (2 quarts/bird).

Additional savings on cost of refrigeration could be realized by installing an energy recovery system on the chiller overflows and using this chilled water to cool makeup water to the water chiller. However, this system would be ineffective during times when city water is as cold or colder than the overflow from the chillers.

Refrigerated spaces - Refrigerated spaces should be well insulated and the insulation should be maintained in good condition. Doorways into refrigerated spaces should be equipped with air curtains which will be activated when the door is open. These air curtains will minimize the loss of refrigerated air and thus reduce refrigeration load.

Electrical demand control - Although control of peak electric demand will not actually conserve electric energy, such control will result in reduced electric energy costs due to the nature of the electric demand. Scheduling of large electric loads, such as the icemaker, for times other than peak load periods may be feasible. Control systems for monitoring peak electric demand and reducing plant loads at a predetermined demand value are available but their applicability to processing plants has not been evaluated.

Lighting system: USDA requirements for illumination levels are 50 foot-candles for inspection stations and 30 foot-candles in all other working areas. Illumination readings taken in a processing plant have indicated
over 100 foot-candles at inspection stations and approximately 60 foot-candles at working stations. Thus, lighting levels could be significantly reduced while remaining within required illumination levels. Even if reduced lighting is not considered desirable, lighting system power consumption could be reduced by turning off lights whenever possible, such as during clean up shift in areas already cleaned.

Maintenance of Energy Consuming Systems

A great deal of energy can be wasted due simply to neglect of various components of the systems in the processing plant which consume energy. Listed below are suggested maintenance measures for assuring peak energy efficiency.

Steam System

1. Boiler efficiency should be checked daily and combustion air intake adjusted to maintain peak boiler efficiency (80-85%).

2. Insulate all steam distribution piping and periodically inspect insulation, repairing where needed.

3. Periodically inspect all steam valves, coils, traps, etc. for steam leaks and repair when necessary. A leak 1/8 inch in diameter in a 100 psig steam line can represent a loss of $1400/year when firing on fuel oil.

Electrical Systems

1. Maintain ventilation rates at minimum required values to minimize loss of conditioned air. Make certain that all openings to conditioned spaces are closed whenever possible.

2. Maintain insulation on walls of refrigerated spaces, on refrigerant lines on chilled water lines, and on ice storage and conveying equipment.
3. Make periodic amperage checks of large capacity electrical equipment to identify possible current leaks or equipment faults.

Energy Conservation in Poultry Rendering Plant

Boiler efficiency - As stated in the section on the processing plant, the boiler has a controlling effect on the overall efficiency of the conversion of fuel energy to give the desired effect, i.e., cooking the offal. In other words, the overall efficiency of the (fuel steam cooked product) cycle must always be less than the boiler efficiency. Boiler efficiency is limited to a maximum value of approximately 80-85%, depending on the boiler. The remaining 20-15% of the energy released by burning fuel oil or natural gas is lost with the hot stack gases. Thus, a boiler operating at 75% efficiency is wasting 5-10% of the fuel up the boiler stack.

The boiler combustion efficiency is easily tested using an inexpensive carbon dioxide test kit. This testing should be carried out daily, in order to identify any change in boiler combustion efficiency. A drop in combustion efficiency can indicate that the boiler is "out of tune," meaning the fuel and combustion air are not entering the boiler in the most efficient proportions. The boiler can usually be tuned by adjustment of the intake air damper, unless there is a fault in the fuel system or in the boiler internals. Keeping the boiler tuned will have the obvious advantage of most efficient operation.

Steam system efficiency - Once steam has been produced in the boiler, minimizing losses in the steam distribution system will reduce the amount of steam required from the boiler. All steam piping should be insulated with at least 1-1/2 inches of insulation (fiberglass is inexpensive), and the insula-
tion should be maintained in good condition. All steam traps should be inspected and kept in good repair. Condensate return lines should also be insulated, as should the condensate holding tank. Steam flow to equipment which is not in use should be shut off with appropriate valves. Insulation around cookers and driers should be maintained in good repair. All insulation should have a jacket of vinyl or other material to protect insulation from moisture.

Heat recovery - A great deal of heat which originates in the boiler is presently lost with the waste water discharge from the hot wells. We recommend that a heat recovery system be installed that will transfer heat from the hot waste water to incoming river water which is used for boiler makeup and cleanup. The system would consist of a heat exchanger with hot water from the incoming river water. The heated river water could be stored in a tank or simply flow through the heat exchanger whenever hot water is needed.

An additional suggestion for heat recovery would be to replace the two existing cookers which presently do not return condensate to the boiler with equipment which would allow the return of condensate. An economic analysis of this suggestion should be made to determine the feasibility of equipment replacement.

Stage of Implementation

As of date the steam lines have been insulated and the boiler maintenance efficiency program has been adopted. Commitments have been made for this plant to participate in a federally funded research project concerning energy conservation. Remaining recommendations will be implemented at that time.
Description

The prime function of this facility is the preparation of frozen vegetables packaged for the retail trade. Their operation is seasonal, contingent upon the availability of the raw vegetables, and employment ranges from 800 to 1000 persons. Operating on a two-eight hour shift, five days per week basis, the company yields a sales volume of approximately thirty million dollars per year. Of this $30 million, an estimated $630,000 constitutes energy expenditures.

Company Selection

Criteria for selection of case study companies were formulated by the project staff and by the area office staff and included the following major categories:

1. Use of Energy Intensive Processes,
2. Size of Total Industry Segment (potential for transfer of methodology to other similar companies),
3. Management Interest,
4. Size of Company in Industry Segment,
5. Degree of Existing Sophistication in Energy Conservation,
6. Potential Impact of Energy Curtailment on Employment,
7. Potential Cost Savings to be Derived from Energy Conservation.

Using these criteria a master list of approximately 100 firms representing those that were potential case studies was compiled. Subsequently, several meetings involving project staff and area office representatives were held and the list of 100 firms was narrowed to the ten which had showed greatest promise as case study firms. Of these ten, this particular firm was chosen.
Initial Contact

The initial contract for this firm was established through their Director of Energy Conservation. This included a telephone interview during which the project goal and objectives were explained and the general company interest was ascertained. Judging by their response to our program, a definite interest was established.

Energy Inventory - Form

The primary fuels consumed at this plant were electricity and natural gas. Electricity, with a cost of $530,000 per year (1975), is primarily used in the refrigeration systems, conveyors, and lighting. Natural gas costs in 1975 were billed at approximately $100,000 and gas was used mainly to fire the boilers to produce steam for heating up the water. Oil is on standby for the same use, but 1975 data reveals that none was needed.

Energy Inventory - Process

In general, the three major types of vegetables processed here are peas, turnips, and greens. All are received directly from the fields via truck. Upon entering the plant the vegetables are moved through city water for their initial washing. In the case of turnips and greens, the vegetables are moved to a cutting area where they are cut up according to the desired size. In the case of peas and turnips, they are then moved to a large tank of 200°F water where they are mixed approximately 3 1/2 minutes. Greens, on the other hand, bypass this process and instead are blanched. The blanching process consists of the greens passing through a hooded area where live steam at 100 psi is introduced into the area. At this point all products are packaged, labeled and put into a deep freezer set at about -20°F for approximately 2 hours. Upon their removal from
the freezer they are stored in a large warehouse maintained at 0°F until shipment. See Figure 4.

Observations Made in Plant

A two-day trip was made to this facility. The first day consisted of talking to management, explaining the project and energy conservation in general. Their opinions and ideas concerning areas they felt needed attention were discussed. After this discussion a food technologist was assigned to give the plant tour. In looking at each process the foreman responsible for the area was also available for providing the details involved.

The second day was spent reviewing those processes identified the first day as having the most potential for energy conservation. In many cases measurements were taken in order to better analyze possible savings. The following areas were regarded as potential energy savings.

Steam is produced by gas and oil fired boilers at 80 psig. The prime use of this steam is for the blanching of vegetables. A calculation was made to determine the BTU required for blanching based on the specific heat of the product and the temperature rise. This number was compared with the gas consumption of the steam boilers. No space heating was required during the test period. This comparison indicated that the overall efficiency -- heat to the product to boiler input -- was only 6%.

The reasons for this low efficiency were identified and it was determined that some of the losses that can be reduced are:

a. Boiler combustion,

b. Steam line insulation,

c. Poor control at blanching machines,

d. Hot water waste,
FIGURE 4. PROCESS DIAGRAM OF A VEGETABLE PROCESSING PLANT
e. Steam leaks,
f. Condensate return.

Programs for improving the efficiency of all of the above factors were developed. A goal of a 50% reduction in these losses has been established which can result in a savings of approximately $40,000 per annum.

As would be expected from the function of this facility, there was a large quantity of heat rejected to the atmosphere via evaporative condensers from the 2,400 HP ammonia refrigeration systems. In an initial comparison of the quantity and quality of rejected heat available to the requirements of vegetable blanching and space heating, it appeared that a significant percentage of the presently wasted heat can be utilized. All heat so utilized would be a direct reduction on the steam boiler load. It appeared from the preliminary study that it could be possible to supply all of the plant's requirements for heat from the heat rejected by the refrigeration system.

Processes such as the lighting, heating and air conditioning were disregarded due to the adequacy of their present levels. Likewise, motors and conveying systems represented no potential for energy savings.

Analysis

A. Steam Utilization

An overall analysis was made of the efficiency of utilization of the heat energy in the steam system and calculations indicate that only 7.8% of the heat content of the natural gas is actually utilized in product heating. Steam systems of this type should be expected to operate with efficiencies of 40%.

The efficiency calculations were made by taking the heat required for blanching and comparing to the heat input of the boilers.
Natural gas consumption and fresh production for 1975 were used as the basis for the calculations.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Production</td>
<td>28,856,204 lbs.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>55,042 MCF</td>
</tr>
</tbody>
</table>

The approximate heat required for the fresh production processing was calculated by the formula:

\[ Q_v = \text{lbs.} \times \text{SpHt} \times (T_2 - T_1) \]

- \( Q_v \) = quantity of heat in BTU
- \( \text{SpHt} \) = specific heat -- the amount of heat required to raise one pound of the product by one degree. For purposes of this calculation the \( \text{SpHt} \) was assumed to be 1.
- \( T_2 - T_1 \) = final product temperature minus initial product temperature.
  In this instance, 150°F was the assumed temperature rise.

\[ Q_v = 28,856,204 \times 1 \times 150 \]
\[ = 4,320,000,000 \]
\[ = 4.32 \times 10^9 \]

The BTU input to the steam boilers was determined by multiplying the number of cubic feet of gas consumed by the BTU value of a cubic foot of natural gas.

\[ \text{Boiler Input} = \text{cu. ft. gas consumed} \times \text{BTU per cu. ft. of gas} \]
\[ \text{cu. ft. gas consumed} = 55,042 \times 10^3 \]
\[ \text{BTU per cu. ft.} = 1,000 \]

\[ \text{Boiler Input} = 55,042 \times 10^3 \times 1,000 \]
\[ = 55,042 \times 10^6 \]

Overall Efficiency = \( \frac{Q_v}{\text{Boiler Input}} \)

\[ = \frac{4.32 \times 10^9}{55,042 \times 10^6} \]
\[ = 7.8\% \]
B. Green's Lines Live Steam Blanchers

The blanchers on the green's lines are especially inefficient from a heat energy utilization standpoint and the escape of live steam into the plant is contributing to the excessive humidity problems.

During our visit, two lines were in operation when we measured the heat loss through the vent hood system.

Size of discharge opening -- 18'' x 24''

Velocity -- 1,000 ft. per minute

Temperature -- 155°F

Cu. ft. of this discharge per minute --

\[
= \frac{18''}{12} \times 2' \times 1,000 + 3,000 \text{ CFM}
\]

Cu. ft. per hour -- 3,000 x 60 = 180,000 CFM

Weight of air at 155°F -- 18.5 cu. ft./lb.

Pounds of air discharged per hour --

\[
= \frac{180,000}{18.5} = 9,729
\]

Heat content of the discharged air above the plant air -- 289 BTU/lb.

Heat discharged per hour -- 9,729 x 289 = 2,811,681 BTU/hr.

The large size of this number can be appreciated when it is compared to the capacity of steam boilers. The boilers are each rated at 13,800 pounds of steam per hour or a total of 27,600. The heat loss from the hood vent system of 2,800,000 BTU per hour is equivalent to 2,361 pounds of steam per hour, or 8.2% of the total system production capacity. Based on natural gas fuel cost for 1975 of $98,898, this loss amounts to $8,406 per year.

This loss was experienced with only two of the green's lines in operation and accounts for the heat taken out by the vent duct system. We were not able to measure the energy loss through the walls of the blanchers or the steam.
loss that did not enter the duct system. From inspection these losses are substantial.

It is our recommendation that this green blanching process be thoroughly studied. Among the items which should be considered are:

1. Redesign of equipment to prevent escape of live steam. Water traps may prove acceptable.

2. Installation of insulation on the steamer. For protection of the insulation and sanitary reasons, the insulation could be covered with metal.

3. Install new steam control system to accurately control the process and prevent waste. New quality temperature and pressure gauges should be installed to provide process monitoring.

C. Heat Recovery from Ammonia Refrigeration

A study was made for the determination of the practicality of heat energy recovery from the plant's refrigeration system. The calculations show that by the installation of a water-cooled desuperheater in the ammonia compressor discharge lines 140°F, water would be available for boiler water makeup. This would have a dollar value at today's fuel cost of $17,018 per year with 4,032 hours per year operation. (The calculations are given in detail on the next page.) We estimate the equipment installation cost to be $20,000.

It should be noted that in addition to the heat available from desuperheating (1.912 NMBTU/hr.) that 11.065 NMBTU/hr.) are available from the heat of condensation (the change from gaseous ammonia to liquid ammonia). This heat is only available at 100°F and at the present time we do not know how advantageous use of this source could be made.

All refrigeration systems work on the principle of removing heat from one area, elevating its temperature, and discharging the heat in another area.
In this instance, the refrigeration system removes heat from the product and discharges this heat to the atmosphere through evaporative coolers on the roof. With the low cost of natural gas and other fuels, little attention has been paid to the heat energy which is available from refrigeration systems. Due to the changing fuel situation and the possibility of severe shortages of natural gas, this picture is changing, and there are a number of systems now being devised to use this refrigeration waste heat.

**Facility Systems**

**Heat Loss Calculations**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>1,500 HP</td>
</tr>
<tr>
<td>Booster</td>
<td>900 HP</td>
</tr>
<tr>
<td>Approximate tonnage</td>
<td>875 tons</td>
</tr>
<tr>
<td>Evaporator temperature</td>
<td>-20°F</td>
</tr>
<tr>
<td>Condenser temperature</td>
<td>110°F</td>
</tr>
<tr>
<td>Compressor exit temperature</td>
<td>225°F</td>
</tr>
<tr>
<td>Heat absorbed in evaporator</td>
<td>10.284 MM BTU/hr.</td>
</tr>
<tr>
<td>Approximate enthalpy change of ammonia in evaporator</td>
<td>430 BTU/lb.</td>
</tr>
<tr>
<td>Flow rate of ammonia</td>
<td>23,900 lbs./hr.</td>
</tr>
<tr>
<td>Super heat (225°F to 110°F)</td>
<td>80 BTU/lb.</td>
</tr>
<tr>
<td>Total Super Heat</td>
<td>1.912 MM BTU/hr.</td>
</tr>
<tr>
<td>Approximate enthalpy change of ammonia in condenser</td>
<td>463 BTU/lb.</td>
</tr>
<tr>
<td>Heat loss in the condenser</td>
<td>11.065 MM BTU/hr.</td>
</tr>
</tbody>
</table>

**Desuperheater System**

Install a desuperheater to desuperheat the ammonia of the discharge of the compressor from 225°F to 120°F. This would increase condenser capacity by 10% and hence a lowering of the compressor work by 2%.
Energy Savings Calculations

Heat available from superheated ammonia = 1.673 MM BTU/hr.

Energy savings @ 80% boiler efficiency = \begin{align*}
\frac{1.673}{0.8} &= 2.091 \text{ MM BTU/hr.}
\end{align*}

Working 16 hrs/day, 21 days/month and energy cost of $1.80/MM BTU,

Dollar savings from recovered heat = 2.09 MM BTU/hr \times 16 \text{ hr/day} \times 21 \text{ days/month} \times $1.80/\text{MM BTU}

= $1,264/\text{month}

= $15,168/\text{year}

Electricity savings from 2% reduction in compressor work

= 0.02 \times 1500 \text{ HP} \times 0.746 \text{ KW/HP}

= 22.38 \text{ KW}

Energy consumed by additional pumps

= 5.76 \text{ KW}

Working 16 hrs/day, 21 days/month and an average cost of electricity of 2.176\text{c/KWh},

Dollar savings in electricity = 16.62 \text{ KW} \times 16 \text{ hr/day} \times 21 \text{ days/month} \times $0.0276 \text{ KWh}

= $154.12/\text{month}

= $1,850/\text{yr}

Total dollar savings = $17,018/\text{yr with 4032 hour/yr operation}

Estimated cost of system = $20,000

Payback period = 1 yr, 2 months

Heat Recovery From Condenser

As was mentioned earlier 11 MM BTU/hr of heat is lost in the condenser. A possibility of heat recovery in the condenser would be to replace the existing evaporative condensers with shell and tube condensers and running the water from the condenser to the desuperheater to pick up more heat. This would require major modifications of the existing system and a detailed feasibility study should be done before it can be implemented.
Compressor Cooling Heat Recovery

The cooling water for the compressors that has picked up some heat could be run through the desuperheater to pick up more heat.

D. Excessive Humidity Damage

It was observed that the humidity level in the main production area of the plant was excessively high. There is evidence of rusting of steel and other moisture damage. This is especially serious as it affects the electrical switch gear. Excessive humidity causes malfunction in electric controls, premature failure and can create hazardous conditions.

While the quantity of open water contributes to the excessive humidity level, most of the moisture comes from the release of live steam into the space. This is especially true of the greens blanchers. As commented on in another section of this report, the blanchers are costly in the waste of heat energy and the loss of live steam is causing damage to the plant.

E. Steam and Return Main Insulation

Insulation of steam and condensate return mains has long been recognized as an effective means of conserving energy, however in practice the value of insulation has frequently been neglected. It is common to find bare steam lines resulting from equipment changes, new lines installed, insulation damage, etc. Except in the most unusual circumstances all steam and return mains should be insulated.

Listed below are the average heat losses from bare steel pipe when handling steam at 80 psi pressure which is the nominal pressure carried in your plant.
<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>BTU Loss</th>
<th>Cost/100ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>$501.5 \times 10^6$</td>
<td>$1,129.00$</td>
</tr>
<tr>
<td>4&quot;</td>
<td>$348.8 \times 10^6$</td>
<td>$748.00$</td>
</tr>
<tr>
<td>2&quot;</td>
<td>$192.8 \times 10^6$</td>
<td>$434.00$</td>
</tr>
<tr>
<td>1&quot;</td>
<td>$111.7 \times 10^6$</td>
<td>$251.00$</td>
</tr>
</tbody>
</table>

Above based on 4000 hrs per year operation, a cost of $1.80 per MM BTU.

F. Energy Conservation--General

This section is devoted to some general observations on energy conservation. In energy conservation programs there is a term, Housekeeping, which has come to cover those myriad of items which individually are small but taken together account for significant dollar cost. There are numerous instances when these items account for 10 to 20% of all energy consumed.

Among the items which fall into this category are:

1. Failure to promptly secure lights, fans, office air conditioning, etc. after hours.
2. Excessive lighting for task requirements.
3. Leaking steam traps.
4. Out of calibration thermostats.
5. Leaking valves.
7. Steam leaks.
8. Refrigeration door seals.

For the most part these items and other like them are common sense concerns which tend to be ignored in the press of daily business. It is our recommendation that an energy conservation committee initiate an active program for the reduction of these losses.
Stage of Implementation

Although none of the engineering analysis has been completely installed, all the ideas presented have been well received and they are currently looking into the budgeting for implementation of these projects.
FOOD & KINDRED PRODUCTS INDUSTRY

TECHNICAL ASSISTANCE CASE 2.6

Description

This company processes canned meats and sauces for an international market. It has 250 employees. Annual gross sales total $20 - 30 million. Annual energy usage and costs are as follows: electricity - 1,800,000 kwh - $60,000, for lighting, small electric motors and 20 tons of refrigeration; natural gas - 51,000 mcf - $50,000, to run two 500hp boilers; No. 2 fuel oil - 53,000 gallons - $17,000, as an alternative fuel for the boiler.

Analysis

At present there have been no significant energy-saving projects have been implemented due to lack of support from upper echelon management.

As a result of a survey of the plant recommendations were as follows:

1. It was recommended that the company get a cost estimate from a local installer for insulating the retorts and determine the return of investment based on the calculated energy savings.

2. It was recommended that the company take no action on the installation of economizers on their boilers because the after tax return was estimated at 7%.
Description

This operation involves cleaning and shelling pecans. They also process the pecans and produce candies. They shell two million pounds per year and in addition prepare and sale one million pounds per year of pecans in the shell. Their yearly gross sales is $4 million. This is a seasonal operation and their employees range from 40 to 200. The market is national in that they market through catalog sales. Their electrical bill amounts to approximately $8,500 annually and they utilize propane gas with a cost of approximately $1,200 per year.

Analysis

A tour of their plant facility was conducted. Their facilities have several separate electrical meters and it was suggested that they consolidate these meters through one master meter for reduced electricity cost. An engineering and economic analysis was conducted on the sanitizer that sterilizes the nuts. This piece of equipment utilizes a propane gas burner to heat water 190°F. We tested the combustion efficiency of this burner and recommended that it be adjusted to improve the efficiency. We also recommended that a hood be fabricated for the sanitizer and the entire cabinet be insulated.

The potential savings were calculated for the above recommendations. An estimated $1,130 per year could be saved.
We also did an engineering and economic analysis of the feasibility of heat recovery from the sanitizer when used with the batch dryers. This did not appear feasible and was not recommended. A savings of only $100 per year was estimated with a modification cost of over $1,000.
Description

This is a commercial refrigeration facility. The company rents refrigerated storage space primarily for agricultural commodities. The company receives, warehouses, and ships packaged frozen foods. Generally the food is received freshly prepared and is quick frozen prior to warehousing. The facility is approximately 50,000 square feet in area and employs ten persons. The service of this facility is provided to a multi-county area.

Analysis

Electricity is the principal energy requirement and is used for refrigeration with consumption evenly divided between warehouse refrigeration and quick freezing operations. The electric demand created by the quick freezing operations is about three times that generated by the warehouse refrigeration requirement.

The physical plant is relatively new and well maintained. The company was aware of the energy situation and had excellent control over the operations. The operating schedule of the quick freezer created a peak demand at about 4:00 pm and it was suggested that considerable savings in demand could be achieved by staggering the operations so that the freezer operated at night and also installing a demand controller. A study had to be done by the company to see if their customers could send in the supplies at a later time in the day and the effect it would have on the quality of the products. The end result was that the company decided to buy a demand controller. It has been installed and the expected savings would be in the neighborhood of $15,000 annually.
Introduction

This major group includes establishments engaged in the smelting and refining of ferrous and nonferrous metals and the manufacture of basic products of ferrous and nonferrous metals. The establishments included in this broad classification can be further broken into the following categories:

1) Blast furnaces, steel works and rolling and finishing mills
2) Iron and steel foundries
3) Primary smelting and refining of nonferrous metals
4) Secondary smelting and refining of nonferrous metals
5) Rolling, drawing and extruding of nonferrous metals
6) Nonferrous foundries (castings)
7) Miscellaneous primary metal products

This industry group plays a significantly important part in the U. S. economy. In 1974 the industry employed approximately 1.25 million people and the value added by these people was $37.3 billion, the third largest of the manufacturing industry groups. The value of the industry sales exceeded $95 billion which makes it the second largest of the manufacturing industry groups. In Georgia this industry employs over 11,000 people. The value added by this industry group exceeds $180 million and the sales volume is over $625 million.

Of the total energy consumed by all manufacturing industries in 1974, 19% was consumed by the primary metals industry which makes it the largest energy consumer. The energy consumed by this industry in 1974 was equivalent to approximately $1.1 \times 10^6$ billion Btu's. The approximate break-up of this energy is natural gas 41%, electricity 21%, coke and breeze 13%, fuel oil 12%, coal 6% and other fuels 7%. This shows the tremendous dependence of this
industry on natural gas which is the largest form of energy used. The actual percentage dollar spendings would be significantly lower for natural gas due to the low unit cost of this energy. The large consumption of natural gas by this industry also makes it extremely vulnerable to shutdowns and unemployment due to the increasing curtailments of natural gas and unavailability during the winter months.

In Georgia the total energy consumed by the primary metals industry in 1974 was approximately equivalent to 9,900 billion Btu's of which 47% was natural gas, 25% electricity and 7.3% fuel oil. Hence there is a very large dependence on natural gas, the supply of which is questionable in the future. There could be significant impact on production volume if the supply were cut off which would directly affect employment.

Drastic energy conservation measures and change to alternate fuels is a solution to this growing problem. There is an urgent need for coordinated research and technology transfer in the area of energy related to this industry.

Discussion

The industry response has been extremely enthusiastic. There was a general awareness of the energy shortages, but there was no awareness of the magnitude and urgency of the situation. In most cases natural gas had never been a problem in the past and there was never any major curtailments. In the event of curtailments for critical periods, the companies bought and stored propane to fill the gap. Propane has also been fairly readily available in the past. The low unit cost of natural gas compared to the other fuels has made it become an extremely popular fuel.

It is an inherent characteristic of the primary metal industries to work with high temperatures, either to melt the metals or form them, with the result in most cases being a high temperature exhaust from the process equipment.
It is not unusual to find the stack temperature of an aluminum smelter range between 1400°F to 2000°F. These high temperatures require the use of high strength, high temperature resistant, high corrosion resistance materials in heat recovery equipment. To date there is very little equipment available for heat recovery from extremely high temperature gas streams like those found in the primary metals industry. One of the reasons for this unavailability is that high strength high temperature resistant materials are expensive and require special fabrication techniques. Since the cost of energy, especially natural gas, is extremely low it is very difficult to justify the installation of the recovery equipment based on the dollar savings generated from saving energy.

Another characteristic of this industry is that there is a need for thermal energy at different temperatures within a plant. To illustrate this, the smelting furnace requires a temperature of over 2000°F, the homogenizing oven around 1000°F, the billet heaters 900°F to 1000°F and the anodizing tanks are at temperatures below 210°F. This characteristic of the industry makes a perfect case for an energy management program using a systems approach. There is a great need for research to be done in this area to efficiently use the energy. A possibility is to design the equipment and layout the plant in such a way that the 1500°F exhaust gas stream from the smelting furnace can be used in billet heaters and homogenizing ovens whose exhaust if controlled, could be used to heat water for the anodizing tanks. This would result in a considerable savings of energy since it would eliminate wasted energy from the stacks of the smelting furnace, the homogenizing oven, the billet heater and the boiler. There is a potential for saving over 50% of the thermal energy used in any particular plant if this approach is used.
Description

The company is a manufacturer of aluminum extrusions. The basic raw materials are aluminum ingots and scrap aluminum. The plant is mid-sized for the primary metals industry in Georgia and employs about 200 people. Its products have a national market. The different types of energy used are natural gas, propane, electricity and fuel oil. About 50% of this is natural gas. This plant is highly dependent on natural gas for its production. During the winter, when natural gas is not available, propane is used. Most of the process equipment that uses natural gas does not have an alternate fuel capability other than propane.

Selection of Company

This plant is mid-sized aluminum extruder and is representative of the plants in Georgia. These are large users of natural gas and propane, fuels which are in short supply. The company was chosen because natural gas curtailment would have an adverse impact on employment.

Initial Contact

During the initial contact, which was made in early July, 1976, the general manager was informed about the program, the current energy situation and the potential vulnerability of his industry to curtailments of natural gas. The energy conservation data survey sheets were mailed to him during the second week of July. A plant visit was made by Georgia Tech engineers during the next week.

Process Description

The flow chart of the processes of the plant is shown in Figure 5.
The basic raw material is aluminum ingots and scrap aluminum. These are melted in a smelting furnace fired by natural gas or propane. The molten aluminum is cast into billets 16" to 18" in diameter and about 6-8 ft. in length. These are allowed to cool to room temperature. The billets are then loaded on a cart and placed in a natural gas or propane fired homogenizing oven maintained at 1060°F. The billets are kept in the oven for 18 hrs. After this period they are again allowed to cool. After cooling, the billets are cut to 10" to 16" in length and are sent to the extrusion area. The billets are preheated to 900°F in a natural gas fired billet heater. The hot billets are then extruded by large hydraulic extrusion presses. The extrusions are then aged in an aging oven and some are prepared for shipping. The other extrusions are either sanded or buffed and sent to the anodizing area. The extrusions are anodized by dipping into tanks filled with various chemicals and agitated by air. Some of the tanks have steam jackets to heat the solutions. The anodized extrusions are then dried and shipped.

Observations Made in Plant

Shortly after beginning a tour of the plant, we observed open flames of the size of about 1 1/2' x 1 1/2' x 6' coming out of the top of the melting furnace and into the stack. There were also leaks in all the doors of the smelting furnace giving rise to excessive heat loss.

The billets, after being removed from the homogenizing oven or after casting, were left to cool in the atmosphere. This was a considerable waste of heat that could be transferred to air that could be used in combustion.

The water used to cool the smelting furnace doors and the mold was pumped into a lagoon to cool. This hot water could be used as boiler makeup.
Steam was boiling off the top of some of the anodizing tanks which were maintained at boiling.

There was excessive air leakage through the bottom of the billet heaters which cooled the billets as well as provided too much excess air for combustion.

The plant in general did not have an alternate fuel capability if natural gas or propane was not available.

The thermal efficiency of the smelting furnace was measured and found to be around 15%. The homogenizing oven had an efficiency of about 60%, the boiler approximately 80%, and the billet heater around 20%, based on stack loss. There was no separate metering of the fuel for any of the equipment, nor was there any type of monitoring to determine whether the equipment was performing as required.

Recommendations

Recommendations were made as a result of the plant observation and data analyzed. These recommendations are shown separately as an attachment to this case study.

Stage of Implementation

The management has started installing instruments to monitor the fuel usage in the various equipment. They have made modifications to the burner system in the smelting furnace to improve combustion efficiency. They are also looking into the possibility of installing a recuperator on the smelting furnace.
FIGURE 5. PROCESS DIAGRAM OF AN ALUMINUM EXTRUSION PLANT
Savings by Using Preheated Air in Homogenizing Oven

At present the billets are removed from the homogenizing oven after the homogenizing period at a temperature of 1060°F and left in the open to cool to the ambient temperature.

The system recommended recovers the sensible heat available in the billets by transferring the heat to the air that could be used for combustion in the burners. This would result in a direct savings in fuel and money.

The system required to achieve this would be an inexpensive enclosure into which the cart load of billets could be rolled out from the homogenizing oven. The enclosure should have openings at the bottom to allow entry of air and a ducting from the top to the inlet of the air blower of the homogenizing oven.

Calculations

\[
\text{Monthly Load on Homogenizing Oven} = 1.3 \text{ million lbs.}
\]
\[
\text{Homogenizing temperature} = 1060°F
\]
\[
\text{Temperature of billet after being cooled by air} = 100°F
\]
\[
\text{Temperature drop} = 950°F
\]
\[
\text{Specific Heat of aluminum} = 0.208 \text{ BTU/lb°F}
\]
\[
\text{Heat Available} = 1.3 \times 10^6 \text{ lbs/month} \times 950°F \times 0.208 \text{ BTU/lb°F} = 256 \text{ MM BTU/month}
\]

Assuming the oven efficiency to be 65%

\[
\text{Energy Savings} = 393 \text{ MM BTU/month}
\]
\[
\text{Cost of Natural Gas (Atlanta, Ga)} = $1.00/\text{MM BTU}
\]
\[
\text{Cost of propane} = $ .30/\text{gal} = $3.26/\text{MM BTU}
\]
Oven runs off natural gas for nine months and propane for three months.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Annual savings of natural gas</td>
<td>$3,537</td>
</tr>
<tr>
<td>Annual savings of propane</td>
<td>$3,843</td>
</tr>
<tr>
<td>Total Annual Saving</td>
<td>$7,380</td>
</tr>
<tr>
<td>Estimate cost of preheat system</td>
<td>$5,000</td>
</tr>
<tr>
<td>Payback period</td>
<td>8 months</td>
</tr>
<tr>
<td>Payback period after taxes</td>
<td>1 year, 4 months</td>
</tr>
</tbody>
</table>
Melting Furnace

Upon observing the melting furnace during full load operation it was found that there was an open flame about 5 feet high going through the opening and up the stack. There were also flames leaking out of the doors on three sides of the furnace. All these were waste of energy. The flame leakage through the doors could be eliminated by better sealing of the doors. The elimination of the flame through the stack and methods of improving efficiency are discussed in detail below.

An important factor in the efficiency of the furnace is the efficiency of combustion of the gases. Improper combustion gives rise to lower flame temperature, waste of fuel and lower heat transfer rates from the flame to the furnace.

The air fuel ratio plays a very important part in the flame length and flame temperature. Fuel rich mixtures give rise to long flames while lean mixtures have short flames. The attached graph shows the effect of air fuel ratio on flame temperature.

Since the furnace does not have meterings of the natural gas used and the air used all the calculations below are based on equipment name plate data.

Melting furnace burner capacity = 15 MM BTU/hr
Heat value of natural gas = 1000 BTU/Cuft
Volume of gas required = \( \frac{15 \times 10^6}{1000} \) cfh = \( 15 \times 10^3 \) cfh
Air required for stoichiometric combustion = \( 15 \times 10^3 \) cfh of gas \( \times 10 \) cfh of air
= 150,000 cfh of air
= 2,500 scfm of air
Air requirement with 20% excess air: 3,000 scfm
Present blower capacity: 2,550 cfm

Hence there is just enough blower capacity for stoichiometric combustion. It is recommended that the actual combustion rate and air flow rate be monitored to find the actual air fuel ratio before action is taken to provide proper combustion.

The advantages of proper combustion are: savings in fuel and hence dollars; better heat transfer to the metal due to higher flame temperature and shorter flame, which would result in a reduction of the cycle time for melting; and reduction in stack losses.

Heat Lost Through the Stack

<table>
<thead>
<tr>
<th>Stack temperature</th>
<th>1500°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow rate</td>
<td>2500 cfm</td>
</tr>
</tbody>
</table>

Heat loss = \(1000°F \times 24 \text{ BTU/l°F} \times 0.075 \text{ lb/CuFt} \times 2500 \text{ CuFt/min} \times 60 \text{ min/hr} \)

= 2.7 MM BTU/hr

= $19,440/yr
Steam Sparging in Annodizing Tanks

A number of the annodizing tanks are agitated vigorously by blowing air through the tanks. Some of these tanks are maintained at a specified temperature with steam running through a plate type heat exchanger. The annodizing process requires that the specific gravity and concentration of the liquids in the tanks be maintained to close tolerances.

Steam sparging to provide the agitation as well as the heat would not be a feasible proposition due to the problem of controlling two variables, names specific gravity and temperature with one input, namely steam.
Steam Sparging in Anodizing Tanks

A number of the anodizing tanks are agitated vigorously by blowing air through the tanks. Some of these tanks are maintained at a specified temperature with steam running through a plate type heat exchanger. The anodizing process requires that the specific gravity and concentration of the liquids in the tanks be maintained to close tolerances.

Steam sparging to provide the agitation as well as the heat would not be a feasible proposition due to the problem of controlling two variables, namely specific gravity and temperature with one input, namely steam.
Flame temperature for various fuel air and fuel or gas mixture.

Description

This firm is an aluminum die casting firm. The company facility is approximately 40,000 square feet and 140 persons are employed on a three shift operation. This facility serves the southeastern market. Their products include die cast boxes for the electrical products industry, parts for water skis, etc. Their yearly sales volume is approximately $3.5 million. Their energy usage is electricity ($65,000 annually) and natural gas ($70,000 annually). The major energy using operation is for the melting furnaces where natural gas is utilized to melt aluminum billets.

Analysis

The melting furnaces were analyzed for potential energy savings. These eighteen furnaces expell 1250°F exhaust gases to the atmosphere. Three possibilities were investigated to recover heat from these gases. They were:

1. Heat recovery to preheat burner combustion air.
2. Heat recovery to preheat aluminum billets.
3. Heat recovery to produce steam.

Heat recovery to preheat the burner combustion air was recommended as being the most desirable. The expected savings was calculated to be approximately $10,000 annually. It was also recommended that the firm investigate the feasibility of installing additional insulation to the melt furnace holding tanks.
Description

This firm was established in 1957 and has an employment of 85 persons. Principal products are aluminum extrusions used for windows, door frames, and electronic products. Aluminum is received in the form of billets approximately 8 inches in diameter and 24 inches in length. The billets are heated in a billet heater to $900^\circ$ and extruded by a 600 HP hydraulic press. The extruded lengths are cut to the required sizes and are finished by either anodizing or special painting. Painted pieces are sent to drying ovens for drying and curing. Of the raw stock processed, about 33% is scrap which is sent back to be converted into billets.

The total energy bill of the firm is approximately $250,000 a year, of which one half is for natural gas. The major natural gas consuming equipments are billet heaters that heat by direct flame impingement, the paint drying ovens, and heaters for hot water used in anodizing and painting operations. Electrical loads are the motors for hydraulic presses used in the extrusion process.

Analysis

Although none of the gas consuming equipments are efficient, there is presently no economic incentive to improve the systems due to the low cost of natural gas. The plant is on a firm contract from the natural gas distributor and has had no curtailments of gas. Currently gas costs the firm approximately 52¢ per million BTU. Gas saved would come from the lowest
cost section of the rate and the energy cost would be approximately 40¢ per million BTU. This low cost precludes many energy conservation initiatives due to low economic return. Unless gas price and/or availability changes, energy conservation ideas will not be implemented by the firm.

The majority of the electric loads are directly involved in some part of the production process and production has priority over demand control. Therefore, there is very little incentive for demand control.

The low cost of gas and the production oriented electric loads do not make the plant suitable on detailed case study. Recommendations of improved combustion control in smelting furnace, homogenizing and billet heaters were given. Other possibilities of heat recovery from smelting furnace and homogenizing ovens would become more attractive in the future as fuel prices increase.
Introduction

This major group includes establishments engaged in the manufacturing of glass, cement, clay, concrete, gypsum, stone and asbestos products.

This major SIC category is broken down into manufacturers of the following products:

1) Flat Glass Products
2) Glass and Glassware Products - Pressed or Blown
3) Glass Products made of Purchased Glass
4) Cement Products for Hydraulic Use
5) Structured Clay Products
6) Pottery Related Products
7) Concrete, Gypsum and Plaster Products
8) Cut Stone and Stone Products
9) Abrasive, Asbestos and Miscellaneous Nonmetallic Mineral Products

This industry group in the United States employs over 650,000 people and contributes a value added of over $14.5 billion and is one of the 10 largest industry groups in the United States. In Georgia the industry employs over 17,000 persons and contributes to a value added of over $318 million and a sales volume of $570 million.

In 1974, 10% of the energy used by all manufacturing industries was consumed by this industry group. The energy consumed by this industry in 1974 is approximately equal to 135 million barrels of oil. The approximate breakup of this energy based on costs is electricity 32%, natural gas 30%, fuel oil 15%, coal 12%, other fuels 11%. In terms of energy content the percentage for natural gas would be considerably higher which makes this industry vulnerable to shortages of natural gas.
In Georgia the total energy consumed in 1974 was equivalent to approximately 35,100 billion Btu's. This was derived mainly from natural gas 83%, and electricity 7.9%. Coal provided for about 2.6%, fuel oil for 4.6% and other fuels 2%. Natural gas is relied upon so heavily because some operations in this industry are dependent upon clean burning fuels.

Discussion

The response by this industry has been very enthusiastic and they were aware of the gravity of the energy situation. In fact the case study company in this industry group was the initiator of the contact for an energy conservation program. This industry was dependent completely on natural gas and had no backup facilities at all and so were worried about their production in the event of a curtailment. This is generally true in most firms in this industry group due to their need for burning clean fuels.

The industry in general starts off with a raw material that is in the powdered form (various types of clay for the brick, sanitary ware and tile industries). This powder is mixed with water, usually at a temperature above ambient to form a slurry. The slurry is then pumped into molds and allowed to set over a period of time, also usually at a temperature above ambient. After the moisture content of the product is reduced to a level that the product has a fixed shape, it is taken out of the molds and transferred into an oven or kiln, where they are fired. In most cases these kilns or ovens are direct fired with natural gas. The products have to be raised to a temperature above 1000°F at a very slow rate to prevent cracking. The products are then maintained at this temperature for a period of time, and then cooled back to ambient temperature again at a relatively low rate to prevent cracking. This firing can be done either as a continuous type of operation or a batch type.
The continuous mode is more efficient in terms of energy since it is possible to use principles of counterflow to effectively utilize the heat whereas a batch type system wastes considerable amounts of heat in heating and cooling of the oven/kiln itself for each cycle of operation.

The need for a clean fuel is due to the fact that the systems are direct fired, meaning the combustion gases are directly used to heat the products. If unclean fuels are used, the finish of the product would be unsatisfactory with the alternative being to use an indirect heating system which introduces further inefficiencies.

Electric heating could be used in these types of systems but the relatively low cost of natural gas compared to electricity could not justify using electric heating. But with the supply of natural gas being uncertain there would be a greater incentive to change to electricity. Electrically heated systems are inherently considerably more energy efficient compared to the direct fired systems due to the minimal stack gas requirements. In direct fired systems usually more than 60% of the heat is lost up the stack and after considering other losses the actual heat transferred to the product is usually of the order of 5-10%. In an electrically heated system, efficiencies of around 80% could be achieved. So in the future when the price difference between natural gas and electricity is reduced it may be economically feasible to convert the existing systems to electric heating.

The industry in general does not use heat recovery equipment in most of their processes since the energy savings (due to the low cost of natural gas) could not justify the capital expenditure.
Description

The plant is one of several plants owned by the company. Approximately 120 persons are employed by the plant. The main products are vitreous plumbing fixtures, including sinks, toilets, and other domestic fixtures. Sales volume was not available.

Annual energy costs are approximately $250,000. The major forms of energy used are electricity and natural gas. Nearly 100 percent of thermal energy requirements are met by natural gas. The plant does not have an alternate fuel capability in any equipment.

Selection of Company

This company falls into the major SIC category of stone and clay industries. This industry group ranks very high in energy consumption on a national level and is a significant industry in the State of Georgia. These factors led to the selection of a company representative of the stone and clay industry. The absence of alternate fuel capability for thermal requirements, which would lead to a shut-down in the event of natural gas curtailment, added to the reasons for its selection. The enthusiastic response of the plant management to the suggestions given by the Georgia Tech Engineers and the agreement to invest in capital expenditures for energy conservation were additional reasons for their selection.

Initial Contact

The initial contact with this plant was made by phone in mid May, 1976, by the plant Chief Engineer, who had heard of the energy conservation work
at Georgia Tech. During the initial contact, he expressed concern about his prime energy supply, natural gas. He said he could install an energy recovery system and that, since the plant did not have an alternate fuel capability, he was motivated to conserve energy because curtailment would greatly effect production. He mentioned that, at present, if natural gas was cut off, the plant would have to shut down.

After the initial contact, an appointment was made to visit the plant to identify potential energy saving projects. Additional visits to the plant were made to collect further data and assist in the energy conservation program.

**Process Description**

The operation consists of receiving dry clay and mixing this clay with various chemicals and 200 degree water to produce what is known as slip. The slip is then pumped into molds, such as the mold of a toilet or a sink, and cured in this mold overnight. Typically, they work 8 hours during the day to fill the molds and during the other 16 hours a day the clay in the molds sets and cures. They are cured in the presence of approximately 110°F. Plant design is such that this curing occurs throughout the entire plant. In other words, the entire building must be heated to 110°F every night to obtain the proper schedule of curing the clay before the mold can be removed. After the molds are removed the clay is dried in the open air for seven days. During this seven day period, the moisture content reaches approximately two percent before going to the tunnel kilns.

The tunnel kilns receive the dried, cured product. On a continuous basis, the product is fired at approximately 2,200°F. The tunnel kiln has no heat recovery system at present.
Approximately ten percent of the fired products are damaged either during the firing or during some other process; these have to be patched and reworked. These products are glazed, patched again, and fired in a shuttle kiln, a batch type kiln in which repaired products are placed and fired to 2000° F for a 15 hour period. The finished products are tested, packed and shipped. (The process diagram is shown in Figure 6.)

Observations Made in Plant

In this plant, as with most plants visited, there was only gross metering of the major energy sources, natural gas and electricity. The individual processes were not metered or monitored for measuring efficiency. This plant had never faced a problem with their energy supply and were purchasing it at a relatively low price. In general, the plant used an excess of lighting and, with the large plant area to be lit, a reduction in lighting levels would save a significant amount of money, especially in the moulding, drying and packaging areas. The tunnel kiln and shuttle kiln areas were lit with the proper amount of lighting.

In the kiln area there was a considerable negative pressure, created because the air for combustion in the kilns was drawn from the room and the small windows did not provide sufficient air flow into the area. To aggravate the situation, exhaust fans were kept running to remove the hot air in the room and make the area more comfortable. It was suggested that the size of the opening in the walls be increased to allow greater air flow, reducing the load on the blower for the combustion air and saving electricity. It was also suggested that the exhaust fans be used only when it was necessary rather than all the time. Another possibility would be to move the air intake of the tunnel kiln combustion air blower to a higher elevation within the
room so that the hot air is used for combustion. This would result in some energy savings and may eliminate the use of the exhaust fans.

The boiler used to generate hot water for slip production was operating at a satisfactory efficiency of 81%. The other major energy consuming equipment were the two tunnel kilns, the two refine kilns, and the gas space heaters.

The tunnel kiln is a continuous type kiln into which molded products are sent to be fired at 2,200°F. There are two streams of exhaust gases coming out of the tunnel kiln, the combustion gas stream and the cooling air stream. Because of the continuous mode of operation, the gas streams have an almost constant volume flow rate and maintain a relatively constant temperature. The cooling air stack temperature was found to be around 300°F and, because the stream is clean air, there is a possibility of using a heat recovery device. The plant engineer indicated that they had looked into the possibility of using this cooling air directly in the drying area but because of the large distance to be traversed and the large blower necessary, the project could not be economically justified.

It was suggested that a heat recovery system using this gas stream to heat water would be a better alternative since it could be used for generating the slip. This would reduce the load on the boiler and if sufficient hot water was produced the boiler could be shut down. If there was an excess of hot water produced it could be used for space heating and would replace the direct natural gas fired space heaters.

The tunnel kiln is a batch type kiln and the stack temperatures are cyclic, varying from ambient to about 1700°F. The overall thermal efficiency of the unit was estimated to be around 5-10% which indicates that large amounts of heat are wasted. Due to the cyclic nature of the stack
temperature and the high temperature produced heat recovery would not be a feasible alternative.

An alternative suggested was to convert the shuttle kiln to electric heating. Electric heating would not require a large flow of air and hence efficiencies of the order of 85-90% can be achieved. This would result in an efficiency improvement of 10 times or better. With electricity at off peak hours costing about 4 times as much as natural gas the increase in efficiency may justify the conversion.

Stage of Implementation

Converting the shuttle kiln to electric heating requires equipment which must be custom designed and engineered for this particular operation. Conversation with the manufacturers of shuttle kilns indicated that the conversion is possible with current technology. Information about the process involved and a list of possible manufacturers has been given to the plant. The time and manpower allocated to this project did not allow a detailed feasibility study to be carried out.

The tunnel kiln heat recovery idea was presented with initial analysis of energy savings and dollar savings. Since this plant is part of a large corporation, a proposal will be submitted by the plant to the corporate headquarters for approval along with the annual budget.
Tunnel Kiln Heat Recovery

Heat Requirement

200°F Hot water for slip production = 8 MM BTU/day
110°F Hot air for drying = 140 MM BTU/day

Tunnel kiln combustion air stack temperature - 150 - 175°F
Cooling air stack temperature - 350°F
Cooling air stack flow - 10,000 cfm

There is potential for heat recovery. Two methods of heat recovery appear economical--finned tube air-to-water exchanger; supplementary fined shell-and-tube recuperator.

Heat Recoverable with heat exchanger - 35 MM BTU/day
Heat Recoverable with recuperator - 50 MM BTU/day

Hence all the requirements of heat for hot water and part of the heat for drying air could be fulfilled. There are a number of advantages of recovering the heat into 200°F hot water and using this in forced draft radiators to heat the drying area. The hot water could be stored during the day and used at night for drying. Hot air off radiators is dryer and cleaner than combustion gas and less distribution energy would be required due to better zoning of heated areas. The process water for slip production would be taken directly from the heat exchanger and would eliminate the requirement for blow down and minimize water treatment.

The choice of heat recovery system would depend on the fuel used for heating the drying area. If oil is used for a significant portion of the time, the supplementary fined shell and tube heat recuperator is recommended. The system would use waste gases as preheated air and would increase the drying efficiency from 70% to 95% or better.
SLIP PREPARATION — MOULDING — DRYING

TESTING, PACKAGING, & SHIPPING — FIRING IN TUNNEL KILN — GLAZING

FIRING IN SHUTTLE KILN

FIGURE 6. PROCESS DIAGRAM OF A PLANT PRODUCING DOMESTIC SANITARY WARE
### Shuttle Kiln Heat Recovery

The two shuttle kilns operate on a 24 hour loading-unloading cycle during which the stack temperatures vary from ambient to 2000°F. Due to the cyclic nature of the temperature heat recovery is not feasible since expensive heat exchangers would be necessary.

The present efficiency of the kilns fired by either oil or gas is less than 10%. If electricity were used the efficiency would be over 70%. Since the cost of electricity during off peak hours is only 4 times as expensive as natural gas the improved efficiency when using electricity would result in about 50% reduction in the cost of firing the kiln.

Conversion of the shuttle kiln to electricity is being investigated. Cost and other data have not been completely collected and so it would not be possible for use to presently recommend the change. Major manufacturers are being contacted and either we or the manufacturers will be in contact with you in the near future to discuss the change.
Description

This company makes brick, tile, flue liners, and sewer pipe for its regional market. It has 40 employees. Based on an annual sales volume of approximately $1 million, energy costs and usage for the year are as follows: electricity - $30,000; natural gas - 12,000 mcf/month when available.

Analysis

At present the company is a year round operation but due to insufficient natural gas supplies during winter months the company may be forced to become a seasonal operation.

This company essentially has no energy conservation program and according to its president it lacks the money for substantial capital investments to conserve energy.

Since the present burners in the kilns and dryers cannot use no. 2 fuel oil the company is totally dependent upon propane and natural gas to fire these kilns and dryers. Presently energy costs account for approximately 35% of the total product cost and the president feels his products would not be competitive if he incurred the increased cost of capital investment requirements and higher energy costs of a no. 2 fuel oil system.

As a result of a survey of the plant, recommendations were as follows:

1. That the costs and benefits of installing equipment to utilize no. 2 fuel oil as an alternate fuel be investigated.
2. That the cost of air handling equipment for recovering heat from one kiln during its cooling phase and transferring it to another kiln entering the firing phase be determined to calculate the rate of return for such a project. Fuel savings from this recovery system are estimated at $25,000/yr.
Description

This firm is a major producer of kaolin. Kaolin is a very fine, high quality clay used to produce the white color in paper, cartons, and ceramic products. The plant employs 80 people. It is fully integrated having mining and processing under one management. The mined kaolin has a very fine particle size in the range of one to two microns. It is shipped by rail to customers with a moisture content of less than 1%.

The major operations of this company include mining, milling, separation and drying. Large quantities of water are used to separate and transport the kaolin through the processing. Electrical energy is required to pump water to the mine, kaolin slurry to the plant, and water to the plant. The major energy consuming process is the drying operation. The first stage of the drying is accomplished with large vacuum filters requiring approximately 1,000 horse power for vacuum pumps. This operation reduces the moisture content from 70% to about 50%. Large direct gas or oil fired dryers are then used to reduce the moisture content below 1%.

Analysis

Energy savings may result from improvements in the vacuum filtering process. One possibility, pressure filtration, is being investigated. This does require a process change and should be first tested on an experimental basis. There is a possibility of altering the energy demand control on the water supply system since demand savings are possible by pumping the large amounts of water during off peak hours.
A demand control system alone may not be sufficient since additional pumps may be required to increase capacity for a reduced running time. The potential savings available could exceed $100,000 per year, however, and continued assistance is being provided to evaluate the possibility.

The firm is also experimenting with heat recovery from large direct fired dryers. Since the gas leaving the dryers is below 200 degrees, little heat can be recovered without condensation and savings would only be marginal. The dryer gas contains significantly less heat than the boiler stack gases and is more difficult to recover. Since 100% make-up boiler water is required, the make-up can be used to reclaim the heat in the boiler stacks. Application for this purpose should save over $30,000/ year and would cost less than $40,000.
Description

This company makes gypsum wall board for an international market. It has 100 employees. Annual gross sales were not disclosed; 250,000 tons/yr of gypsum wall board is the annual volume of production. Electric power is used for lighting, large and small electric grinding motors, materials handling and drives for board machine and drying kiln. Natural gas and no. 2 fuel oil are used in the calcination process and drying kiln. Natural gas supplies about 80% of the energy needs.

Analysis

This company has a well established energy conservation program and recent energy related projects include:

1. Installation of equipment to use exhaust gases from calcination process to preheat gypsum rock in the crushing and drying operation.
2. Relocation of air intake for the secondary air supply for the board drying kiln from the outside to inside the building.
3. Installation of no. 2 fuel oil storage system due to the anticipated use of more no. 2 fuel oil.

The company is also considering continuous calcination and refinements in the board drying kiln as possible ways of further reducing energy requirements.

As a result of a survey of the plant, recommendations were as follows:

1. Optimization (reduction) of secondary air supply to the gypsum board dryer to improve thermal efficiency.
2. Preheating of secondary and primary air supplies for gypsum board dryers by recovering heat from dryer exhaust air.
Introduction

This major group includes establishments engaged in producing clothing and fabricating products by cutting and sewing products that are made of woven or knit textile fabrics.

This group is divided into the following categories:

1. Men's and Boys' Suits and Coats
2. Men's and Boys' Furnishings
3. Women's and Misses' Outerwear
4. Women's, Children's Undergarments
5. Hats, Caps, and Millinery
6. Children's Outerwear
7. Fur Goods
8. Miscellaneous Apparel and Accessories
9. Miscellaneous Fabricated Textile Products

This industry employed approximately 1.3 million persons in 1974 and had a value added figure of about 15 billion dollars, with the value of shipments made approaching 31 billion dollars. In Georgia the apparel industry employs around 80 thousand persons who contributed to the value added to the products of 750 million dollars and a sales volume of 1.5 billion dollars. The total energy used by this Georgia industry in 1974 was equivalent to $3.4 \times 10^{12}$ BTU's.
APPAREL INDUSTRY

CASE STUDY 5.1

Description

The plant produces men's shirts, serving as the lead plant in a complex of several plants. As the lead plant, the facility provides services to other plants such as cutting collars, cuffs, etc. The plant is modern and highly automated. Pattern preparations and most sewing operations are automated. The plant employs approximately 650 persons operating 4-1/2 days per week with a limited second shift. Energy consumption for the year is billed at approximately $112,000.

Selection of Company

After a thorough investigation into the apparel industry in Georgia, it was determined that this particular plant was one of the best in its area. The management of the plant had achieved a reputation for being very receptive to new ideas and a small energy conservation program had already been implemented. Although the results were small, their willingness to conserve energy had been established.

Initial Contact

The president of the firm was contacted in early June, 1976. The project was explained to him pointing out those areas which required his time as well as the possible benefits to be received. His response was very enthusiastic and he gave the Georgia Tech personnel his fullest cooperation. A data survey was sent to the plant within a few days and the completed form was returned within two weeks. The initial plant visit took place in late June, 1976.
Energy Inventory

Two forms of energy are used in this plant. Electricity is the primary energy source and annual consumption was billed at approximately $105,000 per year (1976). A much smaller quantity of natural gas, only $7,800 per year, was also used (1976). The plant operates from 7:45 a.m. to 5:15 p.m., 4 days per week, and from 7:45 a.m. to 11:45 p.m. on the 5th day. Occasionally a second shift of 30-35 hours per week is used.

A few in-house energy conservation measures have been implemented. A transient suppressor, installed about six months ago appears to have helped reduce the electric consumption by 10% and housekeeping measures such as turning off the air conditioner and lights after work have been enacted.

Process Description

Sheets of cloth serve as the raw material for production. These are received and stored in the warehouse and enter production in the cutting room where they are cut into various pieces of the garment such as cuffs, collars, etc. Some of these parts are returned to the warehouse where they are shipped to other plants within the company. The rest of the pieces are taken to the sewing area where they are sewn together to produce the final garment. They are then individually laid over a wire form where steam is shot through the wire onto the shirts to dewrinkle them. After a few seconds of steam, hot air is shot through the wire to dry the shirts. The whole steaming and drying process takes about 10 seconds. The shirt is then removed, folded in the folding area, boxed and stored in the warehouse until shipping. (See Figure 7.)
FIGURE 7. PROCESS DIAGRAM - APPAREL MANUFACTURING
Observations of Plant

A meeting with the president of the plant was conducted prior to the plant tour. The importance of energy conservation was discussed along with the description of the plant and those areas the president felt should be of interest to the Tech personnel. An engineer was then assigned to conduct a tour. The tour took a few hours and the Tech personnel were informed as to the details of each process. Upon completion of the tour another briefing with the president took place and the observations made by the Tech personnel were discussed. Based on these observations, a second trip was planned to investigate in detail those areas in which greatest energy savings could be achieved.

The production equipment itself, which included the cutting machines, sewing machines, dryer and boiler, consumed very little energy in terms of the plant's overall energy bill. The machines are electrically operated by fractional horsepower motors, and the dryer and boiler, although very essential to production, were very small and few major conservation measures could be practically implemented (i.e. heat recovery would not be economically justifiable).

The major energy consuming equipment was determined to be the lighting and the air conditioning. The lighting was measured throughout the plant and found to have an average of 100 ft. candles. Although high intensity lighting is required for much of the detailed work, areas such as aisles, storage, etc. where very little work is performed needed only a fraction of what was used. These types of areas accounted for approximately 50% of the lighting space and it was noted that further investigation in this area should be pursued.
The air conditioner was also noted as consuming large quantities of energy. In this particular plant the air conditioning cycle could be cited as a "textbook example." The building, because of the heat generated by the running of the motors and the lighting, had achieved a high internal heat gain that required the building to be cooled. Because the building contained no windows, the air conditioner was used to reduce the temperature. Even in times when the outside temperature was 30° and below, the air conditioner inside was operating. For these reasons it was determined that an economizer cycle be reviewed to see if it could be economically justifiable. The economizer cycle allows cooler air from the outside to enter through proper ducts and dampers rather than use an air conditioner.

In the principal air conditioned areas (cutting room, sewing room) the roof structure consisted of steel framing, 2" cement fiber decking and a built up roof. The roof was measured as giving off heat at the rate of approximately 10 BTU/sq. ft./hr. These measurements resulted in a study of roof insulation.

As mentioned previously, the dryer and boiler required little energy compared to other equipment such as the lights and air conditioner. Several possibilities, however, were investigated. Boiler tune-ups to maintain the efficiency of the boiler were suggested as well as conversion from natural gas to oil in the boiler. The latter idea was presented primarily to reduce vulnerability to gas curtailments rather than to save energy.

Recommendations

The above areas and ideas were researched and the following recommendations were given:
Air Conditioning

An overall analysis of the cutting room and the sewing room air conditioning systems indicated that a considerable savings in operating costs should be achieved by the use of an "economizer cycle". As detailed engineering design work has not been performed, exact costs and projected savings are not possible, but it is believed that a reduction of 20% in air conditioning cost is achievable and this would approximate $8,000 per year in savings.

In air conditioning terminology "economizer cycle" describes a technique for the utilization of outside air for cooling when the air temperature is suitable. The prime applications for air conditioning systems to be equipped with economizer cycles are facilities that have a large internal heat gain from people, lights, and equipment, such as large office buildings and major department stores. For these types of facilities, the "economizer cycle" has become almost standard. Georgia Tech has a number of buildings which utilize this technique.

In essence, when a particular building air conditioning load is such that cooling is required even though the outside air temperature is 65°F or lower, it is more economical to shut down the air conditioning refrigeration compressors and open up a large outside air duct connection to bring in cool outside air. This is done automatically.

The air conditioning load at the plant meets the "economizer cycle" criteria as the plant has a high internal heat gain from people, lights, and electric motors such that cooling is required nearly year around. It is therefore our recommendation that a detailed engineering analysis and design be prepared by a consulting engineering firm experienced in this field.
Roof Insulation

An analysis of the air conditioning load for the cutting/sewing room area indicates that by insulating the ceiling, the air conditioning design load would be reduced by 21%. We do not have sufficiently detailed data to calculate the exact effect this would have on air conditioning cost but we believe the savings would be approximately $16,000 plus the cost of installation.

The floor structure now consists of steel framing, 2" cement fiber decking with a built up roof. This construction has a heat gain of approximately 10 BTU per square foot under design conditions. With the addition of 6" of fiberglass insulation the heat gain would be reduced to approximately 2 BTU per square foot.

### Air Conditioning in Tons

<table>
<thead>
<tr>
<th></th>
<th>Installed Tons</th>
<th>Roof Load Existing</th>
<th>Roof Load Insulated</th>
<th>Net Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting Area</td>
<td>120</td>
<td>42</td>
<td>8.2</td>
<td>33.7</td>
</tr>
<tr>
<td>Sewing Area</td>
<td>240</td>
<td>52</td>
<td>10</td>
<td>42</td>
</tr>
</tbody>
</table>

Net Savings 75.7 Tons

We understand that the present roof may require extensive reworking in the near future. We mention this as it is possible to incorporate roof insulation as part of the new roof design. However, it is our opinion that fiberglass batt insulation installed below the roof, independently of the roof structure, is far more cost effective.
Lighting

The lighting in the sewing and cutting areas is provided by 2 tube 96 inch fluorescent fixtures with an average illumination at 90 foot candles. With the exception of certain critical areas it is our opinion that a foot candle level of 30-40 would be satisfactory.

<table>
<thead>
<tr>
<th>Lighting Cost—3.5c/KWH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing</strong></td>
</tr>
<tr>
<td>Tubes Installed</td>
</tr>
<tr>
<td>Sewing</td>
</tr>
<tr>
<td>Cutting</td>
</tr>
</tbody>
</table>

$11519

Air Condition Load Reduction

3840

TOTAL $15359

The above table was calculated to show the effect of a 50% reduction in light intensity. The last item indicates the savings that would accrue due to a reduction in the air conditioning load from the heat given off by the lights.

It is recognized that one of the factors constituting a satisfactory lighting system is the subjective feelings of the persons affected. This can create acceptance problems. However, many programs of light reduction have been implemented and well accepted by people who were fully informed of its purpose.
Steam Boiler

The plant steam boiler is natural gas fired without oil standby. As steam is essential in the shirt finishing operation, it is recommended that the capability for burning No. 2 fuel oil be added.

The boiler combustion (air-fuel mixture) has not been set by combustion test instruments. This is recommended and based on past experience a 5% reduction in fuel consumption could be anticipated.

Shirt Steaming Operations

In the shirt steaming operations, steam is blown into the garment to be followed by air for drying. An unknown but significant quantity of the heat and humidity generated by this operation is not captured by the existing vent hood system and escapes into the space. As this constitutes a direct load on the air conditioning system, appropriate measures should be taken to reduce this condition to a minimum.

Stage of Implementation

Follow-up work indicated that management was very receptive to all ideas presented. Considerations had to be given to capital expenditures required and employee reaction. However, a plan was developed by management to have all the recommendations implemented, and to date, all the recommendations are in the process of being installed although none have been completed.
Description

This firm manufactures apparel products including quilted jackets, life jackets and sleeping bags. The firm employs over 200 persons. The major energy consumed is electricity which is used in all the machinery. Natural gas is used for space heating only.

Analysis

This firm initially requested technical assistance in energy conservation and to reduce airborne kapok lint in the jacket stuffing area. The solution to these problems involve machine modifications with better conveyor designs, better seating and change to better bearings. This caused a reduction in motor sizes from 32 HP to 8 HP. The firm was planning to purchase a $20,000 air filtering system requiring a 50 HP electric motor. This system is no longer needed and a direct savings in electricity costs of $4,700 per year is anticipated.
APPAREL INDUSTRY

TECHNICAL ASSISTANCE CASE 5.3

Description

This company manufactures bridal slips and plastic suit bags in its 8,000 square foot facility for a national market. It has 40 employees. Based on an annual sales volume of about one million dollars, energy usage and costs for the year are as follows: electricity - 61,160 KWH - $2,983; LPG - 5,245 gallons - $1,860.

Analysis

At the company's request, a visit was made to the plant to determine why the air-conditioning system was not cooling the plant on hot days. The air conditioner was found to be operating properly, but was not able to cool the building below 80°F.

It was observed that building doors were being left open, and that a newly installed paint drying oven was giving off enough heat to overload the air-conditioning system.

The following recommendations were made:

1. Isolate the drying oven area to prevent overloading of air conditioner.
2. Keep all plant doors closed except when entering/leaving.
3. Change the air-conditioning filters on a regular basis such as at least once per month.
Introduction

This major group includes the manufacture of pulps from wood, paper and paperboard, paper bags, paper boxes and envelopes.

This group is further divided into the following categories:

1. Pulp mills.
2. Paper mills.
3. Paperboard mills.
5. Paperboard containers and boxes.

Nationally this industry group employs approximately 646,000 people and contributed to a value added figure of nearly $19 billion with a value of shipments approaching $42 billion. In Georgia nearly 24,200 people employed by this industry in 1972 contributed to $601 million value added and produced $1.3 billion in shipment value.
Description

This firm is a producer of papier mache egg cartons supplied to various egg processing plants around the country. Employing 100 people, the plant operates continuously, 7 days a week, achieving a production of 15,000 tons per month.

Selection of Company

Criteria for selection of case study companies were formulated by the project staff and by the area office staff and included the following major categories:

1. Use of Energy Intensive Processes,
2. Size of Total Industry Segment (potential for transfer of methodology to other similar companies),
3. Management Interest,
4. Size of Company in Industry Segment,
5. Degree of Existing Sophistication in Energy Conservation,
6. Potential Impact of Energy Curtailment on Employment,
7. Potential Cost Savings to be Derived from Energy Conservation.

Using these criteria a master list of approximately 100 firms representing those that were potential case studies was compiled. Subsequently, several meetings involving project staff and area office representatives were held and the list of 100 firms was narrowed to the ten which showed greatest promise as case study firms. This firm was inclusive within the ten firms selected.

Initial Contact

Initial contact was made by a field office representative of Georgia Tech. In talking to the plant manager the project goals and objectives
were explained and general company interest was observed. Their response to the project indicated that their interest as well as cooperation was present.

Process Description

Raw material is obtained in the form of rolled unprinted newspaper. Occasionally when this is unavailable printed newspaper is used creating additional production costs in its ink removal. The paper is mixed in city water with chemicals added. The paper and water mix to form a slurry which is then dumped in a forming machine. The forming machine consists of a large mold approximately 10' wide which rotates down into the slurry. The vacuum inside the roll sucks the thin coating of papier mache on its surface and as the wheel rotates to the top of the machine, the vacuum has dried the product enough so that the carton becomes self-supporting. As the mold reaches the proper angle the air pressure blows the carton off onto a conveyor. The conveyor then travels through a 200 ft. long drying oven. The oven is direct fired with oil and natural gas and although the temperature varies within the oven, the temperature averages 350°F.

Once the product leaves the dryer it goes through a printer where it is printed with the various company's name, product description and classification. The cartons are then stacked, packaged, and stored until shipment.

Observations Made in Plant

On the two day plant trip to this firm the first day was set aside to discuss project goals and energy conservation in general. An initial tour was taken through the plant and those areas which would benefit the most from energy conservation were observed. These areas were noted as dryer operations,
exhaust heat recovery - water heating, and solar heating.

The second day was spent detailing these areas. This included obtaining measurements, gathering nameplate data, and gathering information concerning the general process. Areas concentrated on in the operation of the dryer included physical construction, motor sizes, air flow, burner types, burner controls, exhaust fans, and humidity controls.

In considering heat recovery from the exhaust, detailed measurements were taken. This involved obtaining the exhaust temperature, exhaust CFM, exhaust humidity, exhaust heat (BTU/hr), total exhaust heat of inlet air and energy used (BTU/hr and Therms/ton). All these data were correlated to determine the effectiveness and feasibility of heat recovery.

Previous work had been done in the area of solar energy. Therefore the first step involved was an examination for solar heat adaptability. Measurements concerning the amount of heat which would be required were obtained and compared to the amount of heat which could be provided with an economically installed system.

Items such as motors were disregarded due to the limitation on the savings which could be accomplished. Lighting, heating, and air conditioning were already operating at minimum level and were therefore disregarded for the purpose of the project.

Analysis

Dryer Operations. Analysis of dryer performance data indicates that significant energy savings should be possible by reducing the quantity of exhaust air and its temperature by increasing counter flow dryer operations.

Currently, product dryer efficiency is being extensively studies. Georgia Tech has a research project for the study of energy use in the textile industry and as a part of this work an in-depth analysis of drying is being made. Though this work is not complete, information has been developed
which should have applicability to this situation.

1. Excess Exhaust Air

   It is almost axiomatic that industrial dryers are operated with ex-
   cessive air exhaust unless carefully set up. Calculations have shown that
   is some drying operations three times as much energy in needed to heat up
   the nitrogen as is required for moisture removal. Hence exhaust air should
   be held to the minimum consistent with dryer performance.

2. Counter flow

   Dryers are essentially heat exchange devices and for heat exchangers
   the most efficient performance is obtained by counterflow conditions as this
   gives the highest mean temperature difference. Except to the degree prescribed
   by process restrictions, the product and drying medium should proceed counter
   to each other through the dryer.

3. The specific humidity of the exhaust gases is less of a dryer
   performance factor than the dry bulb reading at normal dryer temperatures.
   This can be understood when it is recognized that product drying can be
   achieved with 100% steam.

4. Instrumentation

   Most industrial dryers are not sufficiently instrumented and controlled
   and adversely affect product quality and operating costs.

5. Mechanical Water Extraction

   Mechanical extraction of water from the product by the use of pressure,
   vacuum and/or centrifugal force has proven less expensive than removal by heat
   when the moisture content of the product is greater than 35%.

6. Radiant Drying

   The drying process should be studied as to the applicability of
electric radiant heat either to do part of the drying or to completely replace
the present direct fired system as the future availability of natural gas for
industrial drying is in doubt.
Preliminary calculations of the potential energy savings that saved result from the above mentioned energy conservation ideas are given below. A rough estimate of the dollar savings that would result from present fuel prices is also calculated. The cost of buying and installing the equipment and the approximate payback indicator the attractiveness of the investments.
Calculations

Savings due to Excess Air Control

BTU Requirement for the dryer that is presently the most efficient:

\[
\begin{align*}
\text{Moisture Removal} & = 5.24 \times 10^6 \text{ BTU/hr} \\
\text{Carton Heating} & = 0.12 \times 10^6 \text{ BTU/hr} \\
\text{Heating Makeup Air} & = 3.48 \times 10^6 \text{ BTU/hr} \\
\text{Housing Loss (Estimated)} & = 0.10 \times 10^6 \text{ BTU/hr} \\
\text{TOTAL} & = 8.94 \times 10^6 \text{ BTU/hr}
\end{align*}
\]

Present Firing Rate

\[
= 14.90 \times 10^6 \text{ BTU/hr}
\]

Estimated Saving/dryer

\[
= 4.00 \times 10^6 \text{ BTU/hr}
\]

\[
= \$43,200/yr
\]

For 3 dryers estimate saving

\[
= \$129,600/hr
\]

Dryer # 1

\[
\begin{align*}
\text{Production Rate} & = 0.867 \text{ tons/hr} \\
\text{Exist Moisture 8\%} & = (0.08 \times 0.867) \\
& = 0.06936 \text{ tons/hr} \\
\text{Dry Weight of Carton} & = (0.02 \times 0.867) \\
& = 0.79764 \text{ tons/hr} \\
\text{Inlet Moisture 75\%} & = \frac{75\% \times 0.92 \times 0.867}{25\%} \\
& = 2.39294 \text{ tons/hr} \\
\text{Moisture Removed} & = (2.39294 - 0.06936) \\
& = 2.32356 \text{ tons/hr} \\
& = 4.647 \text{ lbs/hr}
\end{align*}
\]

BTU's required to remove moisture

\[
= \text{mass/hr (Latent heat + Sensible heat) to heat from 60°F to 210°F} \\
= 2.32356 \text{ tons/hr} (970 + 150) \text{ BTU/lb} \times 2000 \text{ lbs/ton} \\
= 5.204 \times 10^6 \text{BTU/hr}
\]

-152-
BTU's required to heat carton/hr

\[= \text{mass/hr} \times \text{Specific heat} \times \text{Temperature Rise}\]
\[= 0.79764 \text{ tons/hr} \times 2000 \frac{\text{lbs}}{\text{ton}} \times 0.5 \frac{\text{BTU}}{\text{lb} \cdot \text{°F}} \times 150 \text{°F} \]
\[= 0.119646 \times 10^6 \text{ BTU/hr} \]

We chose a humidity ratio (Water vapor/Dry air) of an average of 0.12 which was the quality of air that could perform the drying satisfactorily. We feel this should work since the present drier module #1 exhaust humidity was 0.195 on 3-23-76 and 0.19 on 1-2-76 which is much higher than what we have assumed.

Assuming \[
\frac{\# \text{ Vapor}}{\# \text{ Dry Air}} = 0.12
\]

# Dry heat required \[
= \frac{2.32356}{0.12} \frac{\text{tons water removed/hr}}{\text{hr}} \times 2000 \frac{\text{lbs}}{\text{ton}}
\]
\[= 38725 \text{ lbs/hr}\]

BTU's required to heat air from 80°F to 450°F = mass/hr \times \text{temp. rise} \times \text{specific heat}

\[= 38725 \text{ lbs/hr} \times 370 \text{°F} \times 0.243 \frac{\text{BTU}}{\text{lb} \cdot \text{°F}} \]
\[= 3.48185 \times 10^6 \text{ BTU/hr}\]
Counterflow Firing

Our specific recommendation is to establish to the degree possible counterflow conditions within the dryer in accordance with Figure 8. The limit to which counterflow can be achieved must be established experimentally. For instance, one known limit which will occur is excessive recondensation. The experiment should proceed with care as the oxygen content must be maintained for combustion.
COUNTERFLOW FIRING

1. FIRE ZONES IN REVERSE ORDER
   ZONE 4 HEAVIEST
   ZONE 1 LIGHTEST

2. REDUCE OR STOP EXHAUST FANS IN REVERSE ORDER
   EXHAUST FAN 3 FIRST
   EXHAUST FAN 2 NEXT
   EXHAUST FAN 1 LAST

FIGURE 8. COUNTERFLOW FIRING IN DRYER
Exhaust Heat Recovery--Water Heating

In studying any given process for energy efficiency improvement, one area that should be considered is recovering of useful energy from exhaust streams. In this instance an economizer (water heater) was investigated and the following calculations performed. Please note the accuracy of these calculations is limited by the assumptions.

**Savings Due to Economizer**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat recoverable from moist exhaust gases</td>
<td>$3.268 \times 10^6$ BTU/hr</td>
</tr>
<tr>
<td>De-inking process requirement</td>
<td>$3.984 \times 10^6$ BTU/hr</td>
</tr>
<tr>
<td>Saving by heat recovery</td>
<td>$4,412$/month ($52,944$/yr)</td>
</tr>
</tbody>
</table>

**Heat Recovery - Economizer**

With the assumption that the acceptable humidity ratio is 0.12

- **Dry Air**: 38725 lbs/hr
- **Moisture**: 4647 lbs/hr

Heat recoverable from 38725 lbs of Dry Air in cooling from 450°F to 160°F

\[
\text{Mass} \times \text{Temp drop} \times \text{Specific Heat} = 38725 \text{ lbs/hr} \times 290\degree F \times 0.243 \text{ BTU/lb} \degree F = 2.72895 \times 10^6 \text{ BTU/hr}
\]

Heat recoverable from 4647 lbs of moisture in cooling from 450°F to 160°F

\[
\text{Mass} \times \text{Temp drop} \times \text{Specfic heat}^* = 4647 \text{ lb/hr} \times 290\degree F \times 0.4 \text{ BTU/lb} \degree F = 0.5394 \times 10^6 \text{ BTU/hr}
\]

*The latent heat was not used just be to conservative

Total heat recoverable = $3.268 \times 10^6$ BTU/hr
If the gas was cooled only to 210°F

Total heat recoverable = $2.708 \times 10^6$ BTU/hr

A schematic drawing of an economizer installation is shown in Figure 9. A current rule of thumb is that a natural gas exhaust stream to water economizer should prove economically viable for a process operated over 3700 hours per year.
TO ATMOSPHERE

COLD WATER IN

ECONOMIZER

HOT WATER

HOT WATER STORAGE

HOT WATER TO PROCESS

DRYER EXHAUST

DRYER

FIGURE 9. ECONOMIZER SCHEMATIC
Solar heating was investigated for applicability to the product drying process. The use of solar energy is now of wide interest with the increasing cost of fossil fuels.

As related to this project the following factors were among those considered:

1. Direct heating of air is one of the lowest cost solar energy collector systems.
2. The product drying process under consideration utilizes air both for product drying and combustion.
3. There is extensive unencumbered roof area available for collector location.
4. As experience with practical applications of solar energy is limited, this application must be considered experimental. Therefore a design restriction of 10% of the load from one dryer was adopted.

In developing the design the following quantities and calculations were used.

**Collector Size and Cost**

Typical Dryer Input = \(9 \times 10^6\) BTU  
10% of Dryer Input = \(9 \times 10^5\) BTU

Solar Energy Availability - Yearly Average

\[
\begin{align*}
\text{750 BTU per sq ft per day} \\
\text{75 BTU per sq ft per hour} \\
\text{12,000 sq ft Collector Area} \\
\text{12,000 sq ft X $1.50} = \$18,000 \text{ Collector Cost}
\end{align*}
\]
Energy Value

\[
\frac{750 \text{ BTU}}{\text{day}} \times \frac{365 \text{ day}}{\text{yr}} = \frac{273,750 \text{ BTU/ft}^2}{\text{year}}
\]

\[
273,750 \times 12,000 \text{ ft}^2 = 3,285 \times 10^6 \text{ BTU/yr}
\]

\[
3,285 \text{ Therms} \times 15\text{c/therm gas cost} = \underline{4,927.50} \text{ per year energy value}
\]

Air Quantity and \( T \)

\[
H = 0.018 \times \text{CFM} \times \Delta T \times 60
\]

\[
900,000 = 0.018 \times 20,500 \times \Delta T \times 60
\]

\[
\Delta T = 40.6^\circ \text{F}
\]

Note - CFM taken from No.2 dryer date of 3/23/76

A roof collector of corrugated fiberglass panels in accordance with Figure 10 is of a type that should be suitable. No actual design work has been performed to define the panel height above roof, air flow patterns or support structure.

The collector cost of $1.50 per sq ft used in the calculation was estimated based on other work and a panel cost of 40 cents per sq ft.
CORRUGATED FIBERGLASS PANELS

CONTROL AIR INLET

ROOF LINE

DUCT

DRYER INLET

FIGURE 12.
SOLAR AIR PREHEATER FOR DRYER
Stage of Implementation

Currently the plant manager is implementing those recommendations concerning the dryer operation. While solar heating has not been initiated in the plant, it is under corporate consideration. Discussions are currently underway between the firm and distributors of heat exchange equipment. Management is also considering the use of larger quantities of printed paper which would require increased amounts of hot water. If such is the case, the heat exchanger would prove to be more feasible.
Introduction

This major group includes establishments engaged in the harvesting and processing of wood materials and manufacturing finished articles made entirely or mainly of wood or its substitutes.

This group is divided into the following categories:

1. Logging Camps, Log Contractors
2. Sawmills and Planing Mills
3. Millwork, Plywood, Structural Members
4. Wood Containers
5. Wood Buildings and Mobile Homes
6. Miscellaneous Wood Products

Nationally, this industry employed approximately 675,000 persons in 1974 and had a value added total of $11.6 billion. At the same time the value of industry shipments was nearly $27 billion. In Georgia the lumber and wood products industry employed 28,000 workers in 1972 and had a value added figure of some $368 million with sales approaching $920 million.

The lumber and wood products industry consumed about 2% of the total energy consumed in the United States in 1974 by manufacturers. This was approximately equal to 271,000 billion BTU's. For the same year, in the state of Georgia, this industry accounted for 3.8% of all energy consumed by manufacturers of approximately 9,900 billion BTU's. Of this amount electricity accounted for 18.4%, fuel oil 9.4%, natural gas 35.6% and all other fuels 36.6%. The large amount of natural gas used by this industry makes it vulnerable to economic hardships if its supply of natural gas was curtailed.
Description

This firm produces particle board from wood chips and binders. The plant operates three shifts per day seven days per week and employs approximately 350 persons. The physical plant is approximately five years old and is well maintained. An active energy conservation program has been underway for two years and has undertaken a number of small "housekeeping" measures and three significant projects requiring capital expenditures. These include:

1. Utilization of boiler exhaust gases as make-up for direct fired dryers,
2. Installation of a heat exchanger in the boiler blowdown line,

Analysis

In addition to these projects several other potentials have been identified by the project staff and are being presented to the company. Enthalpy controls for use with gas fired dryers are being considered as replacements for currently used dry bulb temperature controls. Belt conveyors are being studied for use in replacing energy inefficient pneumatic transports at six points in the process. Conversion of fluorescent lights to high pressure sodium lights, installation of skylights, and installation of photo-cell control of outside lights are all being considered as ways to reduce lighting costs. Demand control through operation of sanding operation during off-peak hours and installation of on-site demand recording meters is being evaluated. Natural
gas conservation consumption can be reduced through installation of press-
dryer steam line insulation and through control of boilers with combustion
instrumentation.

All of the above ideas were presented to the company. They are reviewing
them and will plan implementation in the near future.
Description

This firm produces wire-bound wooden boxes. Their facilities are disbursed over large acreage with many separate buildings. Their primary energy cost is electricity since they burn their own wood waste to generate steam. The steam is utilized in their two veneer dryers. We were specifically asked to investigate the potential for increasing the efficiency of their veneer dryers. Even though the dryers for the facility utilize steam generated by burning their own wood waste, they have other facilities where purchased fuel is used to generate steam for similar dryers.

Analysis

A plant tour was conducted and the boiler - dryer system was analyzed. Also, the dryer manufacturer was contacted for his recommendations on efficiency improvement. The boiler manufacturer was also contacted. The following recommendations were furnished.

1. Reduce heat losses of steam lines and dryer cabinets with better insulation.
2. Reduce leakage around doors and feed and discharge ends of dryers.
3. Adjust stack draft for slightly positive pressure within the dryer cabinets.

An engineering and economic analysis was made relative to these recommendations. The results indicated a 14% increase in dryer efficiency could be expected.
Due to the plants' use of wood waste to generate steam and the nature of the request for assistance, no overall data survey was conducted.
Description

This is a large lumber operation that includes pressure wood preserving. The facilities are dispersed over a large land area. They employ approximately 440 persons. They primarily serve the southeastern market. Their purchased energy is primarily electricity. They have refuse boilers that burn their own wood waste to produce steam for their operation.

Analysis

A plant tour was conducted for the purpose of identifying areas of potential energy savings. Due to the nature of this operation, we were not able to identify any specific areas with energy savings potential. An overall energy management program designed to control the many areas of small energy uses was recommended.
Description

This is a firm that processes wood from cut logs into wire bound wooden crates. They also chip logs that are not suitable for crates and sell the chips. The facilities consists of many buildings dispersed over a large acreage. They have approximately 260 employees. They produce approximately six million (18" L by 12" H by 12" W standards) crates annually and they serve the national market. Their major energy usage is for electricity and their annual cost is approximately $100,000. They also use a small amount of natural gas primarily for space heaters. Their natural gas bill is approximately $2,000 annually. This firm has a refuse boiler in which they burn bark and other wood waste that they generate to produce steam for use throughout their plant facility.

Analysis

This operation has many electric motors dispersed throughout their facilities. One large motor was identified for analysis. This was a 800 HP chipper that chips logs and related equipment transfers the chips to rail cars. A engineering and economic analysis was conducted on this chipper to reduce electrical load by eliminating the shaft connected fan. An estimated $3,000 per year on energy savings could be realized with this modification. It was also suggested due to the electrical loads that the firm adopt an energy management system to gain control of their energy usage. It is felt that 25% savings might be obtained from an effective management system.
Introduction

This group includes those establishments engaged in producing basic chemicals and manufacturing products by predominantly chemical processes.

This major group is further subdivided into the following categories.

1. Industrial inorganic chemicals.
2. Plastic materials and synthetics.
3. Drugs.
4. Soap cleaners and toilet goods.
5. Paints and allied products.
6. Industrial organic chemicals.
7. Agricultural chemicals.
8. Miscellaneous chemical products.

Nationally about 866,000 people are employed by this industry group. The value added in 1972 was approximately $44.5 billion with a value of shipments of nearly $811 billion. In Georgia the 13,700 people employed in this industrial group contributed to a value added figure of $560 million with a shipment value of $1.14 billion.
CHEMICAL & ALLIED PRODUCTS INDUSTRY

TECHNICAL ASSISTANCE CASE 8.1

Description

This is a large chemical plant that produces bulk pharmaceuticals. There are many buildings and facilities disbursed over a large area. They have approximately 200 employees. Their annual energy costs are: electricity - $600,000; natural gas - $425,000; #6 fuel oil - $75,000.

Analysis

A plant tour was conducted and energy conservation potential at the power plant and the air conditioning system for building #10 were selected for analysis. The power plant data was analyzed. The overall efficiency of the plant was high. The possibility of installing boiler air preheaters was studied but not recommended due to low stack temperatures.

An engineering and economic analysis was conducted on the air conditioning system for building #10. This 60 ton system presently utilizes 100% outside air. It was recommended that air recirculation be investigated. If recirculation is not possible, heat recovery was recommended. The expected annual savings were given as follows:

- 75% recirculated air - $3,200
- Heat recovery (heat pipe) - $1,461

Technical literature on heat recovery equipment was furnished.
CHEMICAL & ALLIED PRODUCTS INDUSTRY

TECHNICAL ASSISTANCE CASE 8.2

Description

This firm processes sulphur into ground sulphur and sulphur solution for the regional market. They have twenty-five employees. We were specifically requested by the firm to provide assistance in improving the CO₂ generating system. Therefore, no comprehensive energy survey was conducted.

Analysis

The CO₂ generating system was studied. The system utilizes a fuel oil burner and the exhaust gases (including CO₂) forced into the Raymond mill to keep the oxygen level around 4%. The problems with the system are the energy costs ($3/hr.) and lack of control.

An engineering analysis was performed. It was recommended that the present system be used to prime the mills only, and purchased CO₂ in cylinders be utilized to meter CO₂ into the system to offset system leaks. It was pointed out that the system must be upgraded and all leaks be eliminated for efficiency.

It was estimated that this modification would result in a $6,000 annual energy savings.
SIC 34, FABRICATED METAL PRODUCTS

This industry group includes establishments engaged in the manufacture of fabricated ferrous and non-ferrous products.

This major group can be further subdivided in the following categories:

1. Metal cans and shipping containers.
2. Cutlery, hand tools and hardware.
3. Plumbing and heating products.
4. Fabricated structural metal products.
5. Screw machine products, bolts, etc.
6. Metal forgings and stampings.
7. Metal services.
8. Ordnance and accessories.

Nationally the fabricated metal products industry group employs about 1.6 million people with a value added figure of $35 billion and a sales value of $67.6 billion. In Georgia there are 19,200 employees in this industry group which has a value added figure of $343 million and a sales value of $775 million.
Description

This firm occupies 63,300 square feet facility that is completely air-conditioned. Essentially a large machine shop type operation they produce butterfly valves for the national and international markets. They have 125 total employees and operate their machine shop department on three shifts five days per week. Their assembly department only operates one shift. Their sales volume is approximately $8 million annually. Their energy usage is primarily electrical and their electrical costs amount to approximately $50,000 annually. They also use natural gas, primarily for space heating, and this cost is $4,000 annually.

Analysis

A tour of their plant facility was conducted. Major energy using areas were identified for investigation relating to energy savings potential. Engineering analyses were made on the following:

1. Reducing or eliminating the amount of heating and cool air being exhausted through the plant spray booth.
2. Evaluating the feasibility of utilizing economizer cycles on the air conditioners.
3. Evaluation of savings benefit of adding additional roof insulation.

Recommendations were also provided on reducing lighting levels and more efficient operating procedures of the air conditioning system. It was suggested that the firm adopt an energy management system.
The above areas of evaluation included calculations of estimated energy savings. Also, cost of installing the economizer cycles on the air conditioner were provided. Estimated savings of $3800 annually was calculated for the paint booth modification. A $700 per year savings could be realized by installing economizer cycles on air conditioners. Adding additional roof insulation would result in a $1200 annual savings.
SECTION X

CASE STUDY SUMMARIES

Introduction

In the course of the project a number of energy conserving ideas and methods evolved while visiting individual plants. Many of these potentially attractive projects could be applied to most plants within the industry sector. They have been collected and presented by industry sectors in this section. The case study summaries contain a description of equipment under consideration, measures to be taken to save energy, calculations of potential energy savings, approximate capital investments required for the project and return on investment or payback.

It should be noted that in a number of cases since the equipment did not have adequate metering, the calculations were based either on spot measurements or nameplate data with adjustments made based on experience. These calculations are more or less first approximations and are intended more to portray the potential that the ideas represent rather than to generate numbers suitable for engineering specifications.

It is recommended that a detailed set of data be gathered and in-depth analysis done for each concept before deciding on implementing them.
### CASE STUDY

<table>
<thead>
<tr>
<th>SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
</tr>
<tr>
<td>Process</td>
</tr>
<tr>
<td>Modification</td>
</tr>
<tr>
<td>Cost of Modification</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
</tr>
</tbody>
</table>
A common method of dyeing carpet is the use of the atmospheric dye beck. The dye beck by necessity exhausts steam to the atmosphere. Approximately 50% to 60% of the steam used in dyeing is exhausted through the roof. This loss can be reduced by dampering the exhaust fan and opening the damper to the point where steam is no longer entering the room. We believe that at least 50% of the exhaust steam can be eliminated by dampers which would save 25% of the steam used in dyeing. At your plant the following evaluation was made:

<table>
<thead>
<tr>
<th>Steam for dyeing</th>
<th>60,000 lb/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust</td>
<td>30,000 lb/hr</td>
</tr>
<tr>
<td>Exhaust Savings</td>
<td>15,000 lb/hr</td>
</tr>
<tr>
<td>$30 per hr</td>
<td></td>
</tr>
<tr>
<td>$210,000 per year</td>
<td></td>
</tr>
</tbody>
</table>

This system needs to be coupled with the proper steam controls to the dye beck. The accomplishment of exhaust reduction may be obtained by one or more of the following methods:

- Stack Dampers
- Fan modifications
- Sparge modifications
- Dye beck doors
- Steam controls
CASE STUDY

SUMMARY

Industry: Textile

Process: Dye Beck

Modification: Spent dye liquor heat recovery

Cost of Modification: $100,000

Estimated Yearly Savings: $120,000
Spent Dye Liquor Heat Recovery

One of the largest requirements for thermal energy in the textile industry is the boiling of the dye liquor during the drying process. Since the liquid should be at 210°F for dyeing and a considerable amount of water is used, the costs are high. These energy requirements can be reduced if the heat in the spent dye liquor can be reclaimed.

Although standard heat exchangers are generally used for this service, their performance in dye liquor has proven poor since coefficient of heat transfer values range from 20 to 100 BTU/hr°F ft². There are systems used in other industries that can be used to reclaim this heat. One such system would be flash evaporation. This would eliminate the fouling problem present with heat exchangers.

The following evaluation was made on your dyeing operation:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dye Liquor Quantity</td>
<td>350,000 gal/day</td>
</tr>
<tr>
<td>Dump Temperature</td>
<td>190°F</td>
</tr>
<tr>
<td>Available Heat</td>
<td>80 BTU/lb</td>
</tr>
<tr>
<td></td>
<td>233 M BTU/day</td>
</tr>
<tr>
<td>Savings</td>
<td>$120,000 per yr.</td>
</tr>
<tr>
<td>Cost</td>
<td>$100,000</td>
</tr>
</tbody>
</table>
**CASE STUDY**

### SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Textile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Boiler</td>
</tr>
<tr>
<td>Modification</td>
<td>Install Economizer</td>
</tr>
</tbody>
</table>

Cost of Modification $25,000

Estimated Yearly Savings: $28,700
Boiler Stack Gas Heat Recovery

Considerable savings can be realized by preheating the boiler make-up before it is admitted to the deaerator as shown in the attached graph. This can be accomplished with a heat exchanger in the boiler stack as shown below.

Boilers number 2 and 3 connected to a common stack.

Combined capacity of boilers 86,000 lb./hr.
Make-up percentage 100%
Approximate deaerator inlet water temperature 60°F
Deaerator outlet temperature 215°F

<table>
<thead>
<tr>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack gas</td>
<td>485°F</td>
</tr>
<tr>
<td>Make-up</td>
<td>60°F</td>
</tr>
</tbody>
</table>
Assumptions

Fuel--30% #6 oil, 70% gas  
Average cost of fuel--$1.71/mm Btu.  
Operation--7,000 hr./yr.  
Average Load--62,000 lb./yr.

Approximate Cost of Heat Recovery System $45,000  
Annual Fuel Savings $67,000  
After tax savings $35,000  
After tax payback period 15 months
Boiler Exhaust Gas Heat Recovery

Sample Calculation

Enthalpy of water at 215°C water = 183.2 Btu/lb.
Enthalpy of saturated steam at 125 psi = 1191.6 Btu/lb.
Enthalpy difference = 1008.4 Btu/lb.

Assuming a boiler efficiency of 80%

Heat input to the boiler = \frac{1008.4}{0.80} = 1260.5 Btu/lb. of steam

Heating Value of Natural Gas

= 1000 Btu/cu.ft.

Theoretical air requirements for combustion

= 10.0 cu.ft./cu.ft. of gas

Assuming 20% excess air in combustion

Air requirements = 12.0 cu.ft./cu.ft. of gas

Fuel requirement/lb. of steam = \frac{1260.6 \text{ Btu/lb. steam}}{1000 \text{ Btu/cu.ft.}}

= 1.2605 cu.ft./lb. of steam

Hence air requirement

= 1.2605 \times 12 \text{ cu.ft./lb. of air/lb. of steam}

= 15.126 \text{ cu.ft./lb. of steam} \times 0.075 \text{ lbs./cu.ft.}

= 1.1345 \text{ lbs. air/lb. of steam}

If the exhaust temperature was 600°F and was reduced to 225°F in a heat exchanger

Energy Recoverable = 1.1345 \text{ lbs. air/lb. steam} \times 0.2455 \text{ Btu/lb. air°C F} \times 375°F

= 104.44 \text{ Btu/lb. of steam}
Actual Savings in energy assuming a boiler efficiency of 80%  
\[
\frac{104.44}{0.8} = 130.55 \text{ Btu/lb. of steam}
\]

For a 100,000 lbs. steam/hr boiler capacity

Energy Savings  
\[
= 13.055 \times 10^6 \text{ Btu/hr.}
\]
Assumptions:

1) Water enters boiler from deaerator at 215°F
2) Steam pressure 175 psi
3) Fuel combustion with 20% excess air
4) Boiler efficiency 80%
5) Exhaust air dropped to 225 in heat exchanger
6) Energy saved = Energy recoverable / Boiler efficiency
**CASE STUDY**

**SUMMARY**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Textile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Boiler</td>
</tr>
<tr>
<td>Modification</td>
<td>Use of available preheated air</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td>$21,000</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>$35,300</td>
</tr>
</tbody>
</table>
Savings from the Use of Available Preheated Air

Direct savings in fuel could be achieved by using available preheated air for combustion in the boiler. The attached graph shows the energy savings that could be achieved by using various quantities of air preheated by different amounts. In your plant, large volumes of hot air is available from the exhaust of the driers.

Technical Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler capacity</td>
<td>86,000 lb./hr.</td>
</tr>
<tr>
<td>Average load</td>
<td>62,000 lb./hr.</td>
</tr>
<tr>
<td>Temperature of outside air</td>
<td>75°F</td>
</tr>
<tr>
<td>Temperature of drier exhaust air</td>
<td>250°F</td>
</tr>
<tr>
<td>Preheat available</td>
<td>175°F</td>
</tr>
<tr>
<td>Air requirement of boiler</td>
<td>15,630 cfm</td>
</tr>
</tbody>
</table>

Economic Calculations

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy savings</td>
<td>2.954 mm Btu/hr.</td>
</tr>
<tr>
<td>Annual energy savings (7000 hr./yr.)</td>
<td>20,678 mm Btu/yr.</td>
</tr>
<tr>
<td>Dollar savings @ $1.71/mm Btu</td>
<td>$35,360</td>
</tr>
<tr>
<td>Dollar savings after taxes</td>
<td>$18,390</td>
</tr>
<tr>
<td>Estimated cost of modification</td>
<td></td>
</tr>
<tr>
<td>(a) If present burners could be used</td>
<td>$9,000</td>
</tr>
<tr>
<td>(b) If new burners have to be installed</td>
<td>$21,000</td>
</tr>
<tr>
<td>Approximate payback period even in worst case</td>
<td>1 yr. 2 mos.</td>
</tr>
</tbody>
</table>

An added advantage of this system is that particulate matter in the drier air would be combusted and with tighter environmental restrictions this may be the best way to dispose of these particles.
Specific Heat of standard air = 0.24 Btu/lbm°F

Density of standard air = 0.075 lbm/cu.ft.

Sample Calculation

Energy Saved by using 100,000 cfm of air preheated by 100°F

= 100,000 cfm x 100°F x 0.24 Btu/lbm°F x 0.075 lbm/cu.ft.

= 180,000 Btu/min = 10.8 MM Btu/hr.
CASE STUDY

SUMMARY

Industry  Food Processing
Process  Refrigeration
Modification  Heat Recovery from Ammonia Condensor
Cost of Modification  20,000
Estimated Yearly Savings:  $17,000
Ammonia Compressor Heat Recovery

Assume the compressor cooling water required for the ammonia compressors to be approximately 0.075 gpm/ton refrigeration.

Assume 300 tons refrigeration on ice-maker.

Cooling water required = 22.5 gallons per minute

Heat recovery system cost:
- Heat exchangers (2 shell tube heat exchangers in series) $1000
- Piping 200
- Valves 200

Total (does not include labor to install) $1400

Energy Savings:
Assume cooling water is cooled from 100°F to 80°F

(225,000 Btu/hr) ($1,000,000 Btu)(29 hr/day)(242 workdays/yr) = $2090/year

Return on investment = $1,400 = 0.67 years = 8 months
$2090/yr.
AMMNONIA COMPRESSOR HEAT RECOVERY

Jacket Cooling Water

Cooling Water From Compressors
30GPM @ 100°F

Compressors

Makeup Water
65 GPM @ 86°F

Cooling Water Return to Evaporative Condenser
30GPM @ 80°F

Cooling Water Return to Evaporative Condenser
30GPM @ 80°F

Makeup Water
65 GPM @ 70°F

COST OF HEAT RECOVERY SYSTEM:

Heat Exchangers $1000
Piping 200
Valves 200
TOTAL $1400

Scald Tanks
High Pressure Pumps

ANNUAL SAVINGS - (225,000 BTU/hr) X 24 hr/day X 242 days/yr = 1.307 X 10⁹ BTU/yr.

(1.307 X 10⁹ BTU/yr) X $0.16/100,000 BTU = $2090/yr
Heat Recovery From Ammonia Refrigeration

A study was made for the determination of the practicality of heat energy recovery from the plant's refrigeration system. The calculations show that by the installation of a water cooled desuperheater in the ammonia compressor discharge lines 140°F water would be available for boiler water makeup. This would have a dollar value at today's fuel cost of $17,018.00 per year with 4032 hour per year operation. We estimate the equipment installation cost to be $20,000.

It should be noted that in addition to the heat available from desuperheating (1.912 MMBTU/hr) that (11.065 MMBTU/hr) are available from the heat of condensation (the change from gaseous ammonia to liquid ammonia). This heat is only available at 100°F and at the present time we do not know how you could make advantageous use of this source.

All refrigeration systems work on the principal of removing heat from one area, elevating its temperature, and discharging the heat in another area. In your instance the refrigeration system removes heat from the product and discharges this heat to the atmosphere through evaporative coolers on the roof. With the low cost of natural gas and other fuels little attention has been paid to the heat energy which is available from refrigeration systems. Due to the changing fuel situation and the possibility of severe shortages of natural gas, this picture is changing, and there are a number of systems now being devised to use this refrigeration waste heat.
Compressor = 1,500 H.P.
Booster = 900 H.P.
Approximate tonnage = 857 tons. [1.75 comp HP/ton]
Evaporator temperature = -20°F
Condensor temperature = 110°F
Compressor exit temperature = 225°F
Heat absorbed in evaporator = 10.284 MM BTU/hr
Approximate enthalpy change of ammonia in evaporator = 430 BTU/lb
Flow rate of ammonia = 23,900 lbs/hr
Super heat (225°F to 110°F) = 80 BTU/lb
Total Super Heat = 1.912 MM BTU/hr
Approximate enthalpy change of ammonia in condensor = 463 BTU/lb
Heat loss in the condensor = 11.065 MM BTU/hr

Desuperheater System

Install a desuperheater to desuperheat the ammonia of the discharge of the compressor from 225°F to 120°F. This would increase condensor capacity by 10% and hence a lowering of the compressor work by 2%.

Energy Savings Calculations

Heat available from superheated ammonia = 1.673 MM BTU/hr

Energy savings @ 80% boiler efficiency

= \frac{1.673}{0.8}

= 2.091 MM BTU/hr
Working 16 hrs/day, 21 days/month and energy cost of $1.80/MM BTU,

Dollar savings from recovered heat = 2.09 MM BTU/hr x 16 hr/day x 21 days/month x $1.80/MM BTU

= $1,264/month

= $15,168/year

Electricity savings from 2% reduction in compressor work = 0.02 x 1500 HP x 0.746 KW/HP

= 22.38 KW

Energy consumed by additional pumps = 5.76 KW

Working 16 hrs/day, 21 days/month and an average cost of electricity of 2176c/KWh,

Dollar savings in electricity = 16.62 KW x 16 hr/day x 21 days/month x $0.0276 KWh

= $154.12/month

= $1,850/yr

Total dollar savings = $17,018/yr with 4032 hour per year operation

Estimated cost of system = $20,000

Payback period = 1 yr 2 months

Heat Recovery From Condensor

As was mentioned earlier 11 MM BTU/hr of heat is lost in the condensor. A possibility of heat recovery in the condensor would be to replace the existing evaporative condensors with shell and tube condensors and running the water from the condensor to the desuperheater to pick up more heat. This would require major modifications of the existing system and a detailed feasibility study should be done before it can be implemented.
## SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Food Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Chiller tanks</td>
</tr>
<tr>
<td>Modification</td>
<td>Insulation</td>
</tr>
</tbody>
</table>

Cost of Modification $2,320

Estimated Yearly Savings: $2,320
Insulation of Chillers

Surface area of chillers to be insulated is approximately 800 ft.$^2$

Insulation Cost:

1-inch thick "Armaflex" insulation - $1.35/ft^2$
Adhesive - .05/ft$^2$
Protective insulation jacket - 1.50/ft$^2$

Total $2.90/ft^2$

Insulation cost:

$(2.90/ft^2) (800 \text{ ft}^2) = 2320 \text{ (Does not include labor to install)}$

Uninsulated chiller heat gain: 111 BTU/ft$^2$-hr.
Insulated chiller heat gain: 94 BTU/ft$^2$-hr.

Annual savings - Assume ice must be added to maintain chiller temperature.

$(101.6 \text{ BTU/hr-ft}^2)(800 \text{ ft}^2) \div (288,000 \text{ BTU/ton ice}) = 0.282 \text{ tons/hr}$.

$(4/\text{ton ice}) (0.282 \text{ tons/hour}) (8.5 \text{ hr/shift}) (242 \text{ working days/yr.}) = \$2320 \text{ yr. saved.}$

Return on investment: $rac{2320}{2320} = 1 \text{ year.}$
## SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Food Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Steam Distribution</td>
</tr>
<tr>
<td>Modification</td>
<td>Insulation</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td>$1,400</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>$3,100</td>
</tr>
</tbody>
</table>
I. Insulation of Bare Steam Pipe

Bare pipe to be insulated:

- 2" pipe - 300 lin feet = 157 ft$^2$
- 2 1/2" pipe - 75 lin feet = 49 ft$^2$
- 3" pipe - 350 lin feet = 275 ft$^2$
- 4" pipe - 150 lin feet = 157 ft$^2$

Total 638 ft$^2$

Insulation cost: Cost included 1-inch thick fiberglass pipe insulation and aluminum jacketing around insulation.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Insulation $/ft.$</th>
<th>Jacketing $/ft.$</th>
<th>Total Material Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; pipe</td>
<td>$0.80</td>
<td>$0.46</td>
<td>$378</td>
</tr>
<tr>
<td>2 1/2&quot; pipe</td>
<td>$0.90</td>
<td>$0.57</td>
<td>$110</td>
</tr>
<tr>
<td>3&quot; pipe</td>
<td>$0.99</td>
<td>$0.64</td>
<td>$571</td>
</tr>
<tr>
<td>4&quot; pipe</td>
<td>$1.29</td>
<td>$0.90</td>
<td>$329</td>
</tr>
</tbody>
</table>

Total $1388

(Does not include labor to install)

Energy savings: Assume boiler is fired on natural gas with a cost of $0.12/therm with an efficiency of 75%.

Energy Cost = $0.12/therm = $0.16/100,000 BUT $0.75

Heat loss through bare pipe - 387,904 BTU/hr.
Heat loss through insulated pipe - 46,574 BTU/hr.

Energy Saved 341,330 BTU/hr.

Annual Savings:

$(341,330 \, \text{BTU/hr.}) \times (\frac{0.16}{100,000 \, \text{BTU}}) \times (24 \, \text{hr/day}) \times (242 \, \text{days/yr.}) = $3172/yr.

Payback period: \$1388 \div \$3172 = 0.44 \, \text{yr.} \approx 5 \, \text{1/4 months.}
CASE STUDY

SUMMARY

Industry: Primary Metals
Process: Smelting Furnace
Modification: Combustion efficiency

Cost of Modification

Estimated Yearly Savings: $10,800
Melting Furnace

On observing the melting furnace during full load operation it was found that there was an open flame about 5 feet high going through the opening and up the stack. There were also flames leaking out of the doors on three sides of the furnace. All these are a wastage of energy. The flame leakage through the doors could be eliminated by better sealing of the doors. The elimination of the flame through the stack and methods of improving efficiency are discussed in detail below.

An important factor in the efficiency of the furnace is the efficiency of combustion of the gases. Improper combustion gives rise to lower flame temperatures, wastage of fuel and lower heat transfer rates from the flame to the furnace.

The air fuel ratio plays a very important part in the flame length and flame temperature. Fuel rich mixtures give rise to long flames while lean mixtures have short flames. The attached graph shows the effect of air fuel ratio on flame temperature.

Since the furnace does not have metering of the natural gas used and the air used all the calculations below are based on equipment name plate data.

<table>
<thead>
<tr>
<th>Melting furnace burner capacity</th>
<th>15 MM BTU/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat value of natural gas</td>
<td>1000 BTU/CuFt</td>
</tr>
<tr>
<td>Vol. of gas required</td>
<td>$\frac{15 \times 10^6}{1000}$ cfh = $15 \times 10^3$ cfh</td>
</tr>
<tr>
<td>Air required for stoichiometric combustion</td>
<td>$15 \times 10^3$ cfh of gas x 10 $\frac{\text{cfh of air}}{\text{cfh of gas}}$</td>
</tr>
<tr>
<td></td>
<td>= 150,000 cfh of air</td>
</tr>
<tr>
<td></td>
<td>= 2,500 scfm of air</td>
</tr>
</tbody>
</table>
Air requirement with 20% excess air 3,000 scfm

Present blower capacity 2,550 cfm

Hence there is just enough blower capacity for stoichiometric combustion. It is recommended that the actual combustion rate and air flow rate be monitored to find the actual air fuel ratio before action is taken to provide proper combustion.

The advantages of proper combustion are: savings in fuel and hence dollars; better heat transfer to the metal due to higher flame temperature and shorter flame, which would result in a reduction of the cycle time for melting; and reduction in stack losses.

Heat Lost Through the Stack

<table>
<thead>
<tr>
<th>Stack temperature</th>
<th>-</th>
<th>1500°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow rate</td>
<td>-</td>
<td>2500 cfm</td>
</tr>
</tbody>
</table>

Heat loss = 1000°F x 24 BTU/lb°F x 0.075 lb/CuFt

x 2500 CuFt/min x 60 min/hr

= 2.7 MM BTU/hr

= $19,440/yr
Flame temperature for various fuel air and fuel or gas mixture.*

## CASE STUDY

### SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Primary Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Melting Furnace</td>
</tr>
<tr>
<td>Modification</td>
<td>Install recuperator</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td></td>
</tr>
<tr>
<td>Estimated Yearly Savings</td>
<td></td>
</tr>
</tbody>
</table>
Considerable savings in energy could be achieved by installing a recuperator on a melting furnace (aluminum, copper, or sheet). The recuperator recovers the heat from the high temperature exhaust streams and preheats combustion air. The typical fuel saving percentages can be found from the following graph.
CASE STUDY

SUMMARY

Industry	Primary Metals
Process	Homogenizing Oven
Modification	Air preheater

Cost of Modification	$2,000
Estimated Yearly Savings:
	$5,000
Savings by Using Preheated Air in Homogenizing Oven

At present the billets are removed from the homogenizing oven after the homogenizing period at a temperature of 1050°F and left in the open to cool by itself to the ambient temperature.

The system recommended recovers the sensible heat available in the billets by transferring it to the air that could be used for combustion in the burners. This would result in a direct savings in fuel and money.

The system required to achieve this would be an inexpensive enclosure into which the cart load of billets could be rolled out from the homogenizing oven. The enclosure should have openings at the bottom to allow entry of air and a ducting from the top to the inlet of the air blower of the homogenizing oven.

Calculations

| Monthly Load on Homogenizing Oven | - | 1.3 million lbs |
| Homogenizing temperature | - | 1050°F |
| Temperature of billet after being cooled by air | - | 100°F |
| Temperature drop | - | 950°F |
| Specific Heat of aluminum | - | 0.208 BTU/lb°F |
| Heat Available | = 1.3 x 10^6 lbs/month x 950°F x 0.208 BTU/lb°F |
| = 256 MM BTU/Month |

Assuming the oven efficiency to be 65%

| Energy savings | 393 MM BTU/Month |
| Cost of Natural Gas (Atlanta, Ga.) | $1.00/MM BTU |
| Cost pf propane | $.30/gal |
| | $3.26/MM BTU |
Oven runs of natural gas for nine months and propane for three months.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual savings of natural gas</td>
<td>$3,537</td>
</tr>
<tr>
<td>Annual savings of propane</td>
<td>$3,843</td>
</tr>
<tr>
<td>Total Annual Saving</td>
<td>$7,380</td>
</tr>
<tr>
<td>Estimated cost of preheat system</td>
<td>$5,000</td>
</tr>
<tr>
<td>Packback period</td>
<td>8 months</td>
</tr>
<tr>
<td>Packback period after taxes</td>
<td>1 year 4 months</td>
</tr>
</tbody>
</table>
## SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Stone &amp; Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Tunnel Kiln</td>
</tr>
<tr>
<td>Modification</td>
<td>Heat Exchanger/Recuperator</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td>$45,000/90,000</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>22,000/34,000</td>
</tr>
</tbody>
</table>
Tunnel Kiln Heat Recovery

Heat Requirement

200° Hot water for slip production = 8 MM BTU/day
110° Hot air for drying = 140 MM BTU/day

Tunnel kiln combustion air stack temp - 150-175°F
Hence there is no potential for heat recovery from this stack.

Cooling air stack temperature - 350°F
Cooling air stack flow - 10,000 cfm

There is potential for heat recovery. Two methods of heat recovery appear economical—finned tube air to water heat exchanger; supplementary finned shell-and-sube recuperator.

Heat Recoverable with heat exchanger - 35 MM BTU/day
Heat Recoverable with recuperator - 50 MM BTU/day

Hence all the requirements of heat for hot water and part of the heat for drying air could be fulfilled. There are a number of advantages of recovering the heat into 200° hot water and using this in forced draft radiators to heat the drying area. The hot water could be stored during the day and used at night for drying. Hot air off radiators is dryer and cleaner than combustion gas and less distribution energy would be required due to better zoning of heated areas. The process water for slip production would be taken directly from the heat exchanger and would eliminate the requirement for blow down and minimize water treatment.

The choice of heat recovery system would depend on the fuel used for heating the drying area. If oil is used for a significant portion of the time, the supplementary finned shell and tube heat recuperator is recommended. The system would use waste gases as preheated air and would increase the drying efficiency from 70% to 95% or better.

<table>
<thead>
<tr>
<th></th>
<th>Heat Exchanger</th>
<th>Recuperator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of System</td>
<td>$45,000</td>
<td>$90,000</td>
</tr>
<tr>
<td>Annual Energy Savings</td>
<td>$22,000</td>
<td>$34,000</td>
</tr>
<tr>
<td></td>
<td>2 years</td>
<td>2 yrs. 9 months</td>
</tr>
</tbody>
</table>
CASE STUDY

SUMMARY

Industry       Stone & Clay
Process        Shuttle Kiln
Modification   

Cost of Modification

Estimated Yearly Savings:
Shuttle Kiln Heat Recovery

The two shuttle kilns operate on a 24 hour loading-unloading cycle during which the stack temperatures vary from ambient to 2000°F. Due to the cyclic nature of the temperature, heat recovery is not feasible since expensive heat exchangers would be necessary.

The present efficiency of the kilns fired by either oil or gas is less than 10%. If electricity were used the efficiency would be over 70%. Since the cost of electricity during off peak hours is only 4 times as expensive as natural gas the improved efficiency when using electricity would result in about 50% reduction in the cost of firing the kiln.

Conversion of the shuttle kiln to electricity is being investigated. Cost and other data have not been completely collected and so it would not be possible for us to presently recommend the change. Major manufacturers are being contacted and either we or the manufacturers will be in contact with you in the near future to discuss the change.
CASE STUDY

SUMMARY

Industry  Apparel
Process     Building
Modification Roof insulation

Cost of Modification $16,000

Estimated Yearly Savings: $12,000
Roof Insulation

An analysis of the air conditioning load for the cutting/sewing room area indicates that by insulating the ceiling, the air conditioning design load would be reduced by 21%. We do not have sufficiently detailed data to calculate the exact effect this would have on air conditioning cost but we believe the savings would be approximately $16,000 plus the cost of installation.

The floor structure now consists of steel framing, 2" cement fiber decking with a built up roof. This construction has a heat gain of approximately 10 BTU per square foot under design conditions. With the addition of 6" of fiberglass insulation the heat gain would be reduced to approximately 2 BTU per square foot.

\[
\begin{array}{cccc}
\text{Air Conditioning in Tons} & \text{Installed} & \text{Roof Load Existing} & \text{Roof Load Insulated} & \text{Net Reduction} \\
\text{Cutting Area} & 120 & 42 & 8.2 & 33.7 \\
\text{Sewing Area} & 240 & 52 & 10 & 42 \\
\end{array}
\]

\[
\text{Net Savings} \quad 75.7 \text{ Tons}
\]

We understand that the present roof may require extensive reworking in the near future. We mention this as it is possible to incorporate roof insulation as part of the new roof design. However, it is our opinion that fiberglass batt insulation installed below the roof, independently of the roof structure, is far more cost effective.
## CASE STUDY

### SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Apparel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Steam Boiler</td>
</tr>
<tr>
<td>Modification</td>
<td>Boiler Tuning</td>
</tr>
</tbody>
</table>

Cost of Modification

Estimated Yearly Savings:

5% of fuel
Steam Boiler

The plant steam boiler is natural gas fired without oil standby. As steam is essential in the shirt finishing operation, it is recommended that the capability for burning No. 2 fuel oil be added.

The boiler combustion (air-fuel mixture) has not been set by combustion test instruments. This is recommended and based on past experience. A 5% reduction in fuel consumption could be anticipated.
<table>
<thead>
<tr>
<th>SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry: Apparel</td>
</tr>
<tr>
<td>Process: Air conditioning</td>
</tr>
<tr>
<td>Modification: Economizer cycle</td>
</tr>
<tr>
<td>Cost of Modification:</td>
</tr>
<tr>
<td>Estimated Yearly Savings: $8000</td>
</tr>
</tbody>
</table>
Air Conditioning

An overall analysis of the cutting room and the sewing room air conditioning systems indicated that a considerable savings in operating costs should be achieved by the use of an "economizer cycle". As detailed engineering design work has not been performed, exact costs and projected savings are not possible, but it is believed that a reduction of 20% in air conditioning cost is achievable and this would approximate $8,000 per year in savings.

In air conditioning terminology "economizer cycle" describes a technique for the utilization of outside air for cooling when the air temperature is suitable. The prime applications for air conditioning systems to be equipped with economizer cycles are facilities that have a large internal heat gain from people, lights, and equipment, such as large office buildings and major department stores. For these types of facilities, the "economizer cycle" has become almost standard. Georgia Tech has a number of buildings which utilize this technique.

In essence, when a particular building air conditioning load is such that cooling is required even though the outside air temperature is 65°F or lower, it is more economical to shut down the air conditioning refrigeration compressors and open up a large outside air duct connection to bring in cool outside air. This is done automatically.

The air conditioning load at the plant meets the "economizer cycle" criteria as the plant has a high internal heat gain from people, lights, and electric motors such that cooling is required nearly year around. It is therefore our recommendation that a detailed engineering analysis and design be prepared by a consulting engineering firm experienced in this field.
CASE STUDY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Apparel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Lighting</td>
</tr>
<tr>
<td>Modification</td>
<td>Reduction to Right Level</td>
</tr>
</tbody>
</table>

Cost of Modification $300

Estimated Yearly Savings: $15,300
Lighting

The lighting in the sewing and cutting areas is provided by 2 tube 96 inch fluorescent fixtures with an average illumination at 90 foot candles. With the exception of certain critical areas it is our opinion that a foot candle level of 30-40 would be satisfactory.

<table>
<thead>
<tr>
<th>Lighting Cost--3.5c/KWII</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing</strong></td>
</tr>
<tr>
<td><strong>Tubes Installed</strong></td>
</tr>
<tr>
<td>Sewing</td>
</tr>
<tr>
<td>Cutting</td>
</tr>
</tbody>
</table>

$11519

Air Condition Load Reduction

TOTAL $15359

The above table was calculated to show the effect of a 50% reduction in light intensity. The last item indicates the savings that would accrue due to a reduction in the air conditioning load from the heat given off by the lights.

It is recognized that one of the factors constituting a satisfactory lighting system is the subjective feelings of the persons affected. This can create acceptance problems. However, many programs of light reduction have been implemented and well accepted by people who were fully informed of its purpose.
## CASE STUDY

### SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Pulp &amp; Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Air drier</td>
</tr>
<tr>
<td>Modification</td>
<td>Air preheater</td>
</tr>
<tr>
<td></td>
<td>using boiler exhaust</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td></td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

-220-
Energy Conservation

The main energy consuming equipment is the drier that uses steam at 70 psi in drums over which the paperboard is run and hot air at 400°F that blows over the paper at select points.

The steam is generated in a boiler rated at 25,000 lbs/hr and 260 psi. The normal operating conditions are 15,000 lbs/hr at 125 psi. The stack temperature was around 400°F.

The hot air is produced in a combustion chamber burning natural gas. The volume of air used is about 16,000 scfm.

The plant has been interrupted in its natural gas supply and uses No. 2 oil as an alternate fuel in the boiler.

The room in which the drier is located is relatively hot and the exhaust fans exhaust the hot air which is at a temperature of about 140°F.

Savings in energy would be achieved by using preheated air for the boiler as well as in the air heater. Since the drier room is adjacent to the boiler room and the air heater room, one simple possibility is the place the air intake of the two blowers in the drier room. This would result in a direct saving in fuel as well as the possibility of reducing the exhaust fan horsepower requirement and adding to the comfort of the room. The estimated savings would be about $6,000/yr and would cost a few hundred dollars for the changes.

A possibility that the management is currently looking into is ducting the air exhausted from the driest section over the drier into the intake of the air heater. This is a reasonable proposition but the above recommended change is simpler.

Another possibility is to directly use the boiler stack gases in the hot air heater. It could be ducted into the intake of the air heater blower if it would not affect the combustion. If it would affect the combustion it should be combined with the hot gases after combustion. This would result in a saving of about $10,000/yr.
CASE STUDY

<table>
<thead>
<tr>
<th>SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
</tr>
<tr>
<td>Process</td>
</tr>
<tr>
<td>Modification</td>
</tr>
<tr>
<td>Cost of Modification</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
</tr>
</tbody>
</table>
Calculations

Savings due to Excess Air Control

BTU Requirement for the dryer that is presently the most efficient:

<table>
<thead>
<tr>
<th>Description</th>
<th>BTU/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Removal</td>
<td>5.24 X 10^6</td>
</tr>
<tr>
<td>Carton Heating</td>
<td>0.12 X 10^6</td>
</tr>
<tr>
<td>Heating Makeup Air</td>
<td>3.48 X 10^6</td>
</tr>
<tr>
<td>Housing Loss (Estimated)</td>
<td>0.10 X 10^6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>8.94 X 10^6</td>
</tr>
</tbody>
</table>

Present Firing Rate = 14.90 X 10^6 BTU/hr
Estimated Saving/dryer = 4.00 X 10^6 BTU/hr

= $43,200/yr

For 3 dryers estimate saving = $129,600/hr

**Dryer # 1**

Production Rate = 0.867 tons/hr
Exist Moisture 8% = (0.08 X 0.867) = 0.06936 tons/hr
Dry Weight of Carton = (0.02 X 0.867) = 0.79764 tons/hr
Inlet Moisture 75% = 75% X 0.92 X 0.867 = 2.39294 tons/hr
Moisture Removed = (2.39294 - 0.06936) = 2.32356 tons/hr

BTU's required to remove moisture
= mass/hr (Latent heat + Sensible heat) to heat from 60°F to 210°F
= 2.32356 tons/hr (970 + 150) BTU/lb X 2000 lbs/ton
= 5.204 X 10^6 BTU/hr
BTU's required to heat carton/hr
= mass/hr X Specific heat X Temperature Rise
= 0.79764 tons/hr X 2000 lbs X 0.5 BTU/1b° F X 150°F
= 0.119646 X 10^6 BTU/hr

We chose a humidity ratio (# Water vapor/#Dry air) of an average of 0.12 which was the quality of air that could perform the drying satisfactorily. We feel this should work since the present drier module #1 exhaust humidity was 0.195 on 3-23-76 and 0.19 on 1-2-76 which is much higher than what we have assumed.

Assuming \( \frac{\text{Vapor}}{\text{Dry Air}} = 0.12 \)

# Dry heat required
= \( \frac{2.32356}{0.12} \) tons water removed/hr X 2000 lbs/ton
= 38725 lbs/hr

BTU's required to heat air from 80°F to 450°F = mass/hr X temp. rise X specific heat
= 38725 lbs/hr X 370°F X 0.243 BTU/1b°F
= 3.48185 X 10^6 BTU/hr
Countercflow Firing

Our specific recommendation is to establish to the degree possible countercflow conditions within the dryer in accordance with Figure 8. The limit to which countercflow can be achieved must be established experimentally. For instance one known limit which will occur is excessive recondensation. The experiment should proceed with care as the oxygen content must be maintained for combustion.
COUNTERFLOW FIRING

1. FIRE ZONES IN REVERSE ORDER
   ZONE 4 HEAVIEST
   ZONE 1 LIGHTEST

2. REDUCE OR STOP EXHAUST FANS IN REVERSE ORDER
   EXHAUST FAN 3 FIRST
   EXHAUST FAN 2 NEXT
   EXHAUST FAN 1 LAST

FIGURE 8. COUNTERFLOW FIRING IN DRYER
## CASE STUDY

### SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Pulp &amp; paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Drier</td>
</tr>
<tr>
<td>Modification</td>
<td>Heat recovery from exhaust</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td></td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>$53,000</td>
</tr>
</tbody>
</table>
Exhaust Heat Recovery—Water Heating

In studying any given process for energy efficiency improvement, one area that should be considered is recovering of useful energy from exhaust streams. In this instance an economizer (water heater) was investigated and the following calculations performed. Please note the accuracy of these calculations is limited by the assumptions.

Savings Due to Economizer

Heat recoverable from moist exhaust gases 3.268 X 10^6 BTU/hr
De-inking process requirement 3.984 X 10^6 BTU/hr
Saving by heat recovery $4,412/month ($52,944/yr)

Heat Recovery—Economizer

With the assumption that the acceptable humidity ratio is 0.12

| Dry Air | 38725 lbs/hr |
| Moisture | 4647 lbs/hr |

Heat recoverable from 38725 lbs of Dry Air in cooling from 450°F to 160°F

Mass X Temp drop X Specific Heat
= 38725 lbs/hr X 290°F X 0.243 BTU/lb°F
= 2.72895 X 10^6 BTU/hr

Heat recoverable from 4647 lbs of moisture in cooling from 450°F to 160°F

Mass X Temp drop X Specific heat
= 4647 lb/hr X 290°F X 0.4 BTU/lb°F
= 0.5394 X 10^6 BTU/hr

*The latent heat was not used just be to conservative

Total heat recoverable = 3.268 X 10^6 BTU/hr
If the gas was cooled only to 210°F
Total heat recoverable = 2.708 X 10^6 BTU/hr

A schematic drawing of an economizer installation is shown in Figure 9. A current rule of thumb is that a natural gas exhaust stream to water economizer should prove economically viable for a process operated over 3700 hours per year.
TO ATMOSPHERE

COLD WATER IN

ECONOMIZER

HOT WATER

HOT WATER STORAGE

HOT WATER TO PROCESS

DRYER EXHAUST

DRYER

FIGURE 9. ECONOMIZER SCHEMATIC
## SUMMARY

<table>
<thead>
<tr>
<th>Industry</th>
<th>Pulp and Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Drier</td>
</tr>
<tr>
<td>Modification</td>
<td>Solar Air Preheater</td>
</tr>
</tbody>
</table>

Cost of Modification: $18,000

Estimated Yearly Savings: $4,900
Solar Heating

Solar heating was investigated for applicability to the product drying process. The use of solar energy is now of wide interest with the increasing cost of fossil fuels.

As related to this project the following factors were among those considered:

1. Direct heating of air is one of the lowest cost solar energy collector systems.

2. The product drying process under consideration utilizes air both for product drying and combustion.

3. There is extensive unencumbered roof area available for collector location.

4. As experience with practical applications of solar energy is limited, this application must be considered experimental. Therefore a design restriction of 10% of the load from one dryer was adopted.

In developing the design the following quantities and calculations were used.

Collector Size and Cost

Typical Dryer Input = 9 \times 10^6 \text{ BTU}

10\% of Dryer Input = 9 \times 10^5 \text{ BTU}

Solar Energy Availability - Yearly Average

\[
\begin{align*}
\frac{900,000}{75} &= 12,000 \text{ sq ft Collector Area} \\
12,000 \text{ sq ft} \times 1.50 &= $18,000 \text{ Collector Cost}
\end{align*}
\]
Energy Value

\[
750 \frac{\text{BTU}}{\text{day}} \times \frac{365 \text{ day}}{\text{yr}} = 273,750 \text{ BTU/} \text{ft}^2/\text{year}
\]

\[
273,750 \times 12,000 \text{ ft}^2 = 3,285 \times 10^6 \text{ BTU/yr}
\]

\[
= 32,850 \text{ Therms}
\]

\[
3,285 \text{ Therms} \times 15\text{c/therm gas cost} = \$4,927.50 \text{ per year energy value}
\]

Air Quantity and T

\[
H = 0.018 \times \text{CFM} \times \Delta T \times 60
\]

\[
900,000 = 0.018 \times 20,500 \times \Delta T \times 60
\]

\[
\Delta T = 40.6^\circ\text{F}
\]

Note - CFM taken from No.2 dryer date of 3/23/76

A roof collector of corrugated fiberglass panels in accordance with Figure 10 is of a type that should be suitable. No actual design work has been performed to define the panel height above roof, air flow patterns or support structure.

The collector cost of $1.50 per sq ft used in the calculation was estimated based on other work and a panel cost of 40 cents per sq ft.
FIGURE 12. SOLAR AIR PREHEATER FOR DRYER
## SUMMARY

<table>
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<td>Lighting</td>
</tr>
<tr>
<td>Modification</td>
<td>change from fluorescent to High Pr Sodium</td>
</tr>
<tr>
<td>Cost of Modification</td>
<td>$9,800</td>
</tr>
<tr>
<td>Estimated Yearly Savings:</td>
<td>$6,200</td>
</tr>
</tbody>
</table>
LIGHTING

An analysis was prepared of the general lighting system for the main building to determine its economic efficiency when compared to some other available lighting sources. Our conclusions are that the high pressure sodium system should be given serious consideration. For instance under one possible scheme, new fixtures could be purchased and installed with a payback time of one year and seven months with an ongoing $6,200. per year energy cost saving.

In abbreviated form these are the nominal lighting efficiencies from lamps for general service:

<table>
<thead>
<tr>
<th>Type</th>
<th>Lumens/Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>22</td>
</tr>
<tr>
<td>Fluorescent</td>
<td>75</td>
</tr>
<tr>
<td>Metal Halide</td>
<td>80</td>
</tr>
<tr>
<td>High Pressure Sodium</td>
<td>120</td>
</tr>
<tr>
<td>Low Pressure Sodium</td>
<td>150</td>
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</tbody>
</table>

Your present fluorescent system is exceeded in efficiency to a significant degree by only the high and low pressure sodium lamps. The low pressure sodium source is essentially monochromatic in a narrow yellow band and in our opinion would not be suitable for your purposes. The high pressure sodium lamp while dominant in the yellow band does have a full light spectrum and could possibly prove satisfactory for your needs. There are now a number of manufacturing facilities which use H.P.S.

To provide some preliminary feasibility information we utilized General Electric’s computer program. Two runs were made—each with three schemes. Run 1, System 1 is your present system which was run for comparison. The other five systems are all based on various layouts, foot candle levels and lamp sizes.
FINAL REPORT

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TRANSFER PACKAGE

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SECTION I
INTRODUCTION

Organization and management of an energy extension service program is a challenging task. This "transfer package", developed as part of a pilot energy extension service program at the Georgia Tech Engineering Experiment Station, documents materials used by the staff in organizing and managing the project. Its purpose is to aid those in other states who would wish to begin their own energy extension service programs.

The goal of the program itself is to provide energy conservation assistance so as to maximize the amount of energy conserved in industry within a particular state. A schedule of the program is shown in Figure 1. The approach to such an effort is four-fold:

1. In-depth assistance, documented by case studies for individual plants, including the recommendation of capital expenditures to conserve energy.

2. Technical assistance on a limited basis to a larger number of companies to increase the awareness of management in ways that energy can be conserved in their plants.

3. Conducting workshops to raise the awareness of larger groups of people in ways to conserve energy (using the experience of case studies).

4. Develop methods of motivating implementation of energy conservation ideas and using audio visual techniques.

This transfer package should be useful to a number of organizations in other states, including university staffs, state government agencies, or sub-state districts. Some highly skilled engineering talent is required for the
Figure 1. Program Schedule
program to be successful; this transfer package discusses ways to make the best use of such talent. The project staff at Georgia Tech consisted of a group of non-teaching professional research and service personnel from the research arm (the Engineering Experiment Station) of Georgia Tech. The majority of the staff is located on the Georgia Tech campus in Atlanta. The remaining staff members are part of a network of seven field offices located throughout the state.

Except for management and support personnel, home office staff members have bachelor's degrees and/or advanced degrees in engineering, primarily mechanical engineering, with intense experience in systems which have energy conservation potential in manufacturing industries. The field office personnel are also technically oriented, with degrees in engineering, but with a broader base of industrial experience and with little previous exposure to energy conservation systems.

The transfer package is organized into sections which will be used roughly in the order in which they are presented. The section on organization, for example, discusses personnel selection and initial assignments. The section on training includes the outline of the training session and some of the materials to be used in such a session. The section on management discusses ways to insure responsible and timely program operation. The case study section documents work with particular plants within the industries in Georgia accounting for largest energy consumption. The section on workshops discusses methods for promoting successful workshops and presents material used in such workshops. Finally, the section on audio-visual aids describes the slide tape show that was developed under this project.

In using this transfer package it is important to recognize that each state is unique in the following:
1. Organization;
2. Industrial Patterns; and
3. Spheres of Influence.

For example, in one state, a certain trade association may have considerable influence, whereas in another state the same trade association may have little or no influence or may not even exist. The same example could be used for the various state agencies, for sub-state organizations, and in fact for the university system itself. As such, this transfer package should serve as a guide but not as a rule book to the operation of similar programs in other states.
The technical nature and the diversity of manufacturing industries and especially of energy conservation systems for such industries, calls for the selection of highly trained and talented individuals for the program if long start-up delays are to be avoided. Once selected, these personnel must be given appropriate tasks to prepare them for what is certainly a rigorous job and one which must be closely coordinated in order to assure timely responses to industry's needs.

Personnel Selection

As an example of the type of personnel required in such a program, the qualifications and experience of the personnel involved in the Georgia Tech project are listed:

Grant B. Curtis, Jr.  B. S. M. E., Professional Engineer, Former head of engineering, Georgia Tech Physical Plant, was responsible for plans and execution of all campus building and remodeling, maintenance and operation of all mechanical systems, including central power plant, central air conditioning plant (6,000 tons), 19,800 volt electrical distribution system. In this position he reduced total energy consumption at Georgia Tech by 22% through intensive energy conservation program.

Robert H. Fulford  B. S. E. S. M., Professional Engineer, formerly lead engineer for design of 250 megawatt oil-fired power plant; managed, designed, and managed construction of 3,000 ton per day sulfur recovery unit; and numerous studies in total energy systems and solid waste energy recovery.
Jerry L. Birchfield  M. S. E. E., Project Director and Chief, Productivity Systems Division. Responsible for project management and execution. Chief liaison with industry associations and companies.

Richard S. Combes  B. M. E., credits towards M. M. E., has worked in poultry industry to implement recovery systems, was chief design engineer for environmental systems for a new fossil fuel power plant where he designed recirculating cooling water piping, cooling tower chemical treatment system, demineralizer system, water and sewage systems, cooling and makeup water, and complete plant waste water treatment plant.

Gopalaswamy Soora  M. S. M. E., formerly plant engineer of manufacturing plant which produced parts for coal crushers, electrical fixtures, and main switches.

John E. Dawkins  B. S. M. E., M. B. A., was responsible for performing and directing engineering functions related to the concept design, fabrication, installation, and reporting for major aircraft mechanical/hydraulic product development test systems; designed, fabricated, installed, and tested a 10,000 gallon, 1 ton per day anaerobic fermentation system for converting poultry waste into useful methane and effluent products.

Ron Pearl  M. S. E. E., has background in marketing; performed research and organized workshops in industrial energy conservation and helped develop a computer program for monitoring energy consumption in industry.

Field Office Personnel

William C. Darley, Jr.  B. I. E., M. B. A., worked in equipment layout, job evaluation, wage administration, materials handling, production control, quality control; supervision of cargo port clearance operations.

Larry R. Edens  B. Ch. E., M. B. A., engaged in pilot plant design, operation, supervision of testing, establishment of test procedures, personnel and union interface, statistical analyses, capital budgeting studies, considerable experience with technical assistance to small industries.
Bill Studstill

B. I. E., experienced in plant layout, work simplification, and scheduling, inventory control, design of electrical and heating systems, ventilating and air conditioning systems; experience in sales; considerable experience with technical assistance to industry.

To summarize, a description of qualifications for engineers in the home office for such a program could be as follows: Mechanical engineer--experienced in design, installation of industrial processes in several manufacturing industries; master's degree or 10 years of experience required. The qualifications for a field office person could be as follows: Field engineer--with engineering degree and industrial experience; M. B. A. or management experience desired. It is of course desirable for qualifications of personnel selected to be related to large energy consuming industries relevant to the program.
SECTION III
FIELD OFFICE STAFF TRAINING

A key component of this project is the provision of technical assistance to firms in Georgia in the area of energy conservation. Georgia Tech maintains a staff of field engineers in seven offices throughout the state. This valuable resource is being used to promote the program, to assist project engineers in working to develop case studies, and to provide technical assistance to firms in the state. To ensure that the field representatives had the appropriate technical skills for providing technical assistance, a three day intensive training course was designed and presented to 10 members of the field staff. The training course outline is shown in Appendix I.

The course was presented on May 5, 6, and 7, 1976 at Georgia Tech. As can be seen from the course outline, all aspects of industrial energy usage were treated and the participants were exposed to actual operating equipment at Georgia Tech. Direct experience was gained in key areas such as boiler combustion efficiency measurements. Instrumentation was purchased and is being used by the area office representatives to conduct measurements in the field. Use of this instrumentation was explained in the course.

The first topic covered at the seminar was combustion and since this plays such an important role in energy conservation this subject was discussed in great depth. A detailed breakdown summary of those topics covered on combustion is shown in Appendix II.

The fundamental combustion processes were discussed, including the basic elements of fuel and air, their mixture in the products of combustion, and the different types of combustion techniques. The second item under combustion
was a thorough briefing on natural gas. A review of all the commercially available equipment for burning gas included natural draft burners, forced draft burners, control valves, regulators of gas and air pressure, operating controls, and limiter safety controls.

The next topic on the agenda was jurisdictional authorities. This involved the body of laws set up at the federal, state, and local levels as well as by certain laboratories (such as the American Gas Association Laboratory and the insurance companies). These laws state certain limitations involved in burning gas.

The final topic was measurement. Topics included the measurement of quantity, use of the various types of gas meters, and the determination of quantity based on orifice size and pressure drop.

Following the discussion on combustion, the agenda included a tour of the Georgia Tech campus's main power plant. The purpose of this tour was to let the group see actual equipment similar to what had been discussed under combustion. In the central power plant two 40,000 lb./hour steam boilers, a 20,000 lb. and a 60,000 lb. boiler are in operation. These boilers are primarily fired with natural gas and use number 6 fuel oil as a secondary fuel. Inclusive was an elaborate consensate return system, heaters for the #6 fuel oil, induced and forced draft fans, and a boiler control system. This major steam plant contained all the components normally expected in a field plant.

The next area visited was the section of the power plant where chilled water is generated for campus air conditioning. The central chilled water plant has two 1000 ton chillers and two 2000 ton chillers for a total of 6000 tons capacity of chilled water. The units use hermetic electric centrifugal compressors.
Chilled water is produced in this plant at 40° and is returned at 58°. At present, this system serves about 30 buildings on the campus and is piped underground a distance of one and one quarter miles. The group went through the plant in detail and saw all the pumping arrangements and the control arrangements as well as the size of the equipment. On the tour the group saw the operation and maintenance of the large cooling towers.

The afternoon session began with a discussion of electrical distribution. This covered the standard voltages, distribution systems, transformer connections, etc. The terminology for the disconnects in the starters was explained and safety as it related to high voltage electrical distribution system found in many plants was discussed. A thorough briefing was given on what types of electrical distribution systems to expect in plants. Following the discussion on electrical distribution systems an industrial engineer from Georgia Power Co. gave a presentation on electric rates, including demand control, and electricity supply in the state of Georgia.

The subject of lighting was discussed, including the major sources of lighting, types of lighting fixtures (incandescent, fluorescent, and mercury vapor), discharge type lamps (high pressure sodium and low pressure sodium), and lighting efficiencies. Calculations on the amount of current used for any given light level were demonstrated. Lighting levels at Georgia Tech were used as an example. The lighting level adopted on the Georgia Tech campus is now 50 foot-candles, reduced from previous levels of as high as 120 to 150 foot-candles. Each participant was trained in the use of foot-candle meters.

An energy conservation study of the Harry L. Baker Building, a three story brick building of about 120,000 square feet, was assigned to the group. The study involved a complete energy analysis, including observations
of lighting and air conditioning systems, and a follow up report with the concluded recommendations. The first two hours of the study were spent becoming familiar with the building and making observations. The second two hours were spent in class writing the report.

On Thursday morning a tour of the Electrical Engineering Building and the Civil Engineering Building was given. In each case, heating and air conditioning equipment, fans, filters, and control systems were observed in the presence of a representative of the Georgia Tech Physical Plant in charge of operating the particular building. The buildings were selected because each had a different, commonly found system.

Following the tour an industrial engineer from the Atlanta Gas Light Co. gave a presentation to the group about natural gas, its rates, and the present and future supply situation within the state of Georgia. Each participant was given copies of rates of the Atlanta Gas Light Co. and each rate was discussed in detail.

Concluding Thursday morning's session was a presentation on heat recovery, primarily from the standpoint of recovery from waste streams, either air or water. Discussion included various types of heat exchangers (water to water, air to water, water to air), sizing procedures, fouling factors, and heat transfer coefficients. Heat recovery from boiler stacks and dryers was discussed, and physical and economic limitations were examined. Examples of heat recovery from water waste streams included blow-down on boilers and drying operations.

The discussion on steam started with the fundamental principals of how steam is generated, its characteristics, pressure temperature curves, the steamer, sizing of steam mains, sizing of return lines, and pressure drops. Steam traps discussed included impulse traps, bucket traps, and thermostatic
traps. Also discussed were the practical constraints in laying steam mains. Next was a presentation on types of return systems, condensate pumps, pressure return on condensate, and steam systems.

Refrigeration was the next subject outlined. A fundamental discussion of refrigeration, primarily conventional compressor cycles utilizing freon gas and ammonia, was followed by a discussion of the characteristics of the various refrigerants, their controlling devices, and areas of prime use. Included in refrigeration was a discussion on compressors, piston compressors, screw compressors, vane compressors, and the centrifugals.

The final topic for the day was space heating and air conditioning. Discussion began with simple home heating and air conditioning systems and progressed through the various types of systems that are used in industry. For example, presentations on large air conditioning systems include dual duct systems, terminal reheat systems, mixing boxes, duct construction, duct insulation, control systems and multi-zone systems.

The last day of the training session commenced with a review of combustion, a discussion of combustion analysis, and the various techniques available for controlling and monitoring combustion. A discussion on fuel and air ratios centered on the analysis of flue gas and the measurement of the oxygen, carbon dioxide, carbon monoxide, and stack temperature. Afterwards, the group went to a boiler room located in the Alexander Memorial Building on the Georgia Tech campus. They talked with the power plant foreman for Georgia Tech and witnessed combustion tests performed on the boiler (measuring the oxygen, carbon dioxide, carbon monoxide and stack temperature). In accordance with the calculations relating to the efficiency of the boiler, the burner on the boiler was changed, the air quality was changed, and new tests were run to show the group the effect of their changes.
The afternoon session began with a summary of the topics presented in the course. A question-answer period followed. In concluding the course, the process of selecting the companies which would participate in this project was reviewed. This technique is discussed in Volume 1, Section IV.
SECTION IV

MANAGEMENT

The traditional three functions of management—planning, organization, and control—are reflected in the tasks necessary to successfully complete the program. Within each of these three functions, a management approach must be taken which maximizes the feedback available to the manager.

Planning

Due to the large amounts of data which must be collected on a project such as this, much of the planning function centers around the design of forms necessary to collect the various types of data needed.

The Energy Inventory Form, shown in Appendix III, was designed for this program to collect the data necessary to analyze the energy conservation potential of each plant visited. The form, which breaks down energy consumption in considerable detail, is normally filled out by either the field office representative or by the company itself.

It is now the opinion of most project personnel that the form is indeed too detailed for the needs of an experienced group. Such a form is, however, necessary if used by someone not familiar with what to look for in a particular industry.

The Evaluation Form, shown in Appendix IV, was developed for use in determining the effectiveness of the program as perceived by each company involved in the program, on either a case study or a technical assistance basis. In this program the form was mailed or delivered to each company involved, and the primary company was asked to fill out the form and send it back to Georgia Tech. A summary of the evaluations is found in Volume 1, Section VI.
A second evaluation form, to be used at the conclusion of energy conservation workshops, will be found in the section on workshops.

Organization

The management task of organizing personnel so as to be responsive to industry requests is a challenging one. The job of scheduling tasks to be accomplished must be given high priority. A typical case study schedule is shown in Figure 2. In this program a status board displaying the status of our work with each company was developed. Codes for each of the companies were listed along the vertical axis. Along the horizontal axis were a number of categories describing the company itself and the status of technical assistance or case study work with the company. These categories are as follows:

1. Standard Industrial Classification
2. Case study or technical assistance
3. Field person responsible
4. Home office person responsible
5. Initial field contact date
6. Trip report received for initial contact
7. File started
8. Previous data merged into file
9. Summary sheet started (date)
10. Summary sheet completed (date)
11. Home office visit (date)
12. Verbal recommendations given
13. Process diagram drawn
14. Data collection and/or measurement started
TYPICAL CASE STUDY SCHEDULE

- Company Selection
- Initial Contact
- Energy Inventory
- In-Plant Recommendation
- Data Analysis
- Written Recommendation
- Evaluation
- Follow-up

Figure 2. Typical Case Study Schedule
15. Data collection and/or measurement complete
16. Thank you letter mailed (date)
17. Home office trip report complete (date)
18. Data analysis started (date)
19. Data analysis completed (date)
20. Written recommendations mailed (date)
21. Evaluation form mailed (date)
22. Evaluation form received (date)
23. Follow-up phone call (date)
24. Company progress letter received (date)
25. Final report write-up complete (date)
26. Company selected for tape interview and photographs
27. Tape interview complete

Control

Once the means for charting the status of technical assistance and case study work with each company are available, it is imperative that sufficient management time be scheduled for the control of these activities. Priorities change often as company decisions are made or as company timetables change. The task of finding a company ready to spend capital dollars and finding at that same company an energy conservation opportunity with attractive payback is difficult indeed. However, if the project is organized in such a way that personnel can respond to such situations, very successful case studies will result and maximum effectiveness will be achieved. The methodology for performing case studies is presented in detail in Volume 3. A sample case study is found in Appendix V.
This section describes the methodology followed in the case study and technical assistance sections of this project. In-depth case study analysis was done in 10 plants and technical assistance was provided to 29 other plants.

Selection of SIC Sectors

Manufacturing industries are classified according to a Standard Industrial Classification (SIC) developed by the Bureau of Census. The first task was to decide which of these sectors could benefit greatest from this energy conservation program. The sectors that were selected are listed below.

<table>
<thead>
<tr>
<th>SIC</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Food &amp; Kindred Products</td>
</tr>
<tr>
<td>22</td>
<td>Textile &amp; Mill Products</td>
</tr>
<tr>
<td>23</td>
<td>Apparel</td>
</tr>
<tr>
<td>24</td>
<td>Lumber &amp; Wood Products</td>
</tr>
<tr>
<td>26</td>
<td>Paper &amp; Allied Products</td>
</tr>
<tr>
<td>28</td>
<td>Chemicals &amp; Allied Products</td>
</tr>
<tr>
<td>32</td>
<td>Stone, Clay &amp; Glass Products</td>
</tr>
<tr>
<td>33</td>
<td>Primary Metal Industries</td>
</tr>
<tr>
<td>34</td>
<td>Fabricated Metal Products</td>
</tr>
</tbody>
</table>

Greatest emphasis was given to the Textile and Food and Kindred Products sectors due to high value added, large employment and large energy consumption in the State of Georgia.
Selection of Participating Companies

Firms have been selected for participation in this project from those who were involved in EDA Grant # 99-6-09359 and from those who were known by Georgia Tech Office personnel to have specific interest in receiving energy conservation assistance. Two types of firms were to be included in this project; those which would consent to being involved in in-depth case studies and those that required technical assistance on specific energy problems. Criteria for selection of case study companies were formulated by the project staff and by the area office staff and included the following major categories:

1. Use of Energy Intensive Processes,
2. Size of Total Industry Segment (potential for transfer of methodology to other similar companies),
3. Management Interest,
4. Size of Company in Industry Segment,
5. Degree of Existing Sophistication in Energy Conservation,
6. Potential Impact of Energy Curtailment on Employment,
7. Potential Cost Savings to be Derived from Energy Conservation.

Using these criteria a master list of approximately 100 firms representing those that were potential case studies was compiled. Subsequently, several meetings involving project staff and area office representatives were held and the list of 100 firms was narrowed to the twenty-five which showed greatest promise as case study firms.

Initial Contact

The selection procedure was initiated by either personal or telephone interviews with company executives conducted mainly by the field office staff of the Engineering Experiment Station. During this contact the plant executives were briefed about the goals and objectives of the project, the activities of
the Georgia Tech engineering team related to their plants and their commitment of cooperation. In most cases the plant executives were very enthusiastic about the project and were willing to give their fullest cooperation. In a few cases where the company had an on-going energy conservation program they were skeptical of the value of the Georgia Tech assistance. One plant in particular felt that they had given energy conservation the fullest attention and nothing more could be done, but were willing to allow the project staff to tour the plant. When they heard the ideas of potential energy conserving projects given by Georgia Tech, they were very impressed with the potential, that this plant became one of the more important case study companies.

Energy Conservation Data Sheet

The purpose of this form is to collect basic information about the plant related to energy conservation. A blank form is attached in Appendix III. It requests information on the types and costs of the major utilities used by the company, the major products produced, the employment at the plant, the hours of operation, number of shifts worked, a brief description of the major energy consuming processes or equipment and the status of any existing energy conservation programs in the plant. In most cases it was found that this type of information was easily available from the accounting section or the engineering office. It was found that in most cases there was only gross metering of the major fuel sources in the plant and this was of no value to the engineer in determining the energy conservation potential. So in some case study plants where more detailed information of energy consumption and waste for individual processes was necessary, this form was not found adequate and was not used.
Plant Visit

On a date agreed upon during the initial contact, the plant was visited by a team of Georgia Tech engineers and scientists. The objective of this visit was to determine potential energy conservation methods and projects. This goal was viewed with the following in mind:

1) Finding methods for improving the energy efficiency of the process by minor changes in operating procedures, without major capital investment.

2) Defining methods of improving energy efficiency by recovering waste heat or resources for use in the same process.

3) Identifying heat and resource recovery from a systems viewpoint and trying to match the wastes from one process to the need of another within the plant.

4) Finding alternate energy sources and processes that could replace those in short supply.

5) Identifying new technology and process modifications that are more energy efficient and can replace existing methods.

Plant Visit - Energy Audit

The procedure followed in identifying potential energy conserving opportunities consisted of conducting a detailed energy audit in the case study companies or a less detailed energy audit for the technical assistance plants. This was carried out by first identifying all the processes in the plant and determining the energy flow to and from the individual processes. Since in most plants there wasn't adequate metering to measure energy flow directly, indirect measures of efficiency and losses had to be used. This involved taking measurements of various properties using a number of instruments and using this data to calculate
the energy efficiency of equipment. In a few cases where measurements were not possible, design data of the individual components had to be used to see if they were sized to produce the optimum energy efficiency. Since most equipment was designed to maximize production rates, there was an associated compromise in energy efficiency. With the present rising costs of energy and curtailments, the design criteria have to be changed and existing equipment have to be re-evaluated and may be modified to take into account this change in the energy situation.

The above procedure can be carried out in different levels of detail. However, due to the time and manpower constraints of this project, the procedure used was to concentrate on the more energy intensive processes and those involving thermal energy since they had the greatest potential for energy savings.

Plant Visit - Observations

In a large number of plants there was no in-house engineering capability or even if there were an engineering staff, they were primarily interested in production and maintenance rather than energy conservation. In the past, energy has been a very small percentage of the cost of the product and has been neglected. But now with curtailments, energy has shown its power to impact employment and production and has become much more important.

Another observation was that in a few plants management had purchased and installed heat recovery equipment but had no idea of the performance of these equipment, since there was no adequate metering devices to monitor performance. Consequently the equipment was operating at some undetermined level of performance. In fact, in several situations the installed heat recovery system was costing the company more money in operation and maintenance than the dollars saved by the recovery of energy. This was due to the fact that the management did not
have the knowledge or information necessary to evaluate the proposal submitted by the equipment manufacturer nor to evaluate performance.

Another major finding during the visits to the plants was that there has been no coordinated effort on the part of the various equipment manufacturers to best utilize energy in the plant. A typical example would be that in a food processing plant, there is a large requirement for hot water as well as a large requirement for refrigeration and ice. The present practice is that the hot water is supplied by a boiler that generates steam which is used to heat water. A large ammonia or freon refrigerating unit supplies the refrigeration and ice. The important fact is that the refrigeration unit, in addition to providing the required cold temperature, also rejects large amounts of heat into the atmosphere at the condensors. This heat could be utilized to generate at least part of the hot water demand of the plants. There are a number of examples of this type of energy wastage in different types of industries due to the fact that there has been no coordinated thinking using a systems view to minimize the amount of energy usage. In the future it may be necessary to lay out plants using energy usage as a controlling criterion rather than material handling or other present day criteria.

Analysis and Recommendations

From the energy audits and experience of the project staff a number of energy saving methods and concepts were developed. The recommendations involved various degrees of capital investments. In a number of cases, especially the technical assistance plants, the recommendations were more of the nature of general housekeeping and minor modifications in process operation. It is rather difficult to quantify the savings due to these types of measures without detailed instru-
mentation. A typical plant can save of the order of 10 to 15% of its energy usage by relatively simple measures such as boiler combustion tuning, adjusting dampers to cut down excess air in kilns, maintenance of steam traps, elimination of leaks in steam or fuel lines, basic insulation of high temperature distribution systems, installing timers or thermostatic control valves, etc.

In the case study plants and in some specific technical assistance projects detailed engineering analysis of potential energy savings caused by the introduction of new heat recovery equipment of alternate processing techniques were carried out and recommendations were made based on an analysis of the return on investment of the capital expenditure required. Some typical cases are installation of a recuperator on a aluminum smelting furnace, an economizer for a boiler, use of a heat exchangers to recover heat from the stack of a tunnel kiln in a ceramic industry to generate hot water.

In a few cases the recommendations involved a feasibility study of using alternate sources of energy like solar energy or coal or even conversion from natural gas to fuel oil. It must be stressed that the recommendation did not go into indepth engineering of the projects, but indicated to the plant management the potential of the subject ideas. The actual engineering was to be done either by the staff in the plant or a consulting company.

Follow-Up

After the recommendations were given the plant management contacted various equipment manufacturers or consulting companies to solicit proposals for the projects. The project staff provided assistance in evaluating these proposals and well as guidance in the actual implementation of the projects.
Workshop Scheduling

Whenever possible, a sixteen-week lead time should be planned for workshop scheduling. Figure 3 shows a typical schedule for planning, organizing, and conducting a workshop.

The topic to be selected may cover energy conservation in general or it may relate to a particular industry. Once the topic has been selected, an agenda of the presentations to be made during the workshop should be developed. This information can then be taken to one or more relevant trade associations or other organizations whose membership would benefit from attending such a workshop. This step is, of course, optional; but it is recommended for the guidance and for the assistance in mailing that it provides.

Once agreement is reached on the agenda and on the desired locations and dates, facilities can be acquired. When these arrangements are complete and the final locations and dates are selected, a workshop announcement similar to the one shown in Appendix VI can be composed. After this announcement has been printed, it can be mailed either by the program staff or preferably by the trade associations. The advantage to using a prepared trade association mailing list is that it insures that the proper types of companies are reached and also insures that the person at each company who receives the announcement will be in a position to take action. Announcements should be sent approximately two months before the workshop date in order to allow adequate time for planning on the part of those who wish to attend. The expected backgrounds of the
attendees should be specified to speed implementation of concepts.

Those who wish to attend the workshops will have returned the registration form, which was part of the announcement. These forms can be used to determine the number of attendees and can also be used for preparing name tags in advance. Just prior to the workshop all necessary equipment should be acquired. On the day of the workshop someone should be available to pass out name tags and answer questions.

The preparation of the presentation must be performed primarily by the home office engineers who have performed the case studies. Presentations should be well organized, and are normally more effective when visual aids are used. All presentations should minimize discussion of theoretical concepts and should stress specific proven ideas that could be immediately implemented by the participants. The workshop should start promptly, move quickly while allowing adequate time for questions, and end promptly at the appointed time. A transcript of a sample workshop is attached in Appendix VII.

A number of handouts may be distributed during the workshop to aid in understanding the material discussed. A typical set of handouts distributed is listed in Appendix VIII. Only material generated exclusively by the project staff is attached.

To aid in the development and improvement of workshops an evaluation of the workshop by the participants would be helpful. An evaluation form should be distributed at the end of the workshop to get the required feedback. An evaluation form developed by the project staff is attached in Appendix IX.
TYPICAL WORKSHOP SCHEDULE

Select Topic
Develop Agenda
Contact Trade Association
Contact Facilities
Select Location & Date
Compose Announcements
Print Announcements
Mail Announcements
Prepare Presentation
Prepare Visual Aids
Acquire Equipment
Hold Workshop

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Weeks

Figure 3. Typical Workshop Schedule
SECTION VII
AUDIO-VISUAL PRESENTATION

As a part of the transfer package, an audio-visual presentation was produced for use during workshops in discussing the management aspects of energy conservation. The presentation consists of a cassette tape and a tray of 35 mm color slides. See Appendix X for script.

The presentation was based on a number of tape-recorded interviews with plant managers and plant engineers. The interviews followed a pattern which covered both technical and managerial topics. The interviews were transcribed and edited and then a script was written using selected excerpts from the interviews. The narrative portion of the script was recorded and the interview excerpts were electronically edited on tape. Appropriate photographs were collected, and the tape was "pulsed" to automatically change slides on playback.

The presentation has been used in a number of workshops, and is effective in presenting the challenges management faces in attempting to reduce energy consumption.
A highly recommended component of an energy conservation program is the Advisory Council. The main purpose of an advisory council is to provide direction and guidance throughout the duration of the program. This usually means that the council is composed of representatives with direct expertise in the topic area. However, it is necessary that the council include not only program topic experts, but also individuals who, by their association or position, have a general knowledge of the program topic, and the ability to assist in dissemination of the program findings and results. Members should include people from the following areas: private business and industry; trade associations; chambers of commerce; state and local government; regional federal offices (if applicable); regional planning offices; and legislative bodies.

By combining the knowledge of the business-industry experts and politically oriented members, the Advisory Council can provide a myriad of avenues for project dissemination. Industry and business members provide the knowledge of what is and is not acceptable in the fields they represent. They can also help the project team gauge the area they represent. Finally, they provide valuable economic visibility of energy conservation within industries, technical input for evaluation of the project's technical approach, and methodology. The more politically oriented members provide insight into the social and economic climate for dissemination of project results. They can identify places and people who would be interested in the project results, and help to organize the structure so that information can be disseminated. Finally, all members benefit from council participation by keeping current with the latest developments in the project topic area.
APPENDIX I. FIELD AGENT TRAINING COURSE SCHEDULE

WEDNESDAY - MAY 5, 1976

A.M.
9:00 - 9:30 INTRODUCTION
9:30 - 11:00 COMBUSTION
11:00 - 12:00 TOUR - POWER PLANT

P.M.
1:00 - 2:00 ELECTRICAL DISTRIBUTION
2:00 - 3:00 ELECTRIC RATES
   GEORGIA POWER COMPANY
3:00 - 4:00 LIGHTING
4:00 - 6:00 ENERGY CONSERVATION
   CASE STUDY

THURSDAY - MAY 6, 1976

A.M.
8:00 - 10:00 TOUR - Baker Building, Electrical
   Engineering, Chemical Engineering,
   Civil Engineering
10:00 - 11:00 NATURAL GAS RATES AND SUPPLY
   ATLANTA GAS LIGHT COMPANY
11:00 - 12:00 HEAT RECOVERY

P.M.
1:00 - 2:00 STEAM
2:00 - 3:00 REFRIGERATION
3:00 - 4:00 SPACE HEATING, AIR CONDITIONING
4:00 - 6:00 ENERGY CONSERVATION
   CASE STUDY
FRIDAY, MAY 7, 1976

A.M.
8:00 - 9:00        COMBUSTION ANALYSIS
9:00 - 11:00      BOILER TESTING
11:00 - 12:00    REVIEW

P.M.
12:30 - 2:30       1644 PROGRAM
                    PLANT SELECTION
APPENDIX II

OUTLINE OF TOPICS COVERED IN THE

FIELD AGENT TRAINING PROGRAM
APPENDIX II
OUTLINE OF TOPICS COVERED IN THE FIELD AGENT TRAINING PROGRAM

COMBUSTION

I. Fundamental Process
   1. Fuel
   2. Air
   3. Mixing
   4. Products of Combustion
   5. Cautions:
      Explosions, Insurance

II. Natural Gas
   1. BTU Content
   2. Theoretical Air
   3. Actual Air
   4. Draft
   5. Burners - Natural Draft
      Bunsen
      Drilled Port
      Ribbon
      Upshot
      Inshot
   6. Burners - Forced Draft
   7. Combustion Train
      Pilots
      Standing
      Standing Safety
      Electric
   8. Control Valves
      Solenoid
      Diaphram
      Opening Speed
   9. Regulators
      Single
      Dual
      Typical Pressures
      Zero Pressure
10. Operating Control
   Thermostats
   Room
   Air
   Water
   Other

11. Limit Controls
   Purpose
   High Temperature Limit
   High Pressure Limit
   Water-Low High
   Air Flow
   Gas-High Low

12. Jurisdictional Authorities
   Local Codes
   Utilities
   A.G.A.
   Factory Mutual Underwriters
   Laboratories State Insurance Program

13. Measurement
   Gas Meter
   Low Pressure
      Tin Case
      Readings
   High Pressure
      Readings
      Multiplier
   Name Plate Data
   Input
   Output
   Orifice
      Size
      \( \text{H}_2\text{O} \) Reading
APPENDIX III

ENERGY CONSERVATION DATA SHEET
ENERGY CONSERVATION DATA SHEET

1. Company Name, Address__________________________
   Company Contact, Position__________________________
   Principle Products________________ Production________________
   Employment________________ Yearly Gross Sales________________
   Interviewer________________
   1a) Hours of operation, shifts, employment on shift______ ______ ______
       ______ ______ ______

2. Cost Data (yearly)
   a) Electricity______ c) Propane______ e) Other______
   b) Natural Gas______ d) Oil______

3. Major energy work underway or planned:
   ________________________________________________
   ________________________________________________
   ________________________________________________
   ________________________________________________
   ________________________________________________
   ________________________________________________

4. Action Requested________________
   Next Action________________

III-1
5. Electricity Consumption Data

a. Supplier

b. Rate Structure

c. Monthly Consumption and Cost

<table>
<thead>
<tr>
<th>Month</th>
<th>KWH</th>
<th>Actual Demand</th>
<th>Billing Demand</th>
<th>Cost ($)</th>
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<tbody>
<tr>
<td>Jan.</td>
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<tr>
<td>TOTALS</td>
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</tbody>
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1976

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<thead>
<tr>
<th>Month</th>
<th>KWH</th>
<th>Actual Demand</th>
<th>Billing Demand</th>
<th>Cost ($)</th>
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<td>TOTALS</td>
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</tr>
</tbody>
</table>
6. Natural Gas Consumption Data

   a. Supplier

   b. Interruptible Firm Stored
       Gas_____________Gas_____________Gas_____________

       Attach copies of contracts noting any changes, ex. firm gas, 
demand minimums, etc.

   c. Monthly Consumption and Costs

       **INTERRUPTIBLE**

       | Month | Cubic Feet | Cost |
       |-------|------------|------|
       | 1975  |            |      |
       | Jan.  |            |      |
       | Feb.  |            |      |
       | Mar.  |            |      |
       | Apr.  |            |      |
       | May   |            |      |
       | June  |            |      |
       | July  |            |      |
       | Aug.  |            |      |
       | Sept. |            |      |
       | Oct.  |            |      |
       | Nov.  |            |      |
       | Dec.  |            |      |
       | TOTALS|            |      |
       | 1976  |            |      |
       | Jan.  |            |      |
       | Feb.  |            |      |
       | Mar.  |            |      |
       | Apr.  |            |      |
       | May   |            |      |
       | June  |            |      |
       | July  |            |      |
       | Aug.  |            |      |
       | Sept. |            |      |
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       | Dec.  |            |      |
       | TOTALS|            |      |
6. Continued

d. Monthly Consumption and Costs

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## Monthly Consumption and Cost

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7. Fuel Oil Consumption Data

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8. Propane Consumption Data

   a. Supplier

   b. Storage Capacity

   c. Monthly consumption and costs

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</table>
9. Other Forms of Fuel
   a. Quantities & Types
   b. BTU Content
   c. Costs
   d. Uses

10. Water Usage
    a. Supplier
    b. Rate Schedule (Attach Copies)
    c. Monthly Consumption and Costs

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<tr>
<th>Month</th>
<th>Cubic Feet</th>
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| Oct.  |            |      |
| Nov.  |            |      |
| Dec.  |            |      |
| TOTALS|            |      |
11. Processes to be Aware of in Interview (please note if process is used)
   a. Multiple Metering
   b. Boilers
      Boiler Capacity
   c. Driers
      Drier Capacity
   d. Ovens
      Oven Capacity
   e. Hot Water
      Capacity
   f. Refrigeration
      Refrigeration Tons
   g. A/C Capacity
      Space Heating
   h. Motors
      Horsepower
   i. Turbines
      Turbine Power
   j. Chilled Water
      Chilled Water Per Day
   k. Type of Plant Lighting
      Plant Lighting Level
   l. Other Major Energy Consuming Processes
   m. Distribution of Energy
   n. Air Compressors
   o. Ventilation
   p. Insulation
   q. Humidification
   r. Waste Heat Uses
12. Sketch of Major Energy Consuming Processes

13. What Heat Recovery Systems Have Been Installed?

________________________________________

________________________________________

________________________________________

14. How Much Energy Has Been Saved by Plant? (How?)

________________________________________

________________________________________

________________________________________

15. Comments

________________________________________

________________________________________

________________________________________
APPENDIX IV

PROJECT EVALUATION FORM
A. Site Visit

1. Was the objective of the site visit clear?
   
   Yes ___   No ___

2. At the site visit did the Tech team answer your questions sufficiently?
   
   Yes ___   No ___

B. Recommendations

3. Were the recommendations for energy conservation relevant to your company?
   
   Yes ___   No ___

4. Were the techniques for conservation sufficiently described by the Tech team?
   
   Yes ___   No ___

5. What total percentage of energy do you feel you could save through energy conservation measures?
   
   ____ 0%   ____ 30%
   ____ 5%   ____ 35%
   ____ 10%  ____ 40%
   ____ 15%  ____ 45%
   ____ 20%  ____ 50%
   ____ 25%

C. Assessment of Need

6. Is an office needed to provide technical assistance to companies similar to the assistance provided by Georgia Tech?
   
   Yes ___   No ___
7. If you answered YES to the previous question, this office should be

___ within the University System

___ a new agency of state government

___ a newly formed agency of government or private organization

D. Overall

8. Would you rate the Tech Project successful:

Yes ___ No ___

Worth your investment in time

Yes ___ No ___

9. In the space provided below please add any additional comments on your opinion of the Tech Project.
APPENDIX V

SAMPLE CASE STUDY
Description of Company

The company is a manufacturer of aluminum extrusions. The basic raw materials are aluminum ingots and scrap aluminum. The plant is mid-sized for the primary metals industry in Georgia and employs about 200 people. Its products have a national market. The different types of energy used are natural gas, propane, electricity and fuel oil, of which about 50% is natural gas. This plant is highly dependent on natural gas for its production. During the winter, when natural gas is not available, propane is used. Most of the process equipment that uses natural gas does not have an alternate fuel capability other than propane.

Selection of Company

This plant is mid-sized aluminum extruder and is representative of the plants in Georgia. They are large users of natural gas and propane, fuels which are in short supply. The company was partially chosen because natural gas curtailment would have an adverse impact on employment.

Initial Contact

During the initial contact, which was made in early July, 1976, the general manager was informed about the program, the current energy situation and the potential vulnerability of his industry to curtailments of natural gas.

The energy conservation data survey sheets were mailed to him during the second week of July. A plant visit was made by Georgia Tech engineers during the next week.

Process Description

The flow chart of the processes of the plant is shown in Figure V-1
The basic raw material is aluminum ingots and scrap aluminum. These are melted in a smelting furnace fired by natural gas or propane. The molten aluminum is cast into billets 16" to 18" in diameter and about 6-8 ft. in length. These are allowed to cool to room temperature. The billets are then loaded on a cart and placed in a natural gas or propane fired homogenizing oven maintained at 1060° F. The billets are kept in the oven for 18 hrs. After this period they are again allowed to cool. After cooling, the billets are cut to 10" to 16" in length and are sent to the extrusion area. The billets are preheated to 900° F in a natural gas fired billet heater. The hot billets are then extruded by large hydraulic extrusion presses. The extrusions are then aged in an aging oven and some are prepared for shipping. The other extrusions are either sanded or buffed and sent to the anodizing area. The extrusions are anodized by dipping into tanks filled with various chemicals and agitated by air. Some of the tanks have steam jackets to heat the solutions. The anodized extrusions are then dried and shipped.

**Observations Made in Plant**

Shortly after beginning a tour of the plant, we observed open flames of the size of about 1 1/2' x 1 1/2' x 6' coming out of the top of the melting furnace and into the stack. There were also leaks in all the doors of the smelting furnace giving rise to excessive heat loss.

The billets, after being removed from the homogenizing oven or after casting, were left to cool in the atmosphere. This was a considerable waste of heat that could be transferred to air that could be used in combustion.

The water used to cool the smelting furnace doors and the mold was pumped into a lagoon to cool. This hot water could be used as boiler makeup.
Steam was boiling off the top of some of the anodizing tanks which were maintained at boiling.

There was excessive air leakage through the bottom of the billet heaters which cooled the billets as well as provided too much excess air for combustion.

The plant in general did not have an alternate fuel capability if natural gas or propane was not available.

The thermal efficiency of the smelting furnace was measured and found to be around 15%. The homogenizing oven had an efficiency of about 60%, the boiler close to 80%, and the billet heater around 20%, based on stack loss. There was no separate metering of the fuel for any of the equipment, nor was there any type of monitoring to determine whether the equipment was performing as required.

Recommendations

Recommendations were made as a result of the plant observation and data analyzed. These recommendations are shown separately as an attachment to this case study.

Stage of Implementation

The management has started installing instruments to monitor the fuel usage in the various equipment. They have made modifications to the burner system in the smelting furnace to improve combustion efficiency. They are also looking into the possibility of installing a recuperator on the smelting furnace.
PROCESS DIAGRAM - PRIMARY METALS

1. SMELTING
2. CASTING OF BILLETS
3. COOLING
4. HOMOGENIZING OF BILLETS
5. CUTTING TO SIZE
6. PREHEATING OF BILLETS
7. EXTRUSION
8. AGEING
9. PREFINISHING AND CLEANING
10. ANNODIZING
11. COOLING
12. SHIPPING
I would like to take this opportunity to thank you and your staff for cooperating with us on our energy conservation program. The information you have made available to us has been very helpful in evaluating the energy conservation potential within primary metals. We hope our investigation of this industry and your plant in particular will be both informative and rewarding to you.

As we have explained during our initial meetings, Georgia Tech has been funded to investigate the energy conservation potential in Georgia industry. We felt that the identification of inefficient systems and recoverable waste would be the best route to achieve this. We at Georgia Tech however, can only demonstrate to you the feasibility of currently available options. Our project would be successful if these options are implemented by you. We would appreciate being advised of your plans for the suggested projects.

We have investigated the following areas and our findings are attached.

1. Use of sensible heat of the billets removed from the homogenizing oven to preheat air.
   -- This system would save $7,300 annually and the system would cost approximately $5,000.

2. Improving combustion efficiency in melting furnace by using the right amount of air.
   -- It was found that the blower capacity was not sufficient to match the burner capacity and hence insufficient air was being used. An expected efficiency improvement of 10% would result in a savings of $10,800/year.

3. Possibility of using steam sparging agitation in the anodizing tanks.
   -- Steam cannot be used due to the problem of controlling both temperature and specific gravity in the tanks.

   -- A temperature controller should be installed to prevent wastage of steam.
We will get back with you as soon as we get more data and complete our calculations of the following possibilities:

5. Improving the efficiency of the billet heaters by reducing excess air.

6. Possibility of using the approximately 1500°F stack gases from the melting furnace in the homogenizing oven.

The completion of our project requires your continued contribution. Any questions you may have or suggestions as to how we may better succeed in increased implementation of energy conservation in Georgia industry is welcomed. If you require additional information to evaluate these systems please feel free to call (404 894-3623).

Sincerely,

[Signature]

Robert Fulford
Research Engineer

lm
Enc.
Savings by Using Preheated Air in Homogenizing Oven

At present the billets are removed from the homogenizing oven after the homogenizing period at a temperature of 1050°F and left in the open to cool by itself to the ambient temperature.

The system recommended recovers the sensible heat available in the billets by transferring it to the air that could be used for combustion in the burners. This would result in a direct savings in fuel and money.

The system required to achieve this would be an inexpensive enclosure into which the cart load of billets could be rolled out from the homogenizing oven. The enclosure should have openings at the bottom to allow entry of air and a ducting from the top to the inlet of the air blower of the homogenizing oven.

Calculations

<table>
<thead>
<tr>
<th>Monthly Load on Homogenizing Oven</th>
<th>1.3 million lbs</th>
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<tbody>
<tr>
<td>Homogenizing temperature</td>
<td>1050°F</td>
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<tr>
<td>Temperature of billet after being cooled by air</td>
<td>100°F</td>
</tr>
<tr>
<td>Temperature drop</td>
<td>950°F</td>
</tr>
<tr>
<td>Specific Heat of aluminum</td>
<td>0.208 BTU/1b°F</td>
</tr>
</tbody>
</table>

Heat Available = 1.3 x 10^6 lbs/month x 950°F x 0.208 BTU/1b°F

= 256 MM BTU/Month

Assuming the oven efficiency to be 65%

Energy savings = 393 MM BTU/Month

Cost of Natural Gas (Atlanta, Ga.) = $1.00/MM BTU

Cost of propane = $.30/gal

Cost $3.26/MM BTU
Oven runs of natural gas for nine months and propane for three months.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Annual savings of natural gas</td>
<td>$3,537</td>
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<tr>
<td>Annual savings of propane</td>
<td>$3,843</td>
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<tr>
<td>Total Annual Saving</td>
<td>$7,380</td>
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<tr>
<td>Estimated cost of preheat system</td>
<td>$5,000</td>
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<tr>
<td>Payback period</td>
<td>8 months</td>
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<tr>
<td>Payback period after taxes</td>
<td>1 year 4 months</td>
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</table>
Melting Furnace

On observing the melting furnace during full load operation it was found that there was an open flame about 5 feet high going through the opening and up the stack. There were also flames leaking out of the doors on three sides of the furnace. All these are a waste of energy. The flame leakage through the doors could be eliminated by better sealing of the doors. The elimination of the flame through the stack and methods of improving efficiency are discussed in detail below.

An important factor in the efficiency of the furnace is the efficiency of combustion of the gases. Improper combustion gives rise to lower flame temperatures, wastage of fuel and lower heat transfer rates from the flame to the furnace.

The air fuel ratio plays a very important part in the flame length and flame temperature. Fuel rich mixtures give rise to long flames while lean mixtures have short flames. The attached graph shows the effect of air fuel ration on flame temperature.

Since the furnace does not have metering of the natural gas used and the air used all the calculations below are based on equipment name plate data.

<table>
<thead>
<tr>
<th>Melting furnace burner capacity</th>
<th>-</th>
<th>15 MM BTU/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat value of natural gas</td>
<td>-</td>
<td>1000 BTU/CuFt</td>
</tr>
<tr>
<td>Vol. of gas required</td>
<td>-</td>
<td>$\frac{15 \times 10^6}{1000}$ cfh = $15 \times 10^3$ cfh</td>
</tr>
<tr>
<td>Air required for stoichiometric combustion</td>
<td>=</td>
<td>$15 \times 10^3$ cfh of gas x $10 \frac{cfh \ of \ air}{cfh \ of \ gas}$</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>150,000 cfh of air</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>2,500 scfm of air</td>
</tr>
</tbody>
</table>
Air requirement with 20% excess air \( 3,000 \text{ scfm} \)

Present blower capacity \( 2,550 \text{ cfm} \)

Hence there is just enough blower capacity for stoichiometric combustion. It is recommended that the actual combustion rate and air flow rate be monitored to find the actual air fuel ratio before action is taken to provide proper combustion.

The advantages of proper combustion are: savings in fuel and hence dollars; better heat transfer to the metal due to higher flame temperature and shorter flame, which would result in a reduction of the cycle time for melting; and reduction in stack losses.

**Heat Lost Through the Stack**

<table>
<thead>
<tr>
<th>Stack temperature</th>
<th>-</th>
<th>1500°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow rate</td>
<td>-</td>
<td>2500 cfm</td>
</tr>
</tbody>
</table>

Heat loss \( = 1000°F \times 24 \text{ BTU/°F} \times 0.075 \text{ lb/CuFt} \times 2500 \text{ CuFt/min} \times 60 \text{ min/hr} \)

\( = 2.7 \text{ MM BTU/hr} \)

\( = 19,440/\text{yr} \)
Steam Sparging in Annodizing Tanks

A number of the annodizing tanks are agitated vigorously by blowing air through the tanks. Some of these tanks are maintained at a specified temperature with steam running through a plate type heat exchanger. The annodizing process requires that the specific gravity and concentration of the liquids in the tanks be maintained to close tolerances.

Steam sparging to provide the agitation as well as the heat would not be a feasible proposition due to the problem of controlling two variables, namely specific gravity and temperature with one input, namely steam.
Steam Usage in Tank 20

The hot water seal tank (tank 20) is agitated with air and maintained at 200-210°F with a plate type heat exchanger using steam. Excessive steam is used since there is no control and the steam valve is kept fully open. Energy savings could be achieved by shutting the valve to the extent possible or by installing a temperature controller.
Flame temperature for various fuel air and fuel or gas mixture.*

ENERGY CONSERVATION DATA SHEET

1. Company Name, Address

Company Contact, Position

Principle Products: Aluminum extrusions, Production

Employment: 200

Yearly Gross Sales

Interviewer

1a) Hours of operation, shifts, employment on shift

2. Cost Data (yearly)

   a) Electricity X  c) Propane X  e) Other
   b) Natural Gas X  d) Oil X

3. Major energy work underway or planned:

4. Action Requested

Next Action

V-14 Form A1644-1 5/76
5. Electricity Consumption Data

a. Supplier GEORGIA POWER COMPANY

b. Rate Structure

c. Monthly Consumption and Cost

<table>
<thead>
<tr>
<th>Month</th>
<th>KWH</th>
<th>Actual Demand</th>
<th>Billing Demand</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>547,880</td>
<td>1,658</td>
<td>1,488</td>
<td>$16,040</td>
</tr>
<tr>
<td>Feb.</td>
<td>577,740</td>
<td>1,658</td>
<td>1,488</td>
<td>19,051</td>
</tr>
<tr>
<td>Mar.</td>
<td>510,000</td>
<td>1,658</td>
<td>1,488</td>
<td>18,480</td>
</tr>
<tr>
<td>Apr.</td>
<td>683,500</td>
<td>1,658</td>
<td>1,488</td>
<td>20,247</td>
</tr>
<tr>
<td>May</td>
<td>699,480</td>
<td>1,658</td>
<td>1,488</td>
<td>17,940</td>
</tr>
<tr>
<td>June</td>
<td>642,940</td>
<td>1,666</td>
<td>1,488</td>
<td>16,813</td>
</tr>
<tr>
<td>July</td>
<td>650,400</td>
<td>1,704</td>
<td>1,512</td>
<td>17,337</td>
</tr>
<tr>
<td>Aug.</td>
<td>710,680</td>
<td>1,675</td>
<td>1,488</td>
<td>18,367</td>
</tr>
<tr>
<td>Sept.</td>
<td>657,280</td>
<td>1,640</td>
<td>1,458</td>
<td>17,782</td>
</tr>
<tr>
<td>Oct.</td>
<td>721,820</td>
<td>1,618</td>
<td>1,436</td>
<td>18,754</td>
</tr>
<tr>
<td>Nov.</td>
<td>707,820</td>
<td>1,618</td>
<td>1,436</td>
<td>18,371</td>
</tr>
<tr>
<td>Dec.</td>
<td>697,580</td>
<td>1,618</td>
<td>1,436</td>
<td>17,728</td>
</tr>
<tr>
<td>TOTALS</td>
<td>7,807,120</td>
<td>19,829</td>
<td></td>
<td>216,910</td>
</tr>
<tr>
<td>1976</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>690,080</td>
<td>1,632</td>
<td>1,436</td>
<td>17,605</td>
</tr>
<tr>
<td>Feb.</td>
<td>707,940</td>
<td>1,594</td>
<td>1,436</td>
<td>18,439</td>
</tr>
<tr>
<td>Mar.</td>
<td>624,000</td>
<td>1,458</td>
<td>1,436</td>
<td>15,602</td>
</tr>
<tr>
<td>Apr.</td>
<td>616,500</td>
<td>1,424</td>
<td>1,436</td>
<td>10,117</td>
</tr>
<tr>
<td>May</td>
<td>693,000</td>
<td>1,431</td>
<td>1,436</td>
<td>17,635</td>
</tr>
<tr>
<td>June</td>
<td>732,000</td>
<td>1,485</td>
<td>1,436</td>
<td>18,065</td>
</tr>
<tr>
<td>July</td>
<td>714,000</td>
<td>1,512</td>
<td>1,436</td>
<td>17,357</td>
</tr>
<tr>
<td>Aug.</td>
<td>691,500</td>
<td>1,485</td>
<td>1,485</td>
<td>18,427</td>
</tr>
<tr>
<td>Sept.</td>
<td>732,000</td>
<td>1,512</td>
<td>1,512</td>
<td>N/A</td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>1,398,020</td>
<td>3,226</td>
<td></td>
<td>36,044</td>
</tr>
</tbody>
</table>
6. Natural Gas Consumption Data

a. Supplier ATLANTA GAS LIGHT COMPANY

b. Interruptible Firm Stored
   Gas X       Gas        Gas X (57,620 therms)

   Attach copies of contracts noting any changes, ex. firm gas,
   demand minimums, etc.

c. Monthly Consumption and Costs

<table>
<thead>
<tr>
<th></th>
<th>INTERRUPTIBLE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>成本</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>783,377 (therms)</td>
<td>$ 9,028</td>
</tr>
<tr>
<td>Feb.</td>
<td>200,470</td>
<td>13,996</td>
</tr>
<tr>
<td>Mar.</td>
<td>131,674</td>
<td>13,822</td>
</tr>
<tr>
<td>Apr.</td>
<td>108,499</td>
<td>10,089</td>
</tr>
<tr>
<td>May</td>
<td>84,180</td>
<td>6,522</td>
</tr>
<tr>
<td>June</td>
<td>101,665</td>
<td>7,842</td>
</tr>
<tr>
<td>July</td>
<td>109,979</td>
<td>7,764</td>
</tr>
<tr>
<td>Aug.</td>
<td>101,928</td>
<td>7,197</td>
</tr>
<tr>
<td>Sept.</td>
<td>116,322</td>
<td>8,164</td>
</tr>
<tr>
<td>Oct.</td>
<td>134,332</td>
<td>10,295</td>
</tr>
<tr>
<td>Nov.</td>
<td>96,189</td>
<td>9,609</td>
</tr>
<tr>
<td>Dec.</td>
<td>49,270</td>
<td>7,002</td>
</tr>
<tr>
<td>TOTALS</td>
<td>1,312,936</td>
<td>$111,330</td>
</tr>
</tbody>
</table>

| 1976  |     |       |
| Jan.  | 2,069 | $ 4,604 |
| Feb.  | 24,481 | 8,651  |
| Mar.  |       |       |
| Apr.  |       |       |
| May   |       |       |
| June  |       |       |
| July  |       |       |
| Aug.  |       |       |
| Sept. |       |       |
| Oct.  |       |       |
| Nov.  |       |       |
| Dec.  |       |       |
| TOTALS| 26,550 | $13,255 |
6. Continued

d. Monthly Consumption and Costs

<table>
<thead>
<tr>
<th></th>
<th>FIRM</th>
<th></th>
</tr>
</thead>
</table>
| Month | Cubic Feet | Cost | 1975

<table>
<thead>
<tr>
<th>Month</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td></td>
<td></td>
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<tr>
<td>Feb.</td>
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<td></td>
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<tr>
<td>Mar.</td>
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<tr>
<td>Apr.</td>
<td></td>
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<tr>
<td>May</td>
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<tr>
<td>June</td>
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<td>July</td>
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<tr>
<td>Aug.</td>
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<tr>
<td>Sept.</td>
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<tr>
<td>Oct.</td>
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<tr>
<td>Nov.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td></td>
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</tr>
<tr>
<td>May</td>
<td></td>
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<tr>
<td>June</td>
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<td>July</td>
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<td>Aug.</td>
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<tr>
<td>Sept.</td>
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<td>Oct.</td>
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<td>Nov.</td>
<td></td>
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<tr>
<td>Dec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Continued

   e. Monthly Consumption and Cost

<table>
<thead>
<tr>
<th>STORED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1975</td>
</tr>
<tr>
<td>Jan.</td>
</tr>
<tr>
<td>Feb.</td>
</tr>
<tr>
<td>Mar.</td>
</tr>
<tr>
<td>Apr.</td>
</tr>
<tr>
<td>May</td>
</tr>
<tr>
<td>June</td>
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<tr>
<td>July</td>
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<tr>
<td>Aug.</td>
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<tr>
<td>Sept.</td>
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<tr>
<td>Oct.</td>
</tr>
<tr>
<td>Nov.</td>
</tr>
<tr>
<td>Dec.</td>
</tr>
<tr>
<td>TOTALS</td>
</tr>
<tr>
<td>1976</td>
</tr>
<tr>
<td>Jan.</td>
</tr>
<tr>
<td>Feb.</td>
</tr>
<tr>
<td>Mar.</td>
</tr>
<tr>
<td>Apr.</td>
</tr>
<tr>
<td>May</td>
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<tr>
<td>June</td>
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<tr>
<td>July</td>
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<tr>
<td>Aug.</td>
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<tr>
<td>Sept.</td>
</tr>
<tr>
<td>Oct.</td>
</tr>
<tr>
<td>Nov.</td>
</tr>
<tr>
<td>Dec.</td>
</tr>
<tr>
<td>TOTALS</td>
</tr>
</tbody>
</table>
7. Fuel Oil Consumption Data

a. No. 2 Oil  
b. Supplier___________
c. No. 6 Oil  
d. Supplier___________
e. Other___________  
f. Supplier___________
g. Storage capacity:  
  No. 2___________  
  No. 6___________  
  Other___________

h. Monthly consumption and costs

<table>
<thead>
<tr>
<th>Month</th>
<th>Gallons</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
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<tr>
<td>July</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 1976  |         |      |
| Jan.  |         |      |
| Feb.  |         |      |
| Mar.  |         |      |
| Apr.  |         |      |
| May   |         |      |
| June  |         |      |
| July  |         |      |
| Aug.  |         |      |
| Sept. |         |      |
| Oct.  |         |      |
| Nov.  |         |      |
| Dec.  |         |      |
| TOTALS|         |      |
8. Propane Consumption Data

a. Supplier

b. Storage Capacity

c. Monthly consumption and costs

<table>
<thead>
<tr>
<th>Month</th>
<th>Gallons</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>47,298</td>
<td>$12,245</td>
</tr>
<tr>
<td>Feb.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Mar.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Apr.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>May</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>June</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>July</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Aug.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Sept.</td>
<td>9,000</td>
<td>2,805</td>
</tr>
<tr>
<td>Oct.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Nov.</td>
<td>27,100</td>
<td>8,156</td>
</tr>
<tr>
<td>Dec.</td>
<td>62,999</td>
<td>18,454</td>
</tr>
<tr>
<td>TOTALS</td>
<td>73,398</td>
<td>$23,206</td>
</tr>
</tbody>
</table>

1976

<table>
<thead>
<tr>
<th>Month</th>
<th>Gallons</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>143,701</td>
<td>$41,661</td>
</tr>
<tr>
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<td>55,803</td>
<td>16,511</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
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<tr>
<td>July</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>199,504</td>
<td>$58,172</td>
</tr>
</tbody>
</table>
9. Other Forms of Fuel
   a. Quantities & Types
   b. BTU Content
   c. Costs
   d. Uses

10. Water Usage
    a. Supplier Own reservoir & well
    b. Rate Schedule (Attach Copies) Not metered
    c. Monthly Consumption and Costs Nominal amt. purchased for drinking, etc. from City of Franklin

<table>
<thead>
<tr>
<th>Month</th>
<th>Cubic Feet</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
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<tr>
<td>July</td>
<td></td>
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</tr>
<tr>
<td>Aug.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
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11. Processes to be Aware of in Interview (please note if process is used)
   a. Multiple Metering No
   b. Boilers
      Boiler Capacity
   c. Driers
      Drier Capacity
   d. Ovens
      Oven Capacity
   e. Hot Water
      Capacity
   f. Refrigeration N/A
      Refrigeration Tons
   g. A/C Capacity N/A Office only
      Space Heating
   h. Motors
      Horsepower
   i. Turbines N/A
      Turbine Power
   j. Chilled Water N/A
      Chilled Water Per Day
   k. Type of Plant Lighting Flor.
      Plant Lighting Level
   l. Other Major Energy Consuming Processes
   m. Distribution of Energy
   n. Air Compressors X
   o. Ventilation
   p. Insulation
   q. Humidification N/A
   r. Waste Heat Uses None
12. Sketch of Major Energy Consuming Processes

13. What Heat Recovery Systems Have Been Installed?

14. How Much Energy Has Been Saved by Plant? (How?)

15. Comments

V-23
APPENDIX VI

INDUSTRIAL ENERGY CONSERVATION WORKSHOP ANNOUNCEMENT
Workshop

ENERGY CONSERVATION SYSTEMS FOR MANUFACTURING INDUSTRIES

Presented by the Georgia Tech Engineering Experiment Station

January 31, 1977 — Savannah, Georgia
February 3, 1977 — Atlanta, Georgia

In Cooperation with Georgia Business and Industry Association

Sponsored by The Economic Development Administration U.S. Department of Commerce

Background

The Georgia Tech Engineering Experiment Station has been involved in energy conservation in manufacturing industries for several years. This work has resulted in the identification of several systems that are applicable to manufacturing industries but which are not widely used. These have been evaluated for specific plants to determine technical and economic feasibility. These systems will be described and evaluative procedures will be discussed. In addition, future planned research will be introduced for industry comments. It is our intent to use these comments in order to identify energy-related problems most pressing to industry.

Agenda

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<th>TIME</th>
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<td>8:00 - 8:30 a.m.</td>
<td>Registration</td>
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<td>8:30 - 9:30</td>
<td>Introduction to Conservation and Energy Fundamentals</td>
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<td>9:30 - 9:45</td>
<td>Break</td>
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<td>9:45 - 10:30</td>
<td>Heat Recovery</td>
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<td>10:30 - 11:00</td>
<td>Discussion</td>
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<td>11:00 - 11:45</td>
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<td>12:00 - 1:00</td>
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<td>Utilities and Fuels</td>
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<td>1:45 - 2:30</td>
<td>Boilers and Steam Distribution</td>
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<td>2:30 - 2:45</td>
<td>Break</td>
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<td>2:45 - 4:00</td>
<td>Management and Conservation Discussion</td>
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Who Should Attend

Energy conservation depends upon:
(1) Management commitment, and
(2) technical knowhow.

Highest energy (and money) savings can be achieved with management/engineering team. It is recommended that at least one manager and one engineer or technician from each company attend. The manager who attends should be in a position to implement new man-
agement procedures especially for the measurement of energy consumption. The engineer or technician should have a background in either chemical or mechanical engineering and should be completely familiar with the processes of his plant.

Cost
The Georgia Tech Engineering Experiment Station is operating under a grant from the Economic Development Administration that allows this workshop to be held FREE OF CHARGE.

Featured Speakers
Mr. Grant Curtis, P.E., formerly Head of Engineering at the Georgia Tech Physical Plant has a degree in Mechanical Engineering. For over twenty years he has been associated with “energy to heat” conversion systems and he has a broad background in boiler operations. Mr. Curtis now has the responsibility for developing new energy conservation techniques in a number of industries and types of institutions.

In his position at the Georgia Tech Physical Plant, Mr. Curtis initiated a campus-wide energy conservation program in 1972. Current campus energy consumption is 22% below the level for 1972 and, as a result, over $400,000 has been saved in the last two years alone.

Mr. R.H. (Bob) Fulford, P.E., graduated Summa Cum Laude from the University of Florida and since has acquired extensive experience in energy conversion systems related to energy recovery and in-plant power. He has directed programs in developing the use of coal and solid waste for total energy systems, and programs for energy recovery from solid waste. Current responsibilities at Georgia Tech include the analysis of energy recovery systems for industry and the specification of energy conserving equipment for these industries.

Mr. Ron Pearl, with degrees in Electrical Engineering and a background in marketing, has most recently completed an audio-visual presentation on energy conservation in government operations. He has performed research and organized workshops in the area of industrial energy conservation, and helped develop a computer program for monitoring energy consumption in industry. Current responsibilities at Georgia Tech include the development of educational materials on industrial energy conservation and the identification of new energy conservation products.

Mr. Richard Combes, with a degree in Mechanical Engineering, has performed research to determine the advantages of insulation in solar homes, in commercial structures, and in industry. Current responsibilities at Georgia Tech include the demonstration of the value of insulation of steam lines, hot and cold water tanks and refrigerated spaces.

Registration
Registration should be made as far in advance as possible to insure a place in the workshop. Registration can be made by mailing the attached registration form. If possible, the registration form should be mailed to us no later than one week before the date of the workshop. For questions call: (404) 894-3623.

Locations
The Savannah workshop will be held at:
Armstrong State College Campus
Continuing Education Seminar Room
Room 215 — Fine Arts Building

The Atlanta workshop will be held at:
Georgia Tech Campus
Harry L. Baker Building
Dalney Street (between Ferst and 10th)
Third Floor Conference Room
Application Form
Energy Conservation Systems —
Manufacturing Industries

(Check one)

Manager: Name ___________________________ Title ___________________________

Engineer or Technician: Name ___________________________ Title ___________________________

Company Name ___________________________ Major Product ___________________________

Company Address ___________________________

Company Phone ___________________________ Home Phone (Manager) ___________________________

Mail to: Workshop
Georgia Productivity Center
EES, Georgia Tech
Atlanta, Georgia 30332
APPENDIX VII

TRANSCRIPT OF A SAMPLE INDUSTRIAL ENERGY CONSERVATION WORKSHOP
October 19, 1976

Textile Processing Industry Energy Conservation Workshop

Moderator

My name is Ron Pearl, I'm from the Georgia Tech Engineering Experiment Station, and I'd like to welcome all of you to our workshop on Energy Conservation Systems in the Textile Processing Industry. The introduction to the energy conservation problem today will be in the form of a film produced by the U.S. Department of Commerce. It was produced shortly after the energy crisis of 1973 and I think it will give us an excellent point of reference from which to start our workshop today.

Film

(Showing of the film "Energy: The Critical Choices Ahead")

Moderator

The movie, which was produced in early 1974, quoted that we were, as a nation, importing 15% of our nation's oil needs just prior to the Arab Oil embargo. Relations with the Middle East are something to be concerned about, especially when you consider that now we are importing about 40% of our nation's oil needs rather than 15%. This is an indication of the seriousness of our energy problem.

There are two ways to solve the energy problem. One is through the development of new sources of energy; the other is through conservation. As we saw on the film and as is evident since then, even with massive federal spending by the Energy Research and Development Administration and other agencies to develop new sources of energy, they are a long way away. Georgia Tech is doing over $2,000,000 worth of energy research per year, primarily in solar energy and some other energy sources, and the film was optimistic about how long it's going to take to get new energy sources on line. So the other answer is conservation, that's something we can do right now, the people that you will be hearing from today will be demonstrating how it works.

There are three requirements for energy conservation. The first, the one we'll primarily be talking about today, is technology. It's not new technology for the most part. Some things are new, but for the most part it's the kind of technology we've seen for many years and maybe not used it the way we're going to show it being used.

The second item to conserve energy is commitment by the management, by the top management, to conserve energy. Your plant engineers, maintenance people, and the people on the production line can have all the ideas in the world about how to conserve energy, but if management doesn't listen to them or if they don't take into consideration what can be saved through energy conservation, then it won't happen.
The third is communication between the two, between the management, the people who have the commitment, and the people who have the technology. That is why we will aim this workshop toward both management and the people who are keeping your plants going.

There are three things that we are going to talk about today, basically; they are the steps to conserving energy. First, you find out what you've got, second you eliminate as much waste as you can, and the third is to use the waste you cannot eliminate. The first speaker will be John Dawkins, who will talk about accounting for energy. After a break we will discuss waste reduction in boilers with Mr. Grant Curtis; at 11:10 Dr. John Beard will talk about waste production in dryers; at 1:00 (lunch will be from 12-1) energy waste reduction in dye beck heating, Mr. Bob Fulford; 1:30, energy waste reduction dyeing, Dr. Fred Cook; and then pre-drying at 2:10, Dr. Dave Brookstein; then a break and then energy recovery, again Mr. Fulford.

We want to accomplish two things today. First, we're going to try to tell you what we have learned in the research and the work in the plants that we've done at Georgia Tech. The other part of making this a successful course today is that we want inputs from you.

We are right in the middle of our research work at Georgia Tech, we're expecting additional work in the future, we're anxious to spend our federal contract money, your taxpayer's dollars, wisely. So we're very interested in you telling us the priorities that you see as being the top priorities in your industry. You will have a number of opportunities to do this, including 10 minute question and answer periods after each presentation and also a 50 minute discussion at the end of the meeting. Finally, at the very end of the meeting I will pass out an evaluation form on which you'll have a chance to tell us if you think we did or didn't do a good job, and give us a little information about energy consumption, your company's attitude toward it, and the decision making criteria that you may use to determine whether or not to invest in capital equipment to conserve energy.

In order to get our interchange started I would like to go around the room and have everybody introduce themselves if you'll just stand up or sit down and give your name, title and the company you're with, and your major product. I want to make sure that everybody who is going to be presenting their topics here today to be aware of the diversity of products that we're going to have in the textile industry to make sure that we make an attempt to answer your questions. If we could start, we'll start with Georgia Tech on the end here and go around and if you would, introduce yourself.

(Each participant states his or her name, title, company name, and major products.)

Moderator

Welcome to our neighbors from South Carolina. We're glad all of you could be here. Let's go right into our first topic, "Accounting for Energy", and let me remind you again if somebody doesn't make something clear when they stand up here please jump up and make sure that you understand what they're saying and then if you have some special questions that might take a while to answer jot them down and there will be a ten minute question and answer period.
Here's John Dawkins.

John Dawkins

I'm here to talk to you about accounting for energy, what to measure, and where to measure, and how to measure, and how to analyze. The movie you saw aptly answers another question, why measure energy?

Energy is becoming an increasing cost of doing business, so maybe in the near future you'll have to do the same amount of business with a lot less of it. We need to manage energy just as we manage labor and inventory and other plant factors because, without energy, even though it's still a fairly small percentage of sales, there is no production. You need feedback information in order to manage energy, and just like you need data on inventory and labor in order to manage it. This information can also provide you with data to make decisions concerning alternate fuels, provide information for future expenditures for different kinds of process equipment on amounts to spend on conservation or energy requirements of your different products. The energy use and waste measurement will provide this feedback and this feedback can then be used to eliminate, to reduce, combine, or dictate what energy is best to recover. And finally, the feedback from the measurements can be used to judge the effectiveness of your program in energy conservation and expenditures required to reduce the cost of energy as a percent of sales.

How do you determine what to measure? You need to measure energy to the main production processes, such as the boilers, dryers, dye ranges. I'm not going to cover the dry processing end of the industry since that end is more electrical. We need to measure energy from the major processes, and usually the exhaust gas streams and the exhaust water streams.

So we turn to where to measure the energy. What we're going to measure more or less dictates where. The utility bill will define your gross plant use, to give you a breakdown on electrical and thermal, you need to break that into specifics with the measurements. So first we need fuel, natural gas or fuel oil, electrical, and we need to get into the inlet lines to the boiler, to the dryers. You need to measure the input to the boiler, you need to measure the input to all the major users, the becks and ranges and so forth. The electrical breakdown is probably determined by name plate information, although I feel it should be measured, and a clip-on ammeter may be sufficient to find out if you're using the rated horse power of your motors.

In addition you need to measure energy out...from exhaust streams. We need to know temperature and flow of the exhaust streams, the temperature and flow of gas to the atmosphere, and temperature and flow of heated water to the drain.

That takes us to how to measure. Well, you procure instruments. But to get into some of your instruments, on the fuel end gas is one of the simple ones to measure. Although it's a compressible fluid the density stays constant and the pressure is usually constant. Here are some examples. This is a positive displacement meter, another positive displacement meter, and a turbine gas meter. Now these meters generally run around $1000, in that price range.
There was a question that came up about variations in meters. I feel that for the kind of information that you're looking for, laboratory accuracy is not required. You're going to find so many errors in some of the other measurements that the temperature compensation for natural gas will not introduce that much error. As you talk to the salesman and the experts on their products, ask them the same question, they've had more experience in their particular meters. But I generally feel that the temperature compensation is not needed on that particular one, because we're not after half percentage accuracy, we're after just general and broad over terms, where is energy going in your plant?

When we get to steam we've got a different problem. We've got several different ways of measuring steam. A steam measurement system generally consists of two different elements, a primary element and a secondary element. The primary element is a differential flow device, a venturi valve, because flow of the fluid is proportional to the square root of the differential pressure. So when you select a meter you need to work from a rule of thumb.

Again the specific manufacturers who sell this kind of instrument will give you a lot of help in your selection, but you need to stay in the range of the read-out instrument of one inch of water column or less per psi of static pressure. It can be as simple as just hooking up a manometer across the pressure tabs on an orifice plate. You can do so into your recorders and so forth.

Now we get into compensation corrections which are used if your line pressure varies very much. This may add maybe $700-800 to the price of the meter, but you must look at the errors pressure on the orifice plate will give you. For example if you calibrate an orifice at 120 psi and you actually have 100 psi in your line, the error you would get would be the square root of the 100 divided by 120, which comes out about 9%. Now this type of inaccuracy found in your meter errors will compound and you'll start getting up in the 20-25% range. So with steam measurement I recommend pressure compensation. Temperature compensation of a steam meter, I don't feel is required because most of you are using saturated steam and you get the steam temperature by knowing the pressure.

One of the items that most of the manufacturers omit is steam quality. How much water do you have in your steam? This directly affects the accuracy of the orifice reading, but since it's so hard to determine on an individual basis, whether you have 1% water or 1/2% or 2%, it is generally assumed that you have 100% steam and no intrained water.

I'll go through a few of these devices. This one is a Singer steam readout device, and they all use orifice plates. This is a Westinghouse-Hagan ring balance meter. I like one feature on this, they supply a factory calibrated weight so you can do your field calibrations fairly simply. Basically these are like I said before, differential pressure instruments. This one works on the principal that you have a ring filled with mercury that's attached to a sharp edge fulcrum, as your differential pressure is put in one side or the other it displaces the mercury and the ring turns and the square
root function is taken out of the mechanism. Here is a picture of a
and an orifice plate. If it's used with your plans tabs the orifice plate
is machine calibrated. The data off those plates sticks out so you can read
it, using the plans tabs means you can substitute orifices very readily.

Now let's see if I can get this thing working. This is one of the other
problems associated with steam is that you need plumbing. Then you have
some associated valving, all of this would be explained in whatever litera-
ture you get with the particular brand. To return to the orifice plate
itself, this is your primary instrument. We've got a problem. If you don't
know what your nominal flow is, selecting orifices is a difficult problem.
And it's usually a trial and error thing.

We might point out now that we are engaged in an ERDA sponsored project,
and we're looking at the different major wet processes in the textile industry,
and trying to determine the relative uses of energy and how efficient or
inefficient they make use of energy, so we may be able to give you some ball
dark help, so you have some idea when you go to a manufacturer about what
range of steam flow you're talking about.

Again you need to know your pressure and that would take a pressure
reading where you're going to measure your steam flow and that would get
rid of one of the inaccuracies that is going to pop up. One of the problems
with steam is that your primary elements, the orifice plate, are fairly
cheap. Even calibrated they're fairly cheap and you'd like them throughout
your plant at different places and one secondary instrument that you can move
around. If you don't have about the same pressure differential across the
different orifice plates you can't move the secondary instrument without
calibrating it every time so you just can't hook up without looking at the
individual orifice plate calibration. Another thing is if you have orifice
plates around your plant that haven't been used in several years it may pay
to pull one out and see if the sharp edges have been eroded and if so buy
another one. Now these, I'm talking about maybe, well for sure less than
$100 a plate, sometimes around $50.

To give you an example of the problem of calibrating an orifice, I'll
give you an equation. It's the rate of flow is equal to a Reynold's number
factor, times an area factor, times an expansion factor, times the inside
diameter squared, times the principle meter constant, which is made up of
another constant, times the coefficient of the discharge of the orifice,
times the beta ratio of the orifice, times the diameter ratio, times the
square root of the differential pressure in inches of water, divided by the
specific volume. A lot of places there where some error creeps in. That's
why we leave the calibration up to people who are equipped to do it. If you
can give them as much specific information like what the expectant nominal
or usual pressure is, static pressure I'm talking about, if you take boiler
pressure as 125 and you are 60 feet away through all different kinds of elbows
and valves and so forth and assume that that's going to stay at 125, you'll
have an error there.

I've got a couple of other pressure or steam devices. This one is a
Handybars, and I'm not recommending one over the other. This one is sort of
a glorified pitot tube, again it works on the same idea that the flow is
proportional to the square root of the differential pressure. I came across one, those run I would say in the neighborhood of $1,200 - $1,400, and if you get pressure compensation that's another $600-700; you're generally talking about less than $2,000. You are recording the flow and integrating it over time so that you don't have to go back and reduce data.

I located one using the Venturi principle. It's not a recorder. It's an electronic indicator and here they claim that you can move it around to different Venturi's. I assume you plug in your calibration constant for your Venturi. It costs a little more than $3,500. If you want any more detailed information of what we think of these competing instruments, I'll say all of them will do the job. If you buy them, if you get help from the salesmen who are more than happy to give it to you I'm sure, you can get in the range of 2-3% accuracy which I feel is better to use. You certainly don't want to throw it away if you can keep from it. Because I feel an erroneous reading from an instrument, one where you're way off, can do you more harm than no reading because a lot of times the results of readouts from instruments are taken as gospel, so any time you use instruments remember that they can be off for a number of reasons.

Now let's talk about water. Again you need the temperature and flow to determine waste. Well you could use a thermometer. We could do it with portable temperature indicators. I would again at least try anything you use on at least a two point calibration. Now this could be boiling water, or ice water. That will give you some idea of your temperature indicator; it's very simple to do, if it is anywhere within reason.

You also need flow. In the case of exhaust stacks, you need to know the temperature and the velocity. If you know the area of the duct you can determine the flow. Now velocity can be determined by a number of methods. A pitot tube, velocity meters, anemometers. Personally the simplest one I've seen is the volometer where you just measure the velocity in feet per minute and with the area you determine the flow. With temperature and flow you can determine how many feet you're losing up the stack. In the case of dryers an added one is needing the wet bulb temperature and the dew point. I'll get into why maybe a little later.

Once you get the measurements how do you analyze them? What do you do with them? One thing you can do is get cost per unit production comparisons. This may lead you to alternative processes for your product or even alternative energy supplies. It may lead you to a change in your production schedule. Scheduling effects shows up in your getting into heat recovery and recovering a lot at one time and using a lot at another time. For example, if you have several dye becks and they're all heated up and dumping their hot water at the same time, you need a large storage tank to recover that energy to use later, whereas if you stagger your dumps you use your recovered energy in, you might not need as large a storage tank. You may need a shift in the market. Some products and some colors are more energy intensive. With the information you can make an intelligent decision as to what direction to go with all the other considerations that you already have figured.

I like to take the data and make very simple energy balances. These balances will define some ways so I'll go through some of them. This happens
to be a dryer that we've worked on. It shows your energy coming in, your
electrical energy, and what's happening on the other side. You lose 12
percent in radiation convection on this one, taking 40% of energy on
this one to turn the water to vapor and heat the vapor up. 33% is just
to heat up the air and throw it out, and the rest is nominal. Electrical
energy goes to provide the velocity for your product and to overcome friction.

Once you have the energy balance data, you can manipulate it to see
how the different variables are affected. We have done energy balances for
a number of dryers and have plotted the energy required for drying against
the humidity ratio of the exhaust for various incoming moisture contents
of the carpet. As can be seen from the graph, as the humidity ratio
decreases the energy required increases at an increasing rate. It can also
be seen that there is a significant difference in energy required for
different inlet moisture contents. So the first energy saving possibility
is to move to higher humidity ratio which could be achieved by reducing
the amount of exhaust itself. As an example for an incoming moisture content
of 120% which is the top curve, by increasing the humidity ratio from 0.05
to 0.15 an energy savings of approximately a 1000 BTU/lb of carpet can be
achieved. The other possibility is to reduce the inlet moisture content by
means of mechanical or vacuum predrying. For example, by reducing the inlet
moisture content from 120% to 60% with the humidity ratio maintained at
0.05, about 1300 BTU/lb of carpet can be saved. If the mechanical or
vacuum system can achieve this with less cost and energy, it might be a
way to go. Most of the dryers we have seen have been working with extremely
low humidity ratios and so considerable savings can be achieved by just
reducing the exhaust air.

We've got restrictions here as you know better than I do; those dryers
have got a lot of resin and oil evaporating out and the smoke becomes a
problem. We've got insurance regulations. If you have a lot of idle time
in your dryer, the BTU/lb goes up. What I'm trying to get at is that you
need to look at your dryers. Each one is individual to specific tastes.
Find out if you're using too much exhaust.

We've talked to dryer manufacturers. They were designed for production
rates and so forth, they may have been designed for cotton and you're using
them for synthetics. No thought as yet has been given to tuning up the
dryer. The whole idea we're trying to get at is measurements sometimes
point to obvious wastes. Turn to another example, this atmospheric dye beck.
Here is another way of presenting it. Our measurements surprise me, in that
45-60% of the energy was going right out the stack, right out the top, which
is unnecessary. It's not supplying anything to the process at all. On the
other hand we get a 40-55% loss going out the drain in hot water. This is
all calculated on per pound of product so that if you have a high liquor ratio
it's going to cost you more BTU's per pound than if you have a lot of product
in a pound of water. Then you have 2% or less of other losses such as
radiation convection. Now this same data, the way I like to show it, is
generally that all this thermal energy is either going out the stack or down
the sewer with hot water. Later we'll be getting into some of the reduction
and recovery that there are ways to reduce this loss.

My whole point is that without knowing and measureing some of these things
you have no information to manage any of this. My final point is that once you
become familiar with the measurement data that is associated with energy, you
can start requiring your equipment manufacturer to supply that information as well as anticipated production you get out of a piece of equipment. What’s its energy consumption? In talking with them they say the customer doesn't require this information, you start requiring the equipment manufacturer to supply energy consumption data, they're not going to do it. They're not competitive, they don't need to be competitive in energy consumption because nobody cares.

Moderator

Let's take a 10-minute coffee break.

(Break)

Our next speaker, Grant Curtis, was formerly head of engineering at Georgia Tech. In that position he instituted an energy conservation program on the campus of Georgia Tech in 1972 which to date has dropped our energy consumption by 22%, which has resulted in a savings annually of over $200,000.

He is now doing energy conservation research with us in the Engineering Experiment Station. Grant:

Grant Curtis

I'm going to talk very briefly here about boilers. All of the real engineering work and the excellent selection of metals in boilers was done about 1860-1900. And when all the fundamental process of combustion were developed and known, the only changes that have really been made in boilers in recent years, have been that we have gone over to natural gas and fuel oils. With the introduction of natural gas and fuel oils, the combustion volume required to burn these fuels, as opposed to wood or coal, was much less. So we have come to the point where we keep squeezing down the size of the boilers and primarily in the area of the combustion volume that you're using.

The fundamental combustion process is really quite simple when you look at it in the chemistry, and the chemistry of combustion is pretty straight forward. All of the hydrocarbon fuel, coal, natural gas, fuel oil, essentially consists of 2 elements: carbon and hydrogen and that's the term hydrocarbon. They come in varied percentages, the coal for instance a large percentage of it is pure carbon, but in any event gas and oil and coal and wood for that matter consists essentially of these two items. And when they burn they combine together with oxygen and the products of combustion are CO₂, carbon dioxide, which is the gas you know which forms the bubbles in beer and Coca Cola, that sort of thing, and of course the hydrogen combines with the oxygen to form H₂O, which is water.

So in the exhaust stack coming off of your boiler, the two principal products you've got are simply carbon dioxide and water vapor. Now it goes without saying that in some instances you've got some other elements in there, for instance in the coals and fuel oils, some of the heavier fuel oils, you've got sulfur in there and that's one of the pollutants, when you get your sulfur...
and it burns to SO₂ and it can get on to SO₃ even and combine back with water to form sulfuric acid, H₂SO₄, and that's one of the problems with it. But fundamentally the two things that you get off in the process of combustion are just carbon dioxide and water vapor. This is the open gas flame in your kitchen that you can cook with, fumes don't bother you coming off from that flame.

Now logic tells you that there is a certain amount of oxygen molecules needed to combine, be introduced to the fuel, to properly burn the carbon and the hydrogens. For instance, if you're burning your flame and you're burning it with too little oxygen and air coming in, instead of all of it boiling to CO₂, burning completely, it stops at CO, which is carbon monoxide, which is the one that comes out of your exhaust fumes out of your automobile, the deadly gas. So to prevent this and to get full combustion, it's almost invariably true that you supply an excess amount of air to your fuel so that you will get complete combustion, and also you have to supply mixing that takes place in the burner is not perfect so every oxygen molecule that you put in there doesn't combine, doesn't locate and for instance find the carbon molecules to combine with. So you generally run in the order of about 25% excess air over what the theoretical requirement are.

Now write this number down here because 25% is considered at this stage a pretty good percentage that you can operate at. If you take a boiler and set it to what looks good, you adjust your flame to what looks good, the average person would set it at a point where you would have about 50% excess air going through the boiler, and it's not uncommon at all to have 100% excess air going through. A flame with 100% excess air looks good, short, you know, with gas real blue looking. The problem with excess air is that every bit of the excess air that you put through doesn't enter into the combustion process and it goes through and is heated up and simply goes out the exhaust stack without entering into the combustion process. It simply goes through and is heated up from whatever room temperature is up to exhaust temperature and goes out the stack. Another way of looking at the amount of excess air is that about 20% of the air is oxygen and 80% of it is nitrogen, and nitrogen doesn't enter into the process at all, even under the best of conditions the nitrogen in there just passes through boilers heated. This gives you another indication of why it's important about the amount of excess air you're using.

It turns out that, unlike locating the dew point in the exhaust stack, there is a very simple technique for determining what the combustion efficiency is. And if you do theoretical calculations, which have already been done for us and they're published in tables, you'll know that when you take this carbon and burn it with oxygen and it gets CO₂ out of it, if you burn it completely for any given fuel the amount of carbon dioxide that is in the exhaust gas will be a certain percentage of what is going out. Now it turns out that for instance on natural gas the theoretical maximum percentage is 12.1%. If you were burning natural gas with the exact quantity of air that it theoretically calls for and then you went and measured the percentage of
carbon dioxide in the exhaust stack, you would get a figure of 12.1%. The next step then, any excess air that was going through there would dilute this percent here and it would be less than that. You will not find, if you measure the CO₂ in the exhaust gas or coming off of a boiler, you would not find this 12.1 percent because at all times, almost invariably you've got to have excess air so the excess air would dilute this down and so typically when you measure the exhaust stack you will find, 9, 10, or 8% as the reading of the CO₂ in your exhaust stack.

Now working on the other side, looking at the temperatures, again theoretically you can calculate the temperature that the exhaust stack ought to be. It should be obvious that the temperature of the gases leaving the stack, 600°, 400°, whatever your number is, 300°, this at the same flow rate would loose more heat than this number. Well what they have done for us is they have combined the temperature and the CO₂ reading into a table and by knowing those numbers you can tell what the efficiency of your burner is. And I need to pass these out here. I have made copies of Chapter 17 on combustion and fuel from the ASHRAE Journal, which is the American Society of Heating, Refrigerating, and Air Conditioning Engineers. There is a lot of material in here that is of a rather fundamental nature that you probably won't find necessary at the moment, but as time goes on and new fuels come in I think you will find it a value to understand it; for instance the author starts off with the burning of coal. There are not too many of you in here who burn coal now, but if I read the numbers right we'll all be back into that quite a bit more as time goes on. For the time being will you please turn to page 274. On page 274 in figure 1, are flue gas losses with various fuels. If you'll look at the one on the lower right hand corner it says for fuel oil. Along the bottom are the numbers that represent the percent of CO₂, carbon dioxide, that is in the exhaust gas, and then the curved lines represent exhaust gas temperatures and so once you know the percentage of CO₂ in your exhaust you simply go vertically up till you intersect the curve which represents the temperature of your exhaust gases then you go over to the left and that tells you the percentage of the fuel heat you're losing up the boiler stack. If you will look on the next page, on page 275, you'll see the same sort of information that was given over there for coal and for fuel oil; only this is set up for the various gases. As you see it is an alignment chart for the calculation of flue losses for butane, propane, coke oven and natural gas.

The way this chart works is this: you will notice that over on the right hand side of the page the reading area is percent of flue loss, percent of CO₂ in flue gases for natural and coke over gas. So you use the numbers on the right hand side of that chart, and then in the very center of the chart, the vertical line in the center of it, is the temperature of the exhaust gases. Temperature difference of the flue gases in the room. By the way, in the process of reading this thing it depends on the way the chart is set up but usually you measure the temperature of the gas that's going out your exhaust and subtract the temperature of the air that's going into the furnace. If you're reading 400° and the room temperature is 90° then the difference would be 310°, for example. But what you do is you take a straight-edge and locate your temperature difference on the center chart and come over on the right hand side and locate your percent of CO₂ that you're reading in
gases and draw a straight line between them and that center portion between the two, right here, is percent of flue loss and on the right side it says natural gas, and where they intersect that tells you the loss that you have, going up your flue here.

Any questions? (Question.) He asked the question: What is the acceptable flue gas loss that you would normally expect. Now that figure does turn around 20%. If you get to the 20% level, well, you say, I’m doing pretty good. 20% level is the level of loss that the American Gas Association set up for all American AGA appliances. That’s an example of it, and most boiler ratings that you see and the nominal ratings that you talk about are for 20% stack loss.

To measure the CO₂ content of the flue gas turns out to be a very simple operation. There have been test instruments that have been developed for a long number of years and they’ve been simplified to a degree that they’re quite rugged. One of them I'm holding in my hand here. This happens to be the Fyrite CO₂ reader. This measures the percent of CO₂ that is in a gas sample that you put into it. As you can see it consists of a metal tube connected to a bulb which again is connected to a flexible tubing with a seal that sits over the chamber containing a fluid that absorbs CO₂. When the fluid absorbs CO₂, it expands and the expansion is measured by a scale which reads directly in percentage CO₂ in the sample. To use this you have to first drill a hole in the breaching just past the boiler and insert the metal tube into the breaching. Place the seal over the chamber and squeeze the bulb about 20 times. This brings in a sample of stack gas into the chamber and on releasing the seal the gas is trapped in the chamber. Then turn the chamber upside down twice and let the fluid go back and forth. The percentage of CO₂ can be directly read on the scale. It’s that simple. This unit is good for a couple of hundred tests before the fluid wears out and the replacement cost of the fluid is very nominal.

(Question.) He asked: Do you then feel that CO₂ analysis is more important than O₂ analysis on your flue gas? I'll comment about that in just a minute, about the effluents analysis that you go through. Coming with this kit, you don't necessarily have to get into this and all the alignment charts. They send you this simplified slide rule unit. This one has different inserts but this one is for natural gas and you simply set in this window up here the temperature reading that's on your exhaust stack, then pull this slide down to where you are reading what your CO₂ indication was and, for instance now I have set it on 400° and 10% CO₂ and that gives me a combustion efficiency rating of 81% and again using the rule of thumb that we were talking about a while ago over 20% is almost suspected loss. That is, you're beginning to get in the ball park of a finely tuned boiler. The 81% number: It's fairly typical to get readings down in the order of 75-76 percentage rating, and of course the whole object of this thing is that with a little attention to the combustion process you can rather simply pick up on efficiency of the boiler and not just throw the heat out the stack.

This is a thermometer that Fyrite also furnishes with their kit. It's a stack thermometer and it's got a clip on it so it'll clasp on the stack to hold it in place, and it goes from 300 up to 1000 degrees. Any of the wholesalers, mechanical, plumbing, refrigeration wholesalers, can locate these things for you.
I have a kit, it's an outfit that's been on the market for a long, long time, and we've known about this but gas was so cheap we just didn't pay any attention to it, that's what it was amounting to. I have here a little more elaborate kit and I'll tell you quickly the items I've got in this one. It's a little more elaborate than you need, but this whole case for your purpose is in the $100 range. Here I have another instrument that looks just like it only it's got a green fluid in it instead of a pink one. This measures the amount of O\textsubscript{2}, the amount of oxygen that is in the exhaust stream, and when you get a little more refined in your efforts, and I'll talk in a minute where you need that. This is a sampling test kit for measurement of the amount of carbon monoxide that is in your exhaust stream, and this one also comes with the monometer, for measuring gas pressure and measuring draft differentials across the various places in the boiler.

One of the problems that you have concerning the question asked a minute ago, is about the use of an O\textsubscript{2} analyzer (O\textsubscript{2} is the term for oxygen that's in the air). Typically you're talking about a 10% CO\textsubscript{2} when you're reading gas. Now by the way, on oil this number goes up a number of points, but they're all in this range and whatever fuel you're working on you need the chart to go with that particular fuel. But you can get 10% CO\textsubscript{2} in your exhaust gases under two conditions; if you've got a little bit of excess air, say 20% excess, you'll get about this and you can also get this if you've got about 5% less air than you need.

You've got to think about that a minute. If you go up, if you're watching your combustion air and you kept choking down on your air, assume that you started off with a lot of excess air, and as you choke down on the amount of air keeping the fuel supply the same your CO\textsubscript{2} percentage would start off down here at 6% and then it would go to 8 and 10 and it can go on up to 12.1. Now if you choke down on that air a little more, this percentage would start to drop again. From 12.1 it would drop back down to 11 and 10. Does that make any sense now?

And you don't know when you read this CO\textsubscript{2} meter what side of the chart, of the curve that you're on. Now if you had an O\textsubscript{2} instrument, if you read them concurrently, as you were coming up you would find that you had O\textsubscript{2} in the line as you went up here to optimum point it would decrease to 0 but down here, if you were on the wrong side of the curve as we speak of it, where you were short of air, you wouldn't have any free oxygen, in that you wouldn't have any O\textsubscript{2} reading at all.

Now for my purposes in setting up the standard boiler what I would like to do is to go ahead and deliberately open up the air pretty wide just so that you know you've got more than enough air in it and then start proceeding up the line and you can tell from that which side of this combustion curve that you're on. Of course the problem with running too little air is that instead of burning the carbon dioxide all the way to CO\textsubscript{2} you stop off at CO, which is carbon monoxide. In the first place the carbon monoxide is dangerous but in addition to that you're just not getting all the fuel energy out of your boiler. There's still more energy in it when you burn it to carbon monoxide than when you burn it to carbon dioxide. In essence what I'm telling you is that this is a simple technique for saving yourself some money. But
it is not as simple carrying it out in practice as it is talking about it. Because usually the boiler is hot, the flue gases, you know, you've got to climb up on a ladder and drill a hole and that's another record you've got to keep and it's something that if you do nothing about, nobody will know anything about it except you. So in practice it's one of those things that you know you ought to do but a lot of people just don't do it. A friend back here in Canton just told me his gas bill went up 109%. Pretty soon we're going to be back there checking this thing almost every hour!

I want to get over into water treatment for a few moments. I have been around boilers all of my adult life and when I started into it I thought that water treatment of a boiler was sorcery, a black magic operation. I've been in it now 30 years and I still think it's that type operation. I'll tell you what we do on the Georgia Tech campus if that will be any help. What we do there is that we contract with an outfit that we know to be reliable, that has the capability to do a good job, not that they do a good job, but they have the capability to do a good job. And then we make them give us a written report every 30 days, exactly what they find, with the numbers they get, and then every summer the boiler, each of the boilers in turn is pulled down and cleaned out and we look and see how the water treatment has been working. For instance in the state and government operations, you get back to this same thing about the buying of drugs by brand name or by the generic name at least. Generic name is so much cheaper. And state after state has gone into this, well all you need is the so-and-so chemical, let's buy that, we can buy it for 50c a pound instead of $1 a pound, and they do it. The problem though is that water treatment is still mystery, and as a result of it, what you say will work here won't work across the street. Now don't ask me why, but I'm telling you don't do it.

University of Georgia, bless their hearts over in Athens, got those 200,000 pound boilers over there, two of them in, and what happened? Before 6 months was out, they had aged one of those boilers about 20 years, and they had just burned the tubes up one side and down the other. That can't happen you say, not in this day and time. But that's what happens. But they were following an established water treatment that had worked for them for years, they thought. But that precipitate formed, and got down there on that mud drum on that thing, and it's just like a pan boiling on the stove, as long as you get water in it everything's fine, you can't overheat it. But you boil it out and you've got nothing in that pan down at the bottom or you get some solids that lay down on the bottom and the metal heats up and bam she's gone. One of my very favorite people is a physical plant director down at Florida State. The same thing happened to him. Those of you who've seen that garbage burning plant up in Nashville, Tennessee, go to the Grand Ole Opry. You can't enjoy the Opry for smelling the garbage burning in downtown Nashville, but that's another story. But anyhow, if you've read in the Journal, you've seen what happened to them on water treatment. I don't know the answer on water treatment, but I do know that it is something that you can't neglect. It pays off in increased efficiency, let's keep your tubes clean, so you get proper heat transfer through it. It certainly pays off in the life of the boiler.

I want to comment about those of you who have deaerators. Now quickly what the purpose of a deaerator is, is to "drive off the
dissolved oxygen before it gets into the boiler." Now what they're really
talking about is if you put a pan of water on the stove it starts to heat up,
before it gets to the boiling temperature you will start to see these bubbles
form in there. Well that is air that is dissolved in the water. And the same
thing is true of the water that comes into your boiler. You've got dissolved
oxygen in it, dissolved air, so you want to get rid of it, and one of the ways
you get rid of it is you heat it up. And before you put it into the boiler.
The deaerators, I know some of you have these, you may be tending to neglect
them, I want to tell you the importance of them.

The deaerator is where you bring it into the boiler, you carry it up into
this tank, it's generally operated under about 5 pounds of steam pressure and
you flow it down across a grill of some type so you can get the steam
intimately contacted with it and this heats it up enough to drive the oxygen
off of it. Well every bit of the oxygen you drive off there is oxygen that's
not going into the boiler to rust on you and do all those other bad things.
And it doesn't cost you in energy to do that; the energy that it takes in
heating the water up is less than what the boiler has to put into it when it's
making the steam.

The natural gas that is up in Alaska, taking into account the reduced
consumption of natural gas that we've had in the last few years (by the way
we haven't really reduced consumption that much; it's just that they've been
cutting people off and forcing them over on oil), but even taking that, there
is ten years worth of the stuff left. Think about that one for a minute. I
don't know how much oil is here, I honestly don't. We're talking probably
about 35 years worth of oil counting everything that the Middle East has.

If you were buying a boiler today, it would be a good idea to consider
buying one of the boilers that will burn coal or wood instead of buying the
packaged boilers that burn only oil and natural gas, in other words you have
bigger combustion volume. Now the boiler itself, there's no secret to it. A
boiler that will burn coal, not counting all the peripheral equipment, just
the boiler itself you're probably paying $2 for every $1 that you can buy for
the gas-oil boiler with, and if you should get into coal handling or wood
handling or anything like this sort of thing, you're talking about 4 to 1 in
terms of cost. Whether it's right to do now, I don't know, but very definitely
start looking at boilers that have the combustion volume in them that are
capable of burning these other fuels.

I'll tell you where the problem is--they used to sell boilers by the boiler
horsepower, and they had about 12 square feet of surface area for heat exchange
per every boiler horsepower in the thing. Well now, that thing, they kept making
those boilers smaller and tighter so now I think they're down to about 4 or 3 1/2,
square feet per boiler horsepower due to increased velocity. So here's the pro-
blem, things that never even bothered you in the slightest when you were here
in this range, really hurt when you're down here really forcing the transfer
through. So you're going to have to really get somebody you trust and hold his
feet to the fire.

Georgia Power Company is now de-ionizing the water they use, they need plants
to put down there and put steam in them. I think that's a very good idea, that
not only is it the chemical treatment and deaerator, you don't need the
deaerator if you can get rid of the oxygen another way, but you hold your boiler up with a bunch of chemicals that are likely to precipitate out on you and foul you up. So you've got to look at the total picture.

I had gone to the first job I had of any importance with Fulton Plumbing Company, and I had been at work about one week when this guy walked in the door and he had a device that was a piece of cast iron about the size of two fists together with a hole through it with pipe threads on each end, and you put this on your boiler, no chemicals to it. (Laughter) I'm not trying to be funny, I'm trying to be serious because I don't know, but I haven't seen any of them that work. It's a very difficult thing to prove, you can't prove it, but it hasn't been two weeks ago that another fellow, he'll be calling on you, was showing me one he had. I'm not being facetious but I just don't know. That's one area that if he's wearing suede shoes when he walks in, watch out! I don't know. I know a lot that don't work.

(Question about fuel oil.)

I'll tell you, the folks down there that run our plant at Tech now don't use them because they just don't see the need for them, yes on number 6. One of the problems with No. 6 is what you're getting now and what you'll get tomorrow are two different products. It just varies all over the place, and you've got to have a super fireman to just really watch that stuff.

I've had the rope pulled on me. Thank you.

Moderator

If you'd like to talk with Grant during lunch he will be here.

We've talked about boilers, let's talk about dryers a little bit.

When we included Dr. John Beard's name in the announcement for the workshop we mentioned that he was an industrial consultant, but we failed to mention that he's also a professor at Clemson University in the School of Chemical Engineering. Dr. Beard has been involved in research in dryers and is known around the country in that respect. He is currently doing research for the Energy Research and Development Administration on dryer energy conservation in the Textile Industry. Dr. Beard:

Dr. John Beard

I'm glad to be following Mr. Curtis because he's given you some reasons for cutting down on the consumption of the various fuels, and I agree wholeheartedly. I want to go over some of those points, as he pointed out some of these things that we are talking about doing are a little more trouble.

People, some of the things I'm going to talk about are very similar to the boiler problems. Most people won't know anything's wrong. You may know particularly if you'll look at some of the things that I'm going to talk about today. But I honestly believe that in the next few years it's going to be the people who do the extra things that stay in business and everybody else is going to go out of business, because energy costs just don't have anywhere to go but up.
I'm going to be talking at times, kind of as a side line, really, about using computers. I know that particularly in a plant environment somebody starts mentioning that, there's a tendency to say maybe I don't have a computer, and kind of just turn everything off. I want to show you that the things I'm talking about are plant-oriented, the data came from plants, these things are being done in some plants, and as far as a computer goes, the type computer that I would use on this you can buy for $9,000 or under, that's teletype and computer. So you aren't talking about a lot of money and it isn't that difficult to do, so let's take a look at it and we'll see how it goes.

What I want to talk about is optimizing tenter frame operation. These are some of the techniques that I have used to do this. First off, I'd like you to feel free to interrupt if you have any questions as I go along. If you are going to optimize anything it's just like the boiler, you've got to find out where you are before you can adjust the amount of CO2 in the stack, you've got to find out what the CO2 reading is. And the same type thing applies to frames and anything else. I found that the same general approach that I'm going to discuss today can be used on tenter frames, dye becks, any thing, all sorts of pieces of equipment. So there are two main things that I'd like to get across. One is the results of these studies, in other words, how do you go about optimizing tenter frames operations. But the other thing is the approach, of course you use it on seemingly unrelated pieces of equipment.

Usually the first step that I go through is writing mass and energy balances on a piece of equipment. This is a big help in getting an understanding of how the system operates and I know some of you may not, you may say well I don't have the technical manpower to be able to do this. Well it's not very difficult and you can either do it in house or you can get somebody else to do it for you. Most mechanical or chemical engineers should be able to do it, the type things that I'm talking about.

Now the first slide here, this is a side view schematic of one of the tenter frames that we worked with. The fabric will come out of a wet box through a bath containing some water or some sort of special finishing chemical, this insures that the fabric has even moisture content from side to side and from end to end as it goes through the dryer. It normally will go over a vacuum slot to mechanically remove most of the water, much more efficient and much cheaper to remove it with a vacuum slot than it is with heat in the dryer, and it is to say at this point it is about say .3 pounds of water per pound of dry fabric as it enters the dryer. This particular dryer has its individual gas burner or control system so we can control the temperature in each section independently, and as the fabric moves down the dryer then in these little vills that are supposed to be air jets blowing the air onto the fabric from both sides to give it a high velocity—it gets through the dryer its due to rollup on a roll or put in on another box like this. The exhaust is blown out through stacks and with exhaust fans in there and you have dumpers that you can use to regulate the metals of those exhaust. The make-up air is supplied, the proper amount of combustion comes in with the natural gas and then the rest of the air comes in through fans and through openings where the fabric came in and out and then it leaks and cracks and
what not you've got in there. The tenter in addition must be operated in a slightly negative pressure in order to keep these vills worn out from and keep it from coming out from the run.

These slides show really the small amount of data that you need to do a complete analysis on a tenter frame. I will show you what is down here at the bottom - this is just a natural gas composition number. In this particular analysis the processing eleven ounce fabric 30 yards a minute we have gotten the fabric moisture down to about 4.3 pounds of water per pound of dry fabric. This particular measurement was probably the most difficult one at this time in the way they were equipped.

To get the number we've got some small white weight bottles with brown glass toppers - we had to dry out the bottles, put them on the dessicator to let them cool down and then we weigh them very accurately, and then we put the bottles out of the dessicator and stop the tenter and have the operator grip several samples about like so that was entering the dryer. We stocked them in the bottles and put the cap on it; went back weighed them again, and that gave us the weight of the fabric and the moisture and then we had to clear the bottles. We open the samples up, dry them out thoroughly, and then weigh them again after they cooled in the dessicator and that gave us the weight of the fabric and that difference we've got to weigh on the moisture and calculate the weight of water per pound of fabric. That is a pretty devious operation and I am interested in looking at some of these portable brochures analyzers and later on I will be interested in any comments that any of you may have on using these things if they are favorable or unfavorable as to how they work over several on the market. That's how we got on that number - we measured the humidity and the exhaust stack temperature using wet bulb and dry bulb thermometers. These were not continuous measures but were assumed typical.

The fabric coming out was essentially dry. The make-up air we measured again with a swing slot thermometer drop wet bulb to dry bulb and we got the approximate dual composition from the natural gas company. We don't have any measurements here of Florida. We don't know the natural gas rate at the time we did this analysis. Most people had maybe one meter on all of their gas supply. We, of course, could measure the make-up air because they come in through leaks, cracks, and what not, and the exhaust we could have measured at this time - but we did. We ended up calculating this and calculating that, and we came back later on and installed the meter and we used the anemometer to measure this and we found out that our calculation worked out very good, and very close to being correct.

This next slide shows some reasonable results we think. The make-up air in this particular case was about 450 pounds per minute and that the natural gas rate was about
38 standard cubic feet per minute. Someone back there asked about how to
determine this number, essentially how much is going out with the fabric.
That is a fairly simple thing to do. The heat capacity of various fabrics
are published and for polyester I believe it's .55 BTU/pound of fabric/
degrees F so if you multiply that by the number of degrees F, you can get .
the heat content and that's a very accurate way to do something like that.

The other thing to look at here is this large make-up air rate and the
fact that most of the energy coming out of the thing is coming out with the
exhaust. If you'll notice I didn't even include it in here. It's low when
you're talking about this, maybe 10% here and you're talking about all of
this, I ran off the numbers one time and decided to forget it. You may get
to a point on some tenters, the old ones that aren't insulated, where it
would be significant. This one is a fairly new tenter and it's the kind of
thing that we're going to talk about such gross losses late on that this
probably isn't worth fooling with.

What I've got here is a detailed breadk down from the same calculations
on where the energy is going. For instance, and I have it on each string, for
instance, here in the exhaust that is pounds per minute, BTU per minute,
weight percent and standard cubic feet per minute for the carbon dioxide, in
this exhaust you've calculated to be 5.4 pounds per minute and that would
have an... of 350 BTU/minute, the nitrogen would be 345 pounds a minute, the...
at 24,000, oxygen 97 pounds a minute, water 14.7 pounds per minute with an
associated BTU content of 8,000. We've done this on each of these strings and
then I have it down here on the natural gas also. The important thing to note
here, again, what we did, we just made the analysis and then you sit back and
look at it and say well what do I see? What can I learn from this? And that's
kind of problem here because I can't get both my exhaust and my make-up air on
the same time. But if you look at it here you have 105 pounds of oxygen per
minute going in and here you have about 97 pounds of oxygen coming out. Well
this is the same problem we were talking about a while ago. Only about 7% of
the oxygen is being used, is being burned. The rest of it is just going through
and being heated.

Another thing you could look at here, the nitrogen, the heat content of
the nitrogen is about 24,000 BTU per minute and all of the heat associated with
the water vaporizing and heating the water is only 8,000. So you've got three
times as much energy going to heat up the nitrogen as having anything to do with
the water. So we've got a gross excess of air in the tenter.

Well, these calculations are real simple to do on a computer. Once you've
done it so you can calculate one of these by hand, say any chemical engineer
or mechanical with a little bit of study should be able to go ahead and program
it so that it just runs them off automatically. You could have a load sheet
where anybody could type out a card and put it in the computer. It will come
out and essentially give you these various answers. Once you get it programmed
like that it's also easy to change one variable and see what it does to the
other.
So these plots are going to be somewhere like other plots you've seen because the other pieces are taken in general the same approach. Perhaps it's here, suppose in that case we said okay, this is make-up air down there and the natural gas rate; suppose I change the make-up air and hold all the other independent variables constant what does it do to the natural gas rate. Well, this is the point we have added about 450 pounds per minute and about 38 standard cubic feet per minute. If you want to reduce the make-up air rate to a hundred and fifty pounds a minute you could cut your natural gas consumption in about half down to about 19 — there are other things you could look at, and what would that do to the humidity in your dryer. I would do the same thing here — I've calculated the same make-up air rate you had, say, 450, you had a humidity of about .3 pounds of water per pound of air if you decrease that down to 150 that goes to about .5 — not a great deal, now, if you go much below 150, you could see your humidity really goes up there.

This is a plot where if you again vary the inner moisture control and varied the air rate you could calculate the natural gas. This is a real interesting plot, these are lines of constant air rate. This will be the line of 450 pounds of air per minute and this is the point we were operating at a few minutes ago, let's see...about .3 a, in that moisture, .3, and 450 pounds of air per minute, you'd use about 38 standard cubic feet per minute, and get over here...draw these, again this is the type thing you can get once you start running these analyses — this should be about 38 after all, if it'll be exactly right, but more important it will be if you had no moisture there at all, you'd still be using 31 standard cubic feet per minute with no moisture if you were heating dry fabric so what that really means is that this 31, is really so like an overhead with your temp its running at that rate regardless of what you're putting at it and only seven out of 38 are really being used to dry the fabric. The effect can be that overhead effect — it can be seen very nicely here...where you plot the fabric velocity versus the natural gas consumed per pound of fabric as you again slow the tenter down the natural gas consumption per pound goes up very rapidly.

Let's summarize where we are right now. The things that we have shown this far is that you can't calculate the flow rate without installing meters, now, I don't advise that you don't buy meters, you need them for long-term accounting, and for keeping track of where you are, in fact, that's the most important thing you could do to keep a plot off your consumption from week to week, so that you can tell when you're doing some good, but if you need to make an analysis, you can do it without the meter. It showed that most of the natural gas goes to heat up excess air. If you decrease the exhaust rate and thus the excess air you can make a big savings on natural gas on the order of fifty percent, not just ten or twenty percent.

And those last couple of slides, show that due to that haul overhead, you won't really operate your tenter at the maximum velocity that you can, and still give a satisfactory drying, because it's going to be using essentially the way this particular one was operating — it's going to be using the same amount of natural gas.

I'll take a little different approach here and talk about something slightly different now...
a mathematical model is a set of mathematical equations that you could use to predict what the dryer would do. In this particular case we wanted to predict what the fabric temperature would be down the length of the dryer. And, as I have said, all of these predictions – we have ended up checking with experimental data. Let me tell you a bit about that. This is the kind of thing we were looking for – we were hoping to be able to predict what fabric temperature would be this temperature down the length of the dryer and where this would be the dryer temperature – this one was at 360 degrees down the entire length.

Another output from the model would be the fabric moisture content. This is the fabric moisture down the length of the tenter, one of the reasons for doing this is that if you can write mathematical equations that would predict what a real drying was doing, that means that you have to really understand how that dryer is operated. That is one of the most important things because it makes you ask all sorts of questions that you would not ordinarily ask about your piece of equipment was running and the way you go about that you initially make all the simplifying assumptions you can. You write the model, make all the simplifying assumptions you can, and then you check the model of the results against your experimental datum.

To give you the examples of that, the first model we tried looks something like this – we assumed that this is the type of fabric and this is the thickness that you have just a solid slab of fabric, and we assume that there was uniform drying across the thickness of fabric drying – but, this is the thickness of the fabric. The temperature is 120°, 150°, 200°, 250° all the way across, where we really know that probably it looks more like this that it would start up uniform – but then the edges would get hotter, and that it would still be cool in the center, that you probably get some sort of profile like that, and then finally, when it’s completely dry, it would be the same temperature throughout. But, we say, we’ll try this to see if it works. And we went out and using a radiation pyrometer, this on the left over here is the temperature in degrees right here, again the distance down the dryer – these are the actual measured fabric temperatures within radiation pyrometer and this is the tenter air temperature in the various sections. Then, we ran the model, and I’ll show you there are two constants in there that you have, can adjust, to take care of the individual characteristics of the tenter, but adjust those as we could not get them to go through these points. It started out something like this – was always too low.

The best fit we could get for the model was something like that, so as you say back to the drawing board. And, see this made us think, we got to thinking about it, well this radiation pyrometer, which you kind of just point at the fabric, it was receiving radiation from it, the radiation readings were always too high, compared to what we calculated, so we finally realized that what the pyrometer was seeing was just the very surface of the fabric, the very surface of it, which might be much hotter than the interior.

So we changed the model and tried something else, and this is not a real good slide to show this, but this represents a very small tenter. If you look at this as a side view of the fabric, we looked at it as being a moist layer just like that other model we had, but we sandwiched on either side of that a dry layer so that the heat transfer now has to come through, or has to come from the air to the dry layer, conduction, through the dry layer, to the moist...
layer, and then the moisture will diffuse back out. And when we did this, I'll show you what the equation looked like; these are three first order ordinary differential equations. But really, take my word for it, the hardest part is getting the form and findings, and getting the experimental data like the moisture measurement, once you've got those solving this thing is now no problem at all.

So this is the temperature of the exterior layer, the dry layer that I showed you on either side, this is the interior layer, and this $x$ is the moisture content. Well, we solved those, let me show you, so you get two temperatures out when you solve this thing, the exterior or dry layer and the interior layer. Well this is essentially the model curve we had before, similar to it and you see this exterior layer is running higher, about where the experimental data was running. And from now on I'm going to be talking about that temperature, this external or the dry layer temperature, because that's the one you measure. We can't really measure this other one here.

When we ran the model this time, you see we got a very good set. I guess that's the best I can do. This same experimental data points can be computer calculated curve goes right through here. I should have showed you here that, to take care of the individual tenter characteristics you have two experimentally determined constant to each dryer, that would be this $B$ which is located several places here and this $H_1$ which is an, you can find those using a search routine, on a computer and once those are found, to correctly settle those will make the curve go through here. Now, that's nice and that shows that you have the right form of the model or at least one will do if this can be made to go through there. It really doesn't say whether you've got a good model or not because the real test of a model is will it predict and so to do that what we do, we took that same set of data. That curve that was shown on that last slide is this one labeled 1. It was the model fit to the experimental data, 44% inlet moisture or .44 pounds of water per pound of dry fabric, and 30 yards a minute. And so for the first prediction which is curve 2, we kept the inlet moisture at 44%, reduced the speed to 20 yards a minute. That gave this curve and the second one, we kept the speed the same as the first one but increased the inlet moisture .56 pounds of water per pound of dry fabric. Then we came back and we measured the temperatures at those conditions. This one is the one that the curve 3 I guess it is, 56% inlet moisture, you see that we have a really good fit.

You've got to remember that at this particular time, well there may be 5 minutes difference between taking these readings with the pyrometer. It took us a good bit of time, the equipment was heavy and hard to move, and so you would expect some scattering here, but really that's a quite good fit. And as for the other fit, it looked like this, again, very good. So at this point we were quite happy with the ability of the model to predict what the fabric temperature would be. So once you've got this, just like with the other analysis that I talked about, you could do all sorts of things. I'll just show you a few of them.

This is the effect of fabric weight on temperature profile, with all the other conditions being the same. As you would expect, the lighter fabric dries faster. Other things you can do is you can vary the temperature in the
various sections of the dryer, and look at it. These are just some arbitrary things I've pulled out. First, this first was all three sections at 360°, the second one was with the first section at 400°, and the rest of them at 360°, and this one was the first three sections at 400°, and the rest of them at 360°. I kind of pulled out to see what it would do. There is a similar thing on fabric velocities. Ten, twenty, thirty, forty yards per minute of this dryer. If you were just interested in getting the fabric dry, 40 yards per minute would be perfectly satisfactory. If you had to do some heat setting in here you might want to be on one of these other curves. But this gives you an idea of what the effect of velocity is and it helps you decide what you want to do. This one shows the effect of inlet moisture in the fabric. It shows how big an effect that is, 10% inlet moisture would be here, 50% here, and 90% here. That shows you how much your capacity of your tenter is affected by that inlet moisture and people that we were doing this for consider themselves really enlightened about such things but the vacuum slot that was being used here was really idling along, they had just a few inches of vacuum on it and they thought they were doing a great deal. Well, they were running out about here. Well, as soon as we began to look at things and see what the price was, all they did was open the valve and increase the vacuum, very high vacuum, and we were able to pull the margin down to around 10% on some fabrics which enables you to do all sorts of other things which I'll talk about in a minute.

Now someone asked the question about the humidity of the dryer and what it does to your drying rate. This again is a plot of distance times temperature and what I did was run at two different humidities, one a normal humidity in say this dryer that we first looked at, .028 pounds of water per pound of dry air and then about 7 times that, a humidity of .2. And you see that there is really very little difference in the drying rate. The temperature profile is almost the same, if it reaches 300° at almost exactly the same time. But see the humidity in the dryer is really not having very much effect on it. And when you think about it that's kind of what you'd expect because with these temperatures you could have the dryer full of steam, at 360° and that water, it would still dry the fabric. So this is a kind of important concept that we said if you, the first part of the talk, you can cut back on the air and save a lot of natural gas but in doing so you increase the humidity in the dryer slightly. But here we show that even if you increase the humidity by a large amount it shouldn't affect your drying rate, or you wouldn't expect to loose any capacity by doing that.

Now to give you a run of the idea of how you might use all this, I've drawn up a couple of slides here. I looked at a tenter the other day and this is about the way it looked. Venture line out at 360° and this particular tenter was about 100 feet long. According to the model this thing was essentially drying 13 feet out of 100 feet. And on top of this, they were taking this fabric out and running it through a whole other heat setting range. Of course, it had really been heat set here all the way through to the end of the dryer. So that's really an unnecessary step and an awful lot of tenters are operating in this particular setting. So what can you do? This is very inefficient. One thing, you could probably eliminate that run down from the heat set range, and that is a lot of money. But suppose you couldn't. Suppose for some other reason you wanted to put it down the other range. There's several things you could do, and you can use the model and these calculations to study and try to help decide what experiments you want to run.
I know particularly coming out of a university if I wanted to go into a plant and get somebody to run a test for me, if I have one or two tests, nearly anybody will run those, but if you want to continually change things and get them to run test after test after test they get tired of it pretty quick. So the idea here is to do your studying, decide what field tests you want to run, then the plant will be more than glad to run them for you, if only you're going to do it one or two times to help them out and really show payouts, they're willing to play along with you. So what could you do here? These are some kind of roughed out numbers.

Suppose you just ran a whole dryer at 250, say you're going to heat set it somewhere else. The plot of humidity shows, you're essentially dryer when this rise starts. That's about what it amounts to, you're almost dry, down to less than a percent. The whole dryer at 250, you'd be drying about 25 feet then the rest of it would just be holding there. I figure here if you were using 38 standard cubic feet with all of them running at 360, you'd use about 25 standard feet or about a 34% savings by running at 250, if your process can stand it. And it's perfectly dry so there's probably not much reason for not doing it if you're going to heat set somewhere else. This would amount to about $11,000 a year on a tenter. It's a lot of money.

Suppose you did want to reach 360 right at the outlet of the tenter for some reason, the guy running the tenter frame just insists on it. Well you can do something else, maybe this. And this is the kind of thing you can try on the computer, well you know what's shown over then down at the bottom side, but you could run at 250 until you get right down near the end of the tenter and then go ahead and up it to 360 if you want to. If you did that on the same order as at 38 standard cubic feet for the case of all at 360, and 25 standard cubic feet per minute all at 250, this would be somewhere in between about 28 standard cubic feet and still a savings of about 25% and that's about $9,000 a year, and then there are all sorts of other things that you could conjure up.

Suppose you wanted to heat it up, get it dry, and then try to just idle the rest of your burners back at 200. First two sections were 360, the other sections were at 200. This would save you about 37%, or about $12,000, so that is the type thing that all these calculations can be used for and again they're a little trouble, they take a little more work, a little thought, but the price of natural gas is not going to go anywhere but up, and these are real savings that you can get by doing it. Does anybody have any questions?

(Question) These last ones, I think they were, I may have done some cross comparison. The idea on, well, these last three were, yes, these last ones in red. I may have inadvertently have gotten some of the previous slides at different velocities but these comparisons though were made with only one...

(Question) It was to dry the cloth, but I didn't make a distinction, but it doesn't take a great deal of energy to actually set the finishes, for instance if you had that particular plot, the particular tenter that this thing was done on, did have some finishing operations going on. In other words, it was a polyester and a particular range was used to heat set. That's
the reason that you'd be operating maybe on this curve where at least the last half of the tenter is in the high temperature, and you were doing some heat setting there.

(Question) I don't know. These particular last things were just things I conjured up, you keep it for condensing, I don't know. These are things you have to think about. You might want to pull it down, I'm not necessarily proposing to do it this way, but these are the kind of things that you would not necessarily go out and do with fabric until you have looked at them and thought about them to see what it would do for us.

(Question) That or close to it, I think 250 would probably be a good number. Now all of these things being very conservative, the way I would use this I would normally recommend anybody else using an approach like this, to use these things to set up your other experiments, it raises that question, is it dry at 250, then I, before I ran 100,000 yards of it, test it. But you'd only have one test to make if you decided that 250 was going to be your number. You see, it rises very fast and it doesn't matter if it's 250, 260, 270, it's all so fast that it just takes a couple of feet to get that. Use this as a guide, don't just use it blindly because it really, you've got to remember that is not the tenter, this is just some mathematic equations. A lot of time people get these things programmed and they come around with some nice little curve, and that becomes the real world, that's the very big danger in using this kind of thing. You have to remember Murphy's Law, and most of you probably know Murphy's Law, but if you allow for the possibility of anything going wrong, it will go wrong. And that to me is a cardinal principle to be observed when using these things. Make sure, check everything.

(Question) No it doesn't take that into consideration, it doesn't take the fact that it could get your blowers in balance, it'll blow the cloth off the fabric, oh there's any number of things that could go wrong. Eventually we'll look at things like this, but, that's what I mean you've got to use all of this with some judgement.

(Question) This kind of fabric, yes, but you know it's the first thing we did when we got the model developed was go out and get some experimental data to check it, and I can't emphasize that too much. But this does let you do a lot of experiments on paper. Very fast and very inexpensive way to know what you want to go out and check rather than trying to just go out and take experimental data, even getting one of these profiles is just awful on a well-run tenter.

(Question) Right, this particular case we close all this inlets and these holes here, you can walk by and hold a handkerchief in front of it and it would just suck it in before we start dampering these things down. As you damper them down a little smoke would tend to come out here and down here, you can make yourself a guard, I mean you don't need a hole that wide for your fabric to go through, you can close it off to something like that to make a big difference. You can place gaskets around the doors and all of this thing, what you have to do is keep a slightly negative pressure in here, and that's kind of like in this room. If we wanted to keep a slightly negative pressure like it is now, it wouldn't be too bad at all. But if you opened up those doors in the back and this door here you'd have to pull an awful lot of air through here to maintain a negative pressure, and that's kind of the point. Just replacing worn gaskets and covering up the fronts can make a big difference.
I'd like to emphasize something that was said earlier though that this work is based on drying water out of fabric. Be particularly careful if you've got solvents in there, talk to your insurance people, I don't want to fool with it! If you want to make sure you don't have an explosion, you got water, just water, of course you don't have any problem. But the insurance people inform me this should always be the rule.

(Question) Except that when you get up, you see, you reach different levels of this operation. This particular tenter was operating at .03 pounds of water per pound of dry air. The outside was .01, so there's only about three times the room humidity. Now I think you'd be perfectly safe in tripling that, going up to .1. Probably up to .15 and maybe up to .2, but sooner or later you're going to get to the point where the air is going to be, when it contacts an outer wall, it'll start condensing and it'll get runny, drippy and all sorts of horrible things. So you can't compare this to too high humidity, and the more of this air that you can use from back here means the less total air you have to bring through.

Moderator

Dr. Beard I'd like to thank you very much for taking time to be with us. We talked about Murphy's Law a little bit this morning and we'll get into it a lot more this afternoon when we talk about that black magic process of dyeing, and then a little more maybe when we get into energy recovery. In other words, once you reduce the waste to a minimum for each process, how do you take the remaining heat and tie processes together. Let's break for lunch now and meet back here in one hour.

(Lunch)

Today we are going to talk about energy conservation in dyeing and pre-drying, and energy recovery.

Bob Fulford is a staff member of the Georgia Tech Engineering Experiment Station. He will discuss the topic of heat recovery in the textile industry.

Bob Fulford

We took a look at a dye beck, total system analysis. The dye beck exhaust is 33% of the basic original fuel used for the dyeing operation. The drain in use is approximately 30%. The area that we felt had the most promise was in the reduction of that 33% of the energy required as it filled as it is going out of the exhaust tank. Now this is the area that we would like to look into - we would like to experiment with. Unlike the dryers, the dye beck is a batched process - and every energy consumption is going to be proportional to several things.

Now, obviously, there are some operational procedures, you know with mechanical engineering. We thought we've learned pretty good but when we get to the carpet industry, I found out that they try to boil water into 212 to 215 degrees ... I'm still trying to figure out how they do that, you know, how they accomplished it but, seems to be pretty good. First time I saw one
of these things and saw the steam going out the top and I said - "operator you put too much steam in there" - he says, "No, I am not, I can prove it to you." I said, "How can you prove it?" He said, "Well you see I've got temperature. It never goes above 211 degrees." So again I was proven wrong.

There is one basic modification that could be made to the dye beck to make it more inefficient - and that's all I can think of and you'd take this sparge line out of the water and put it on top and try to impinge steam upon the water to heat it up ... but outside of that I can't think of anything but make it more inefficient than it presently is. So whoever did it did a fairly good job on using up some fuel.

The basic area of modification that we are looking at which we would like to experiment with - we have a small steel dye beck at Tech and if we got some cooperation from a major carpet manufacturing plant that we would be able to do some work. The sparging system that is being used right now is behind the front wall, if you talk to one person the steam is definitely needed to agitate water, you talk to somebody else, they will say the carpet gives plenty of agitation and you don't need any steam agitation. If you talk to some people steam is used by oxidizing the chemicals and therefore the dye sets because it gets steam on it, talk to others - and all you need is temperature. So we haven't found out - but we're checking into that area - but assuming one basic assumption that steam is required for heat in the dye beck and that carpet industry uses the same kind of water that everybody else should use boils at approximately 210 and 212 degrees in the atmosphere.

We look at the heat transfer of the mechanism around the sparging too. One of the interesting things was that some of the places that we checked into had differential pressure cells, basically, measuring the differential pressure from top to bottom to control water level and interesting things that happened whenever you start sparging rapidly at 4 to 5 thousand pounds of steam per hour in a hot bath the level indicator will rapidly start to dry but the only thing that we could see that will cause this was in the actuality in getting a low pressure region here from boiling instead of a liquid heat, we have a steam head above your sparge nozzle the low pressure region does exactly what it obviously does to get water. Now if this system could be a closed system, to where the top of that is closed, because this is where most of the steam goes, and the steam could be desuperheated enough so that the latent heat of vaporation could go in maintenance of the heat and the heat losses, the steam that is boiling off and the water that is coming off could be eliminated. In this case, if you close the top then obviously the place doesn't have any openings for the steam to go out. The steam would have to be injected into the heat of the carpet we believe. Again, we don't know, we haven't tried it yet. But in this case the primary objective here is that you only have a slightly higher pressure in the sparged region rather than a lower pressure. The steam coming in will condense and will be injected into the carpet region and you should be able to maintain the heat at a better point.

Now the next thing which everybody completely objects to is the use of this little item here. A door. A door seems to be almost totally out of
the question. But when I ask some of the people, you know, they're saying we're going to replace some of our dye becks, we're not going to use atmospheric dye becks, we're going to use pressure becks, more efficient. Well, first thing that you find in a pressure beck is that you've got to have a door, it's hard to build pressure without one. If a pressure beck can dye with a door on it surely an atmospheric beck can dye with a door on it. That's strictly just an operational or management type concern. They can be made to be seen through or seen into or otherwise. These modifications and the results from these modifications are hopefully going to save a good deal of that energy. Over 50% of the exhaust energy could be recovered, could be saved, reduced.

In getting good heating, proper heating across to the dye becks, again, we're at the point on there where we've looked at it, we've made some observations, and we feel that these observations would get results that should justify some of these modifications. And I think that's about it as far as we're going to do on the beck. Are there any comments? Any questions?

(Question: "Have you given any thought to indirect heat transfer by way of the radiator?")

We have looked at that, we haven't ruled out the possibility, are you thinking about using plate coils on the back region or another region of it? You could do that, this would eliminate, say, any possibility of radiation loss from the liquid itself. In effect you could even heat trace the beck area to eliminate any type of losses. The losses due to radiation are pretty low and the heat transfer, when you're talking about putting steam coils or something else, you're not going to be able to go to very temperature steam, because then you're going to have localized dye set problems, that carpet sets down on a 350° steam coil? Well, that dye is probably going to set differently than a piece of carpet that doesn't come in touch with that 350° coil, I would think.

(Question: "How about putting the heat transfer device in the front region of the beck?")

OK, now, the question is that put a heat transfer device in hrtr in lieu of the sparging, is that right? If you're going to go with a heat transfer mechanism, the amount of water you're talking about coming from steam isn't going to hurt you. The efficiency of the device, the sparging device, is much better than the efficiency of a coil. Your maintenance is going to be lower. If you have to take something up in temperature you're going to play down on that coil, because that's going to be a localized region of hot water heating, and you've seen hot water tanks or tea kettles or whatever else, you don't have treated water there, in fact you have a hardness range of 652 to 1200 parts per minute as a result of dye.

(Question: "How efficient is your steam sparging?")

Steam sparging? Well, the way they're being used right now, is somewhere between 9% and 11%. But open contact heaters have been known in this region to operate at 90 to 95% efficiency. Basically the evaporative losses.
which are going to occur at boiling temperature, at 210°, is all you could lose. But not a forced boiloff. And this modification, if you start talking about putting the plate coil in there you're going to need a sizeable area to try to get it in, and it's going to be a higher cost, considerably higher cost than just desuperheating the steam and changing the sparger often. And the only thing you haven't done now is forced the steam or heat into the water itself, into the dielectric where the carpet is.

(Question)

Well, desuperheating is going to prevent you from boiling, because as you take steam down every 10° represent one percent of total evaporative losses, roughly, so if you desuperheat the steam, you lower its temperature, you're going to have less superheat available to boil off obviously. You'd have less boiling losses. You can do what you're talking about there with your doors, cutting the fan down and all, you're going to minimize a monster of a make-up air problem and it would be a big asset, which is another savings of energy as your result. In the summertime put in vents somewhere to take that smoke out of the room. The fan is a sizeable use of energy year round the way it's running now, and I mean it could be cut down considerably because all you would need is a slightly negative pressure if all you have is evaporative losses, so much as a hood over a stove when you're cooking it would be the basic requirement and negative pressure could be generated by just the temperature alone, you're going to have some hood effect and some draft effect at that temperature and since it will be hot air above that region we don't know what the draft effect is going to be. But for 100° of heat in a 9 foot stack you can get adequate ventilation. And that seems reasonable to expect...Any other questions?

Moderator

Next on the agenda is Dr. Fred Cook of the College of Textile Engineering. Dr. Cook is looking into the dyeing operation and dye modifications and he's the principal investigator under the ERDA program for energy reduction in textile plants.

Dr. Fred Cook

I hope we'll be able to give you some good advice today on how to save energy through procedural modifications, more so than through equipment modifications. You've heard mostly today equipment modifications that you can make. DuPont estimates that from about their calculations in the Engineering Department you can save about 20% through equipment modifications but you have first and second laws of thermodynamics staring you in the face and you then have to go through procedural changes to up that even further. We're going to show you some figures today of some preliminary data we've got together and I'm going to try not to overlap John Dawkins too much in that, and also talk about some various methods that you can use in your plants, methods for coming up with some ways to save that extra 20-30% beyond engineering modifications.

About 60% of the energy used in the textile industry is used in the wet processing areas. This is taken very thoroughly from the best data that we
have available to us, it includes items like slashing that normally is included in dry processing areas, it includes drying, a lot of different areas.

In '71 used about 67,000,000 barrels of oil to make the textile industry the 10th largest user in the country at the moment. About 50% of the fuel consumed by the industry is natural gas fired, and as you know that is getting to be a real problem, mainly on supply to North and South Carolina, I read the other day that 27% less gas is going to flow through those pipes this year than last, so let's all hope for a good winter.

Approximate cost of energy now is running about 50% of total manufacturing cost, and this slide I will discuss that figure a little bit further. We are estimating that if your procedural and engineering modifications are incorporated on a large scale by the industry, that there's a good potential of saving an extra 14-20,000,000 barrels of oil a year. One thing I want to stress and this goes back to that 10% figure, energy economics are kind of strange. They're different from any that have come into play before and a lot of people are making mistakes and we're seeing it in the plan, an engineer will come up with some savings, value of energy saving, $3500 a year, and he will go to management and try to sell it, on that $3500 a year on say putting in a heat exchanger.

Now $3500 a year does not mean much to the manager in relation to the labor cost. However, when you start figuring in these other costs factors, you wind up with an equation that ties in factors that stem from extreme importance, especially at a time when embargo or a gas shortage or something along this line. That $3500 may multiply as much as 20 fold if these other factors come into consideration. So those of you that are managers, if your engineers or chemists come to you with something along this line make sure that you figure economics along this equation and also in production make sure that you don't sell yourself short as a manager.

On the wet processing side there are several factors that we are concerned with. First of all, Jesse Camp of Jasper County worked up some figures for us, typical utility cost, of water steam and power. Now on the wet processing side we don't have to worry too much about the power cost. However, the steam and water cost is very high, and water cost, pollution is not, water and sewer, water is tied in with that also. Of course to run wet processes we have to have steam, and again to break down Jesse Camp on what it takes to produce 1000 pounds of steam. Natural gas is the cheapest right now, fuel oil second and coal third. That may change if a new regulation comes into play. What can you do to cut these factors? How can you save on that 1000 pounds of steam that you have to generate out of the boiler?

Several things came to our interest, one out of the literature that you may have seen, this is on package dyeing, figures that Russell put out at ICI. I found out later that most of this was calculated data but it does hold some merit in that various dye classes will give you different BTU/pound consumption. The question arose asking if it is true that you can, by juggling your dye classes, match a shape for example, with a direct dye, or when your fiber is reactant is it better to go to a class of dye that does save you energy?
Another piece of work that Dr. Wayne Tincher's worked on in our department at Tech, maybe you're familiar with this, is dye beck recycle. In other words, why do we dump this drain each time, why do we dump the hot water down the drain instead of reusing the bath? Briefly the system that is used is a spoiler, he removes the coil in here at 185°, he analyzes the dye bath with simple spectrophotometer about 3-4,000 instrument, he replenishes the dye bath with dye. We didn't have to replenish any of this, only the dye, brings it back up to strength, he re-enters the batch, at about 185° the second batch and he starts over again. He just goes back through the cycle. He's done this on nylon carpet with acid and acid in his first mixture. He's gone through as many as five cycles with the same shade or altering shades, he's gone up to 10 times from light pink all the way up to dark blue. Projected savings on the 5 repeat one with the same shade, this is the best estimate he's come up with at the moment, 33% chemicals, 58% water, and 66% energy. Three substantial savings here, they're part of this research. This has been done mainly on a one-foot beck, we've got a four-foot beck in now and that experimentation is going to continue on that, he's doing end to end variation, like fashion with fashion, that all that he has to do to make sure this can be scaled up. And we're working with a company here in Dalton who try to simulate as best we can what they're doing in the plant. So we have a lot of hope for the procedural change, this is totally a procedural change, no equipment modification at all.

We're hoping also to be able to transfer this technology to package dyeing and fabric dyeing we're in the process of doing that now. Of course this is a stack system, about 99% of the carpet made today is nylon, and most of that carpet is dyed with the acid on its first dyeing. You go over to something like cotton or cotton polyester and you get into some other problems, different classes of dyes such as directs and reactives present some new problems. Also pressure dyeing presents a new problem, we don't have time to talk about these processes as far as he has been able to expand it.

You've heard a lot about beck dyeing today, this is some data that was worked up for a plant that was running 100% cotton knit. The figure on the exhaust here was taken from a plant that was running somewhat beck, and what we're trying to do is show by the diagram where the energy is going, and you'll notice the main two places are the drain drop, they are using drop field type rinses, more so than running rinses, and exhaust at the hole, two major chunks. So obviously you're going to make some corrections, you've got to do it in those two places.

We also tried to break that data down into sub-processes. As you know when a carpet or fabric enters a beck there may be a number of additional operations done rather than just coloration that have to take place. This particular piece of fabric had to go through a pre-scour, dyeing, after-scour, and that was it, you did not go through fixation, softening, whatever. The question is how many of these operations are gone through without any thought at all, and also on the previous slide. We ran into a problem with people, you go in and say well why do you drop that fabric down to 120° before you pull it out, and they say oh we'll have all sorts of
problems with the quality of the fabric.

Most plants are working on recipes that have been in existence 10, 15, 20 years, before energy became a problem and the carpet side, for example. To get around problems of level by pulling the carpet out at 185°, we've done some work with leveling agents, and we've found that one, we're not going to have any problem at all in pulling the carpet out at 185°, or entering the second bath at 185°. So there are problems involved with manipulating these, but they're not impossible to overcome, and we'll do some more research.

On this business of dyes, some data from the same plant, this comes on a 50-50 polyester-cotton knit. We're looking at a dispersed reactive combination and a first pre-metallized combination. The figure on top, billions of BTU required to dye those to, and these are the same size lots and the same beck, and the bottom of BTU/pound figures. As you can see there's a pretty substantial difference, changing class of the dye on cotton side of those. Apparently Russell's data, even most of it was calculated, most of it is proved to that extent, that there are differences between classes of dye and it conceivably is possible to do a little work on shading that you might switch off from one class of dye to another and save a substantial amount of energy over a year's time.

The question still comes up and those of you know the problems you run into in the dye. You have to take energy in conjunction with chemical costs a lot of the time. For example, this is polyester fabric where we're going through reduction clearing with hydro and you can see what I'm talking about here. It takes $9.67 of chemicals and $5.16 worth of utility costs to do that operation. So some times you get into a case where you're using specialty chemicals and your energy cost indeed at this point is fairly low factor. So this is another root for procedural change. Can you manipulate chemicals and concentrations and go from there? On machine manipulation side, these are some factors that you might want to think about. Again, this is from Jesse Camp from Jasper County. Reduction of water volume, increase loads, decrease temperature, decrease time, eliminate steps, minimize manual interventions, and eliminate operator decisions. Major factors, hard to come by, but it's possible with a little thought.

Most people, and all of us are guilty of this, have been using recipes put out by the dye manufacturers years before energy became a problem. Those recipes need to be questioned, you don't have the facilities to do it yourself, the monkey should be put on the dye manufacturer's back, somebody needs to look at these pretty hard.

Automation is another route, that's possible. Jesse worked this up in comparison to a jet dyeing machine that Jasper County has put out, and they're estimating on our automation side about 20% reduction water usage, 50% reduction in redyes, and corrective adds, 10% increase in production, and elimination of the machine operator, all of these in automated jets.

On the atmospheric beck side, an independent source did some work on the beck and this is his plan, again this is tied in only to his plan and his
estimates, but he is estimating by the recoverable amount of steam that he can get through engineering modifications, we're talking about things like automatic controls to keep your damper in the right place, automatic door catches to make sure the door remains closed, this type thing, he's estimated approximate savings shown and return going to cost him about 395% so in his plan which had a good many becks in place, he is estimating a pretty substantial saving.

The question then came up about what about going to pressure, and pressure jets and pressure becks. This comparison of atmospheric beck on the polyester cotton and 100% cotton was mentioned before. Another plant of pressure jet with 100% polyester, and pressure package again with 100% cotton. This gives you a BTU/pound breakdown. You'll see it creates substantial savings on these two and the question has come up, well if the atmospheric becks are so energy efficient, why don't we go to pressure machines and our pay back would be very short, 2-5 years.

The point we're trying to make is that we feel we can reduce these figures pretty substantially, by procedural engineering modifications. Now if you can do that then these pressure machines, a pay back period would come much longer, and it becomes unfeasible to a certain extent to buy them. Pressure jet for example, latest estimate I heard I think a Mark V is running about $95,000. Got some pretty complicated electronics tied into it. You run into problems with operators, retraining, so this hopefully will be an asset of the research project, generally reduce that figure down.

Finally, the question came up well what about continuous drying? How does this relate to the beck processing? These are some figures that DuPont have come out with, now first of all they estimate about 95% of the energy consumed is required to dry the fabric. Dry the fabric, so obviously you're going to have to look at the other one. And just some other factors tied in about the insulation, infrared units, and so forth but they have come up with a method that they feel will save energy, and I am sure John elaborated on several of these again this morning. Just to show you some numbers, again from Russell, again most of it calculated but at this point it's the best we have. We're trying to get some measurements up for our own to confirm these, and it just goes on to the various types of pad fix operations that are a part of continuous dyeing. It gives you a breakdown in BTU/pound on the other side. Try to give you a comparison, again from Russell, we changed the BTU/100 pounds on this one, we're comparing his, and his calculation on the batch processes shown at the top versus pad fix operations, and generally, except for the direct disperse system on the polyester-cotton, the pad fix operations were more energy conservative and the BTU/pound manner.

Now on the carpet side a lot of people now would like to go to Kusters, and there are problems with Kusters as you probably well know, with the hanging of the carpet and also with the fact that if you have a long thread of carpet hung up in that thing before it comes out the other end you cannot tell whether anything's goofed up in there or not. So there are problems involved with Kusters, it's hard to say whether any major development's going to come up in the next five or ten years to displace that. There has been some talk, we've heard of some fiber manufacturer that has come up with some modification of the fiber that will get us around this hand problem on Kusters. So these are some things that people are looking at pretty hard on these continuous dyeing side of carpet.
That pretty well takes up the 20 minutes of my time. Do you have any questions? Do you have any questions on the dye beck reuse? This is the thing that we've got the most done on right now, and it probably has the most potential for carpet dryers.

(Question.)

This is a modification that we haven't totally worked out. We're working on it now; we've got two becks that are face to face, and we're pulling the carpet out of one, well first of all we're going through a scour bath in the first beck, a pre-scour, then we're going into the dye bath, dyeing it and then bringing it back into the first beck to after-scour it, and then we drop. An obvious modification that's got to be worked out on the engineering side if this thing does go to large scale is: How can we pre-scour and after-scour dark shades? That's an obvious problem, but we don't think it's an insurmountable problem. Maybe a carpet washer or something along that line could be used in conjunction with it.

(Question.)

Now the reference to this is on the bottom. If you want to read a pretty good paper, this paper was presented at IPP, I believe, in 1974 by Seapour and Long, and this book is available, if you have access to a library. The library at Georgia Tech has it and they'll be glad to mail you a copy, I imagine, or a xerox copy. The whole point is that you can't just look at BTU saved; you've got to take these other factors into consideration in order to make an intelligent decision on whether or not to buy a certain piece of equipment. Those who deal with management or are in management know you have to have some extra leverage to get management to go to a system that is not a direct production piece of equipment.

Moderator

In our energy conservation projects in the textile industry, we have shown you most of the team. To qualify for a project like this from ERDA, you've got to show some good credentials, and good research people; therefore, I want to present Dr. Brookstein, from MIT, who's going to talk on pre-drying.

Dr. Brookstein

I'm going to talk about pre-drying, but the way it's presented in the handout might be misleading. I'm not going to talk about infrared pre-drying. Pre-drying is everything that goes on in a continuous process before getting to a tenter frame. It could include infrared drying, but it also can include suction equipment, squeeze rollers, some new devices that I'm going to talk about today. Again, devices that we're looking at in the School of Textile Engineering. You can dry textile materials, and that can be carpets. You can either dry them through mechanical energy, or thermal energy. Now I'm sure Professor Beard spoke about thermal energy, and that's usually what we concentrate on.
What I want to concentrate on the next several minutes is mechanical energy. How we can get mechanical energy to get rid of water. Now it's important because well, with mechanical energy, you only use about 40 times less energy to remove a pound of water than you do with thermal energy, so inherently it's a very economical way to remove water. The main reason is that you're not wasting a lot of energy. There's no phase change— you're not having to worry about the latent heat of vaporization, just take the water off. Now we could take this water off basically in four ways, we can drip, which is the way my wife hangs clothes up outside and actually there's more than just dripping there but obviously the water drips, that's a very uneconomical process there because you'd have to have a lot of clothesline in your mill and that wouldn't look too good.

You have suction drying, which is used a lot, you can have squeezing and you can have centrifuging. Now centrifuging is what we use, of course everyday, in our washing machines, or spin dryers, we're using a centrifuge there to remove water. As you might imagine we're limited there as how much water we can take away because of surface tension effects and viscosity effects.

Here we have squeezing and suction dryers, that I'm going to spend the rest of time talking about, and this line should go down here, but if we're going to squeezing and suction drying we have these difference effects. We have to look at the effect of temperature, the effect of cloth speed, the effect of pressure. We also have to be concerned, of course, with the stresses exerted on the fabric. You can't take a fabric for instance that's very fragile, delicate fabric and really squeeze it, it might fall apart, or you might really change it. You see, you always have to be so concerned with what's going to happen in the end. You might get rid of the water but you might not have any fabric. It may just look like a piece of paper. We're not going to be concerned right now with infrared pre-drying or dielectric pre-drying. I stated this but I can't emphasize it enough so let me just put it up, mainly because I made that slide, but 40 times less energy is required when removing water by mechanical means, and that is extremely important.

Now there's also another effect that we can add in by going through a lot of mechanical water removal. An that is the following. When they look at the energy required, BTU/pound of fabric, to take the fabric. A good rule of thumb as they say, 35% is a number that they fool around with, like to come in at least 35%, well to do that you have to have at your disposal water removal means prior to using a tenter frame. But this one illustrates a little more graphically what we're talking about.

Now if you have a completely wet fabric, the water is found in the fabric in two types; it's either loose water that strips off or it's bound into the fabric. This is called bound water, which represents about 100% of the dry weight of the fiber. There are basically three things here. Adherent water which adheres to the yarn surface and that's what we really try to remove most by mechanical means. The capillary water in the interspaces, between the individual spaces, that's hard to remove. That's the water we try to remove let's say if you can get it all and that's the water that is bound in by surface tension, and that's like I said, a little harder to remove. And lastly the swelling water which is chemically bound by hydrogen bonds and that, you just can't remove that
mechanically. You've got to live with it. That's going to stay in there. You have to have phase change to get that water out.

Some of you might argue that point, but I think it's fairly reasonable to say that this is the water that we want to concentrate on right now, adherent water, and this water here, capillary water.

In suction drying the water content is dependent on three basic things: The initial water content, the suction pressure applied, and the speed of the cloth. Now there was some work done a long time ago on suction drying that appeared in the Textile Institute Journal, in regard to these three effects and the relationships can be seen in this graph.

This graph is important in that it tells you whether it is worthwhile to increase vacuum and by how much. It also shows you the effect of the initial water content on the water retention time. As you can see, the initial moisture content does not affect the water retention for a given vacuum pressure.

This is the comparison of extraction techniques and what we're looking at here is--and this is taken from data--looking at squeeze rollers and vacuum slots and the vacuum roller for the same type fabric. For instance, we have a one hundred percent polyester knit fabric, all the same ounces per square yard, and what I'm looking at here is BTU's per pound of water removed. Now, it's not per pound of fabric, but a pound of water removed and this moisture content here is the initial moisture content as it goes into that device. Well, what this shows you is the BTU's per pound of water removed for the different devices. Excuse me, I said moisture content of the incoming fabric. The moisture content of the fabric as it comes off the device. Well, what I'm showing here is for the vacuum roll you do use more BTU's per pound of water, to remove a pound of water. But the point is: You can get down to about twenty-one percent moisture content, whereas with a squeeze you might only get up to ninety percent with this particular fabric.

The important thing to take from this data here is on the bottom here, and it should be in a lot bigger letters or numbers, is that for a tenter frame you use about a little over three thousand BTU's to remove one pound of water. All right, so you can see from this that it requires forty times less energy to take away a pound of water through mechanical devices as compared to thermal devices. It's so efficient we should use it whenever we can. Now, but we always have the problem that suction cannot remove chemically bound water. By the way, I, addressing your question over there, I did have something I wanted to say here about suction. That was, you do have this problem with suction. You lose your suction after a lot of water is sucked out from the large capillaries in a fabric and all of a sudden you get so limp that you just can't build up the vacuum that you need to keep on taking more water out. Also, and the way you get around this is to increase the suction. But you get one of those things where you can get a dog chasing his tail: after a while you just don't get anywhere.
Let's talk just a little bit about squeezing and then we'll talk about some of the new ideas. With squeezing we see that the temperature, the net pressure, and the speed of the cloth affect the amount of moisture content. And a nice number to know is that if you have a fifteen percent decrease in the amount of water in the fabric, you could increase the temperature of the water as it goes through the squeeze roll.

The nip pressure is important, and going with nip pressure, it turns that hard rollers do a much better job in reducing moisture than soft rollers. The problem is if you get too hard the nip pressure might just crush the fabric, and that's a fine line that you have to watch all the time. Again, you can remove all the water, but there's nothing left. Now, the speed of the cloth is important, there is good correlation here. If you start going faster and faster through a squeeze roller, you start to lose the efficiency real fast there. You can't get that much water off. You could say it's because of film building up under the roll or you could say the water doesn't have a change to run back fast enough. You could come up with all kinds of crazy reasons. Let's not worry about what the reasons are. For the time being, let's just say that as you increase the speed of the cloth, you decrease the efficiency of the squeezing process.

Moderator

Thank you. I think that was excellent preparation for the break we're going to have now. When we come back we're going to look into energy recovery. Let's take a break now and come back in ten minutes.

(Break)

Now that we've heard every possible way to reduce waste, let's talk about how to use the remaining heat with energy recovery systems. Bob Fulford:

Bob Fulford

If after we're through with all our research we're unable to cut out all of this waste energy going out stacks, and down drains and everything else, then we come to the final solution. Now, the final solution may be cheaper than the reduction. That's to recover the energy that's going out in the waste streams from dryers, ovens, dye becks, exhaust from dye becks and from boilers. The proper recovery techniques can significantly reduce the energy requirements. It may be cheaper to recover in some form and reuse.

One of the biggest problems with recovered heat, such as in the dye house, is that when you recover heat you've got to have an application for it. You'll find in most places people saying "I can recover more hot water than I can use." The first thing is that operators won't start with hot water. So you've got a nice big hot water tank out there that reclaimed heat with free energy from your own oil well setting there. If they don't use it it's not any good at all. So one of the things you need to do is look at the places where you can recover heat, where you can use it, and where you can
have control over the use. One of the basic things that you have that you can use is in a boiler house, steam production and the engineering systems themselves. Now, as we get into energy recovery alternatives you have a lot of them now. A lot of them should be applied now because they have short payoffs. Even though we may modify the systems. We may modify how they are operating and you may obsolete them or greatly reduce their effectiveness. But before that could come about you probably would recover your money out of it manyfold. But you need to prioritize your choices and investigate. If you can measure the equipment such as John earlier said and determine: where your energy losses are, what the quality is, how you can recover it, and which one is going to give you the best return. Don't be narrow minded. Don't look at it in a narrow way of one piece of equipment can only use its own recovered heat and its own equipment. Don't overlook some big areas.

One of the plants I have seen had underway a program to put a heat exchanger in some dryer exhaust. Well the dryer exhaust, as typical with most, have condensables. They have rosins, they have wools and to cool them down they're going to foul that heat exchanger. The dryer exhaust for approximately 270° to 285° in temperature and the quantity range between 2000 and 3000 feet per minute. Now less than 100 feet away they had a large 60 inch steel stack that had water exhaust in it. Now the water exhaust ranged anywhere from 25 to 45 cubic feet per minute, 4500 feet per minute, ranged in temperature 400° to 550° and the condensables in there were not fouling, but were abrasive type of condensables. So you had good heat exchange capabilities. Also, the content of that stack in its heat, condensables, and all the portions of it are well known.

People know what are in boiler stacks. You really don't know what's in a dryer stack. You may know today what's in there. The technology on dryer recovery is very poor. You're going to have a low temperature difference. The obvious thing to recover a boiler stack is one of two things. You could use the standard air preheater to preheat air for your boiler. Or you could use the standard say B&W type economizer and run water from your deaerator. However, one of the bad things is that you've got a large make-up requirement in textiles. This make-up water comes in cold. This make-up water is supplied to a deaerator or your boiler feed pump suction tank at a low pressure. It's at a low pressure and a low temperature.

One system the textile industry has available to them to use and apply is to put in a low temperature low pressure heat exchange system in boiler stacks. They wind up being considerably cheaper than a 125, 150 pound economizer. They wind up being smaller because of the 125, 150 pound economizers coming out of your deaerators in general in larger systems, where your temperature is 230°. So you nearly double the temperature difference and so on. You greatly reduce the pressure. So boiler stacks are say a natural resource of the textile industry. It's one of the first areas that I would think you people should start looking at. They are typically
almost always hotter than the dryer stacks. They're easier to handle than the dryer stacks and they're controllable. The dye beck house, you don't have any control over what the dye beck operators do. If they don't want to use hot water and if you have a hot water tank and they decide they want to use water for rinsing, you haven't saved anything anyhow. So do they rinse with your hot water because it's there. So that is one of the areas that should be looked at.

One of the first areas that should be looked at is trying to go with economizer systems. A low temperature economizing system. One of the easiest places to put it is if you have fifty percent or better make-up requirement is to put it into your make-up water prior to your deaerator system. Like all other energy recovery systems this should not affect the reliability of the basic production unit. It should be a standard bypass type of system. You should have an alternate. If your heat recovery equipment doesn't work and it shuts down production the next time you go for a proposal in front of management to try and get a heat recovery system in and they remember that you shut down their system for two or three days production, you're going to have a hard time getting another energy conservation project going. It shouldn't affect production. The systems, very simply, simple schematic for any type of heat exchanger that we would recommend would be one that is an alternate path. In this case this could be a boiler stack, could be a dryer stack it could be anything. But if you put it in line and you have that heat exchanger down and you have a piece of production equipment down you've got management on your back. You've got profits going out the window. One day's production can many times offset a years worth of energy recovery from a piece of equipment.

(Question: Is there any particular reason for its being parallel instead of counter flow?)

Oh! You mean coldest in contact with hottest. Yes, well this particular drawing was done up for a cold water running through boiler stack gases. In this particular case when we were sizing it up the, it was advantageous to have the coldest water in touch with the hottest gas. Therefore the gas and the outside metal temperature did not reach condensable temperatures for the H₂SO₃ or H₂O. Whereas with the counterflow type of operation where the coldest water in touch with coldest gas it would have condensed. So that just happened to be a quirk in that system. Yes, you're right, the most efficient heat exchanger would be counterflow. But many times you don't want the most efficient. This one was drawn up as an example for boiler stack gas recovery. With boiler stack gases you do have a problem in that you have between a 110° and a 127° dew point. You don't want to read that at any point of you can help it. That's the dew point of water by the way. If you've got high sulfur content in your fuels than you have a dew point for H₂SO₄ which will start condensing out at about 400° to 500°.

So but contrary to most of the stuff you read about the content of SO₃ the sulfur does not naturally burn to SO₃. Sulfur dioxide is converted to SO₃ at extremely high temperatures in the presence of a catalyst. The temperature at which this occurred is around 3500°. In general unless you really clamp back
down on your excess air and get in that 5%, 10% category, you don't have 3500° anywhere in that chamber. You have very little SO₃ formation. Very, very little problem with H₂SO₄ condensing out. Not near the proportions that you have when you look at the extremely high pressure, high temperature boilers, and these are controlled anywhere from 3 to 5% excess air in power plants, yes they have one SO₃ molecule for every one-hundred SO₂ molecules, in most cases in general. That's with fuel additives. You don't have as big a problem in this area.

Very little is gone into saying you know exactly what kind of water and where can you use it and where do you get it from. Now, in the textile industry you're dumping two million gallons a day now. So with reasonable concentrations with most boilers it takes less than 2,000 gallons a day to recover the SO₂. So if you're only 10% efficient, you know, go ahead and use 20,000, use 200,000. It's a reasonable approach and this would stand the requirement for tall stacks at least in the textile industry or those with large waste water quantities. But SO₂ is readily soluble in water. The only thing that affects solubility is acidity. Unfortunately, you guys in the carpet industry use acid dyes. So your dye liquid generally is not as good as it could be. But your laundry water is. Your wash water and your rinse water are fine.

(Question: You say you had a dew point of say 120° you've got to preheat your make-up water somewhere above that before you introduce it into this system. Is that right? Is that what you're saying?)

No. If you touch that system anywhere with say 60° make-up water you're going to get a condensate on that flow.

Typical flow rates, the film coefficient percentage is about 20 to 30% on the film coefficient for the water about 60 to 70% film coefficient for the air, gas side and the other 5 to 10% can be across the metal, the barrier, the fins or the various material. Now, if you divide the temperature difference which is one reason the cold water is in front of the hot water in this case. If you divide that temperature difference around, you'll find out the metal temperatures will very seldom go below 175°. Your manual says 150° to 160°. So that's the idea of having the cold water in front. Taking advantage of a low film coefficient using, this is a low speed, and that gives you the film difference your actual metal temperature exceeds your water temperature. If it didn't exceed your water temperature you wouldn't have any heat transfer, obviously. Because that's where it's coming from. So you start from cold and you go out to hot and you confine the temperature at any given point. You know the easiest way is to put everything into its own film coefficients. The other nice thing about it is if it fouls up you can run your temperature a little higher.

I ran into another problem trying to do this in that if you run cold water through the tubes you have a high temperature exhaust going over the fins on the tubes assuming you're using that type tubes. The tubes tend to contract, the fins tend to expand and if you aren't very careful with the nuts and bolts you're liable to break down in the bond between the fin and the coil. If you're using say welded bond electronically bonded or otherwise that's the case.
Now you've got to look at the metal temperature, not the gas temperature at 525° wouldn't you say it would be a maximum case of conditional systems. The advantage there is, again, you get maximum water flow. You get a reduced film coefficient. Your temperature of the metal say a maximum temperature of the metal is going to be about 225°, minimum is going to be about 175° and it can be designed. The basis idea there is that you can control the water flow. When you have the water flow proportional to boiler feed cycle, boiler feed anyhow does not account for flow condition. It's a fluctuating condition and strictly an approximate boiler feed.

You take a look at the temperature that you may have on your stack gas. Say we're producing 30,000 pounds per hour average you've got 450° stack gas, you're capable of saving between 2 and 2.4 million BTU's per hour in fuel. That's basically a linear relationship. On the other side is taking the air and heating it up before it comes in. And amazingly enough it's similar to linear relationship. Unfortunately, we didn't push this within steam we put it in air available because this gets into the next topic that we're working on. This is preheated air made available to the boiler. The amount of preheating above ambient, 25, 50, 75, 100, 125 determines the savings that you would realize in putting it in.

One of the areas that we are looking at is that if the dryer or oven in large textile plants generally runs somewhat in conjunction with boiler loads. If your plants are running hours a day, five and one half days a week, one possible way to recover it rather than sticking a heat exchanger in there, would be to use it as preheated air to a boiler. It has a high oxygen content, generally in the neighborhood of 20 to 22% oxygen, which is roughly 90 to 95% of the actual air. As preheat it is available as fuel and in most cases you have resins that would condense out on the heat exchanger surface. In this case the resin would add to the fuel content. It would actually be combusted.

There are cases, installations where they're actually condensing out the oils in a dryer exhaust. Or it was just a dryer not a backing oven. They're actually condensing out the oil and then using the oil as a fuel. So it is a burnable product. Rather than condensing them out you could use them as a fuel. You could use them directly as preheated air. That is again in the case where the air flow may match, if you have some reasonable match between the air in exhaust out of a dryer and the air input through a boiler and they're not that far off. If the boiler air requirement is greater than the dryer exhaust, again, if you can use all the dryer exhaust you're in good shape. I don't know whether EPA's gotten on to anybody yet around here, but EPA has gotten on to many people in California on the exhaust, the content of the exhaust of dryers; I don't know of it in Georgia. But that's another consideration that's got to come down the road is the pollutants that are coming out.

We have found that in most cases the maximum "u" value that you size a heat exchanger for should be somewhere in the neighborhood of around 80 to 120. This would have to be with frequent chemical cleaning, combined with backwashing. We can only caution at this time that you, if you're looking at buying a heat exchanger to go on the "u" value ought to be looked at. As to what they sized it on and our own recommendation is that if you've got
to specify one, specify between 80 and 120. Now, a lot of people have heat exchangers in, they have put them in. Very few people knew they had the heat exchangers they thought they were doing a good job but in almost every case behind that heat exchanger was a steam heater and inline steam heater. In almost every case the guarantee on the heat exchanger said "we guarantee this system of heat recovery to take so much input water at 60° and put it out at 140°" They never gave a guarantee to take one BTU out of waste water. So they meet that guarantee, as long as you give them enough steam. They don't tell you the limits on steam. They meet that guarantee as long as that steam heater works. Now, they're giving you the impression that they're getting it all out of waste water. But they literally meet the guarantee as long as the steam heater is able to take water from 60° up to 140°. That's not the whole idea behind the thing. Most of the ones we've checked tend to have been costing more money to run in electrical energy, lost available head, and lost money than they've recovered in heat. This is true of almost every one at the time we've looked that we've come across to date.

Unfortunately, there is a lot of economy of scale for these recovery systems. The economy of scale works two ways, for heat recovery equipment to pay for itself it's got to be operated. The more hours per year you operate it the faster the payoff, obviously. Three thousand hours a year apparently is the minimum operating time on heat exchanger type of equipment that we see right now. That may not hold true. I'm sure it's not going to hold true if the price of fuel doubles tomorrow. That's going to fluctuate with the price of fuel. But operating hours and operating time is the basic key to efficiency and return.

Boiler gas can approach at 225° without very much problem in the textile industry. If that's what you mean. You can take your gas temperatures down to 225° in heat recovery. It allows you enough buoyancy for the stack. It allows you enough temperature to not worry about condensing. So whatever boiler gases you have I think you could size the heat recovery system so that it could work in that range. 225 to 250°. Now the efficiency would be equated basically to 1% for every 40° would be a boiler change in efficiency. With approximately 1% improvement in boiler efficiency for every 40° taken out of the gases and put back into the boiler.

(Question: What about the question of efficiency improvement?)

It can be equated to any improvement. That's the efficiency. If you were operating at 80% and you took 125° out of your stack gases, say 420° gases and you took them down to 220° by boiler water, then you were operating at 80% efficiency you would now be operating at 83% efficiency. So you can call it combustion efficiency or heat recovery efficiency or whatever it is. Because now, remember the temperature you're looking at now is the exit temperature of whatever economizer heat recovery equipment you have on the backside.

This is an excerpt from a power commission news release which is trying to get across to you that natural gas looks like it could have problems. This should have been handed out earlier in the day when we were talking about fuel. However, you can see that curtailments, firm curtailments, that is if you've got firm contracts for natural gas. In 1972 they had a
million, a billion thousand cubic feet. Projection for 1977 is three and a half times that. It's growing worse.

So the idea there was basically to give you some food for thought on your firm contracts for natural gas. In case you haven't seen it on the last page we've extracted the FTC curtailment priorities. You'll see the first priority for natural gas is residential, small commercial. Two is large commercial. Three is all industrial requirements not specified in two. Four, firm industrial requirements for boiler fuel used at less than 3,000 therms per day. So you guys are falling in the four to eight category with your gas right now. Obviously four and five with your firm contracts. Even with your firm contracts you're number four and number five on the priority list.

So one of the things that maybe I didn't get across earlier and I forgot to talk about would be people always come back and say gosh you could recover more hot water than you can use. That is actually, virtually, impossible to be true. I hate to disagree with you. But that there, no such system can exist. Unless you're generating energy. Because if you can recover hot water, you can effectively use it. The basic answer is "the hot water I recover is 180, 190°." I say why don't you use it in the dryer. Well my dryer runs at 350° or 275°, 280°. Well that dryer air had to start at ambient conditions. So somewhere it's got to go from sixty up to 160, 170, 180. So a nice simple little radiator system would preheat the dryer air.

Suppose you're running your dryer at 280° on your exhaust side or 280°. You've got available water that will preheat ambient air from 80 to 180°. That's 50% of the dryer fuel requirement can be saved, just by using the preheat system. So if you've got hot water you can find a use for it somewhere. Because every thermal requirement you have winds up somewhere in the hot water at some lower efficiency. And it's starting off back at ambient conditions again. So preheating systems are something that has been totally overlooked in the plants. The applications of preheating systems are just enormous.

So if your people refuse to use the hot water back in your dye beck, which would be one of the most economical places to use, then put them some radiators in front of those air intakes on your tenter frame. But there's a lot of uses and preheating some of the areas should be looked at. How about more questions? Questions to Dave or Fred or Don or....

(Question: Bob, How about telling us about some of your work in solid waste conversion?)

Everybody said that project was garbage. The most experience I've gotten in solid waste was prior to coming here. I was with a company in Jacksonville, Florida, Reynolds, Smith and Hills, and we were looking at solid waste energy conversion systems, primarily for military applications on military bases. The responsibility there lies with the mechanical system, not with the collection and classification of waste so much. The only economical solid waste systems available today are small modular units ranging in the ten to twenty tons per day capacity. They have very few controls,
have manual daily requirements for cleaning out ash contents. There is a starved air incinerator producing a low quality, volatile off gas with a temperature in the range of 600 to 800°. This is then refired in the presence of another fuel, a very low amount of the other fuel which is a pilot light type of thing. Then the heat content of this gas is run through a waste heat boiler, heat exchanger for hot water, whatever. These are environmentally acceptable. They have low pollutants, low emissions, capable of burning unclassified municipal solid waste.

We justified systems from the smallest being about 30 tons per day through 200 or 300 tons per day for some of the larger municipalities. This is the same type of technology that I'd like to apply to the top of the dryers. The top of the backing of it. You have a low quality, volatile fuel coming out of those. Not extremely low quality. Now it's extremely low quality, I mean, we're not even talking about 100 BTU's per standard cubic foot, we're talking about every 5 or 10, which is still the same thing.

You can use the same technology that you've been applying to incinerators for years to put back right off the top of the dryers, burn it, generate steam, your air's preheated, your efficiency there, there's no reason why you couldn't generate steam at 95-100% efficiency. With 100% of the fuel that you put in there coming out in steam in some of those dryers, there's no reason why that couldn't be.

Moderator

This is something that we like to do after any workshop that we put on because we're continually trying to improve them. We'd like to get your overall impression of what you've seen and heard today and especially what you thought was most valuable, so that we can possibly expand on it, what was least valuable, so we can cut down on it. Obviously, you're not obligated to answer some of these questions, but we are interested in what you think the potential savings are in energy in the industry, and on the decision making criteria that management uses when they are trying to determine whether to spend capital money on production equipment or energy conservation equipment.

Comment of Grant Curtis

I think the secret to that is to start putting it in terms not of saving energy but management in terms of dollars. That's one thing they do on this thing and to me that's the secret in trying to convince people. For instance, take a dye beck, they say "I don't like doors, I don't like to have to see the fabric," and all that, but we did some actual measurements on the amount of speed required, with everything on and the fan blowing, and then we put a piece of canvas in front of it, a piece of cardboard on top of it, cut off the fan, and were recording the steam and watched it drop in half. In a fairly small mill this is $50,000 a year, and they began to notice and began to realize that you really don't have to have that beck open after all, if that's the kind of money it's costing, so maybe the trick is to try to put it in terms of thousands of dollars.
The second slide I put up, you can't just talk BTU/pound, you've got to look at both situations and say "well, what is it going to cost the guy if he has to close down for a week?" That can't come from me to top management, it's got to come the other way. I don't care what you do, I can turn this project, and I'm getting approval, dollars for individual projects, but when you're talking about the whole concept of energy savings in a site that has three or four plants on it, the real impetus has to come from the top as it does in safety or anything. It can't go from the bottom up. I still don't see that. I want to start looking at ideas and show a willingness to change our way of doing business, but when that price shoots up and when the plant shuts down, on a technical side we'll be ready for it. The biggest problem is resistance to the change, even if you have the dollars.

A lot of the management doesn't realize how the percentage of energy costs and how the other costs of the products have been increased. With the increase the same as percentage, what portion of that could really be saved? It's not easy to find the answer to what the cost is, it's not easy to track it, especially by process. Some people, even though they haven't been able to break loose a lot of capital to make big changes have, I know, made small changes either with operational differences or with very small investments, jerry-rigged their own devices for conserving energy.

Moderator

If there are no other comments, let me just say that, as you said, I think that the technology, even though there's still a lot to learn, is probably ahead of management commitment in most plants. The most I can say is to be prepared. We're still in the minority, a small minority of people that understand the problem of energy, the difficulty in generating new sources of energy and the difficulty in conserving it. We're starting to learn, not just you people but us too, about the technology behind conserving energy. I don't know what the impetus should be for vast management commitment, I hope it's severe but not too severe, just enough to rattle some cages and get things moving. In any event, I think we're all a little more prepared for that eventuality.

Let me say thank you for coming. I've learned a lot today and I think we all have. Thank you very much.
APPENDIX VIII

HANDOUTS DISTRIBUTED DURING WORKSHOPS
EVALUATION FORM

Energy Conservation Systems in Manufacturing Industries

What part of the workshop was most valuable?

What are the estimated annual energy costs for your plant?

Natural gas

Electricity

Fuel Oil

What percentage of this energy do you feel your plant can save?

Natural gas

Electricity

Fuel Oil

What major energy conservation efforts have you already made?

What major energy conservation efforts are you considering?

What was your overall impression of the workshop?
APPENDIX X

SCRIPT OF AUDIO VISUAL PRESENTATION
INDUSTRIAL ENERGY CONSERVATION

**Narration**

(Machine Sounds)

(Silence)

Bob Allen (in plant)

Well, we use in the neighborhood of 8 to 10 million BTU an hour on the product.

**Narrator**

We are talking to Bob Allen, Packaging Corporation of America, Macon, Georgia.

Bob Allen

About 80% of our energy, our total energy, goes into the drying process. These are different zones, these are zones here and double zones, zone and we have two more down at the other end where the other zone is. There are four zones in a dryer. You can throw the heat separately into four zones. These are the gas controls. These control the burners, the burners are up on the top. These are the settings, and you can set these to whatever temperature you want.

### Video Description

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<td>1. Black slide</td>
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<td>2.</td>
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<td>2. Scene from Packaging Corporation of America plant in Macon, Ga.</td>
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<td>3.</td>
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<td>3. Title, &quot;Energy Conservation&quot;</td>
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<td>4. Bob Allen in plant</td>
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<td>5. Dryers in PCA plant</td>
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<td>6. Gas control panel</td>
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<td>7. Two gas controls</td>
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<td>8. One gas control</td>
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Bob Allen is talking about energy conservation.

As soon as we get a meter on, I tried this without a meter and you don't know what you're doing. You have no way of evaluating your improvements. We have to have a meter installed so we can evaluate the improvements. As soon as we get a meter installed, we are going to determine if these things work or don't work.

Well in the case of PCA they are an example of a company who is alert and who has this commitment from top management to an energy conservation program.

We are talking to Grant Curtis, Researcher at Georgia Tech.

As a result of that, they have gone and looked at all of their processes and have been quite successful.
in conservation measures to date. They have a commitment to further reductions as capital money becomes available and process changes.

Bob Allen

We are gonna put it on one machine and make changes on this one machine and try to evaluate the improvement that we get.

Bob Allen (in office)

We figure we are operating at 168 BTU per ton. We improved it to last year of 157 BTU per ton. We had done this by cutting down on the normal exhaust air leaving the plant. In this year we reduced it even farther, they are down to 144 per ton now. We figure that the rate we are using it now compared to the rate we were using it two years ago that we are saving about $38,000 a year.

Narrator

Bob Allen is not the only example of a person who has been successful with energy conservation.

Grant Curtis

The figure that we are currently
working on is that we are now operating this campus at about 25% lower energy level than we were prior to the energy crisis. This translates into dollars into about $400,000 per year.

Textile Industry Engineer #1

Of this last year we saved in the neighborhood of over $150,000 total in energy savings.

Poultry Industry V.P.

I would say probably 10% maybe.

Primary Metals Plant Manager

At least 20 to 25% reduction not in cost because costs are changing but in consumption of energy.

Bob Allen

We can count on about $75,000 but this isn't counting turning off lights or anything like that.

Narrator

Dollar savings, that's one good reason to save energy, but there's another reason too, energy short-ages.
Grant Curtis

There is a shortage of natural gas, such that people who are large users who used to be cut off just a few days a year, a few weeks a year to burn a number two fuel or some other fuel are now finding out that they are being cut off for the entire winter.

Textile Industry Engineer #1

If residential hospitals and these types of people need the firm gas or need the gas available and there is not enough left over then they start cutting on industry's firm gas. Unless we had sufficient standby in the way of propane gas we would have to shut out.

Textile Industry Engineer #2

The real impact to most users is that the fuel just may not be there period. What kind of alternates do you go to or do you have alternates? This is a factor that not only must the carpet industry but every industry in the country address itself to and I think with much more seriousness and diligence than we have done so far. This is a major concern we have here at this site, a propane backup system. However, I don't
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<td>believe that propane will ever be available in the quantities needed to run this industry or the others that would be in the same boat should natural gas be curtailed.</td>
<td><strong>24. Gas Control - closeup</strong></td>
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<td>Bob Allen</td>
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<td>Why is it a high priority? Basically it is a high priority because it's a matter of survival.</td>
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<td><strong>Narrator</strong></td>
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<td>A matter of survival. We as a nation have become accustomed to the cheap and abundant supply of energy. So accustomed we may not understand that the continued availability of energy is a matter of survival. In the past few minutes we have heard comments by a number of people in industry and we have heard of some of their successes in reducing energy consumption and their concerns about energy shortages. Let us examine the issues these people face and see if we can determine their secrets of success.</td>
<td><strong>25. Industrial Plant</strong></td>
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<td>Bob Allen</td>
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<td>One of these suggestions that I will have is from a maintenance superintendent. He suggests changing the cam which controls the amount of</td>
<td><strong>26. Bob Allen with Maintenance Superintendent</strong></td>
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<td><strong>27. Bob Allen with Maintenance Superintendent with cam</strong></td>
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Textile Industry Engineer #2

First of all we have taken off on the common garden variety type projects that require minimum manpower and minimum capital. Such as reducing lighting levels, reducing the thermostat settings in hotwater heaters, installing dock door seals, reducing thermostat settings, closing off areas that serve as warehouses and reducing the temperature settings in those areas. On the capital intensive type projects, we installed a heat reclaim unit on one of our ovens of the heat wheel type which we are continuing to evaluate. We have in progress now for an addition of an economizer on a common stack out of two of our biggest boilers. We have also looked carefully at our electrical demand curves and for the most part we are having a good demand curve. In our spinning operation though we do have heavy HVAC demands with two big chillers and they are the units that can improve our demand situation if any real improvements can be made. To take advantage of this we have installed a demand controller on the system.
Textile Industry Engineer #1

We plan to be able to cut back our steam use here for a max rating of about 8,000 pounds per hour down to the neighborhood of 3,000 pounds per hour. This is by reducing exhaust fans and of course reducing the input of steam by reducing the need for steam in the oven.

Poultry Industry V.P.

We're interested in recovering heat from our scald area and recovering heat from our boilers that we might transfer to some other part of the plant.

Bob Allen

Basically, we were encouraged by Tenneco, our parent company, to take a long look at the gas situation because they could see what was happening. They suggested that we get anyplace where we could have standby fuel that we do it.

Narrator

Good advice, but let's look at the barriers that we will face in attempting to conserve energy.

33. Textile industry dyeing process
34. Poultry Industry operation
35. Report discouraging use of natural gas
36. Maintenance person outside plant
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<td>Bob Allen</td>
<td>37. Bob Allen with cam</td>
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<td>Small items are of course very easy to justify. The cam idea I spoke of, that was easy. When you get into capital dollars you get into say a $20,000 capital expenditure then you have to justify this on a payout and in order to get it, it has to have a reasonable payback.</td>
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<tr>
<td>Textile Industry Engineer #2</td>
<td>38. Person computing payback</td>
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<td>Capital availability is a big problem because with this company as with many, not all, but many, projects for energy conservation have to compete with projects for productivity increases, product changes, expansion, renewal and replacements on the same basis. They do look at pay out and return. Unless the project offers a very quick payback, a very good return on investment, then it is not gonna receive any preference over another project for productivity increase that would offer a greater pay out return.</td>
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<td>Poultry Industry V.P.</td>
<td>39. Savings computation</td>
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<td>Well we would look at the return on investment. We expect for example in two or three areas we have practiced energy conservation, steam pipe insulation for example. We expect to</td>
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<td>40. Poultry Industry V.P.</td>
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recover our investment in three or four months. With our prechilled tank we expect to recover that in a couple years.

Narrator

But money isn't the only problem.

Bob Allen

Their management has to be ready for it. It has to be from top management to decide that they want an energy program. If your top management isn't ready for it there is no use, it has to come from the top.

Grant Curtis

Well in the case of PCA they are an example of a company who is alert and who has this commitment from top management to an energy conservation program. As a result of that they have gone in and looked at all processes and have been quite successful. Unless there is commitment from top management, operating people generally have very little success in energy conservation programs.

Textile Industry Engineer #2

Employees generally resist
change but the thing is it's a selling job and it's a supervision job. You've got to sell people on the fact that to do their job with less energy requirement is a necessity in order for them maintaining their job, for the company to stay in business. This is a selling job and I heard somebody recently say 75% of effort in energy conservation is selling and promoting the ideas. Of course, supervision comes in the play, too. I don't think there is resistance as long as it is done right. You can't expect people to take the ball themselves.

Textile Industry Engineer #1

Another thing is to know your rate structure. That is number one in energy. Anybody getting into it I'd say that the first thing you should do is dig in and get copies of all rate structures and sit down with all their bills and familiarize yourself very well with them.

Grant Curtis

When you're buying electricity you buy electricity in a manner different from any other commodity. Namely, your time that you buy it has to do with the cost. It has a very important fact to do with the cost.

44. Analysts studying rate structure

45. Analysts studying rate structure
Top management needs to read their utility electric rate and absolutely understand it and understand the implications of it. What you do today can effect you for nine months from now and this is, I'm not sure why, but it is rather a difficult concept to really get a hold of. But all the time spent in doing that in every case I'm familiar with really pays off.

Narrator

We've seen the barriers to conserving energy. We've heard what some people have done to overcome them. Let's find out just how to start an energy conservation program.

Grant Curtis

The place, for an energy conservation program to start is to first determine where you are. By this I mean almost inevitably plants keep track of the dollars of their energy cost in a lump sum variety. But they do not keep track of them in terms of the energy units. The actual energy that it takes to operate the plant. Also, we find that there's an attitude that well energy cost is not anything that we can do anything about so there are situations where there are utility bills
The first thing that you've got to do is to term it an energy audit. That's a dry word, but believe me, it's essential. That is, you dig into it and you spell it out, chart it out, and do these things so that you have your actual energy picture in front of you. The way you are now. Once you do this it's surprising how many times it will almost jump out at you that look this is an area that we've got to look at and sure enough this will be the, by going and looking at this area of operation, why were we so high this month or this or this. Then you will frequently find this is a good beginning point to start your conservation program.

**Textile Industry Engineer #2**

Our case and in many cases it's purely a fact that there isn't enough manpower devoted to energy conservation. It's not an hour a day job or couple days a week or what have you. It's a full time job in a plant of any size. One, you've got to have a
person that's qualified to do this type of analysis you're talking about. But even more importantly, he's got to have the time to do it. It's essentially a full time job. I think this has got to come to be a fact of life.

Narrator

It's a fact of life that as a nation we no longer have a cheap and abundant supply of energy. It's also true that the road to becoming more energy efficient is not an easy one. It's one that requires technical ability, supervisory skills and top management commitment. But as we've seen industry is making progress. In the coming years we hope that each of you will do your part in helping this nation to achieve its energy independence.

Grant Curtis

Energy conservation is fast getting beyond just being an economic matter of the cost of the energy. Management really needs a commitment in two directions. One of them, most definitely is the economics of using the least amount of energy possible to get the job done. To reduce the cost of the product and
this is important. But coming up equally with this is using the energy in the first place because of the shortages that are developing. The energy that they save today can be available then to run the plant tomorrow.

Bob Allen

It's really been easy. Most of the time it's just a matter of getting down and digging in and finding out more about the what's going on. (In most cases you can conserve some energy.) There's usually something available if you look for it.

Grant Curtis

It just makes good common sense to use it wisely.

Bob Allen

Why is it a high priority? Basically it's a high priority because it's a matter of survival.