Chapter 4

The Pulp and Paper Industry

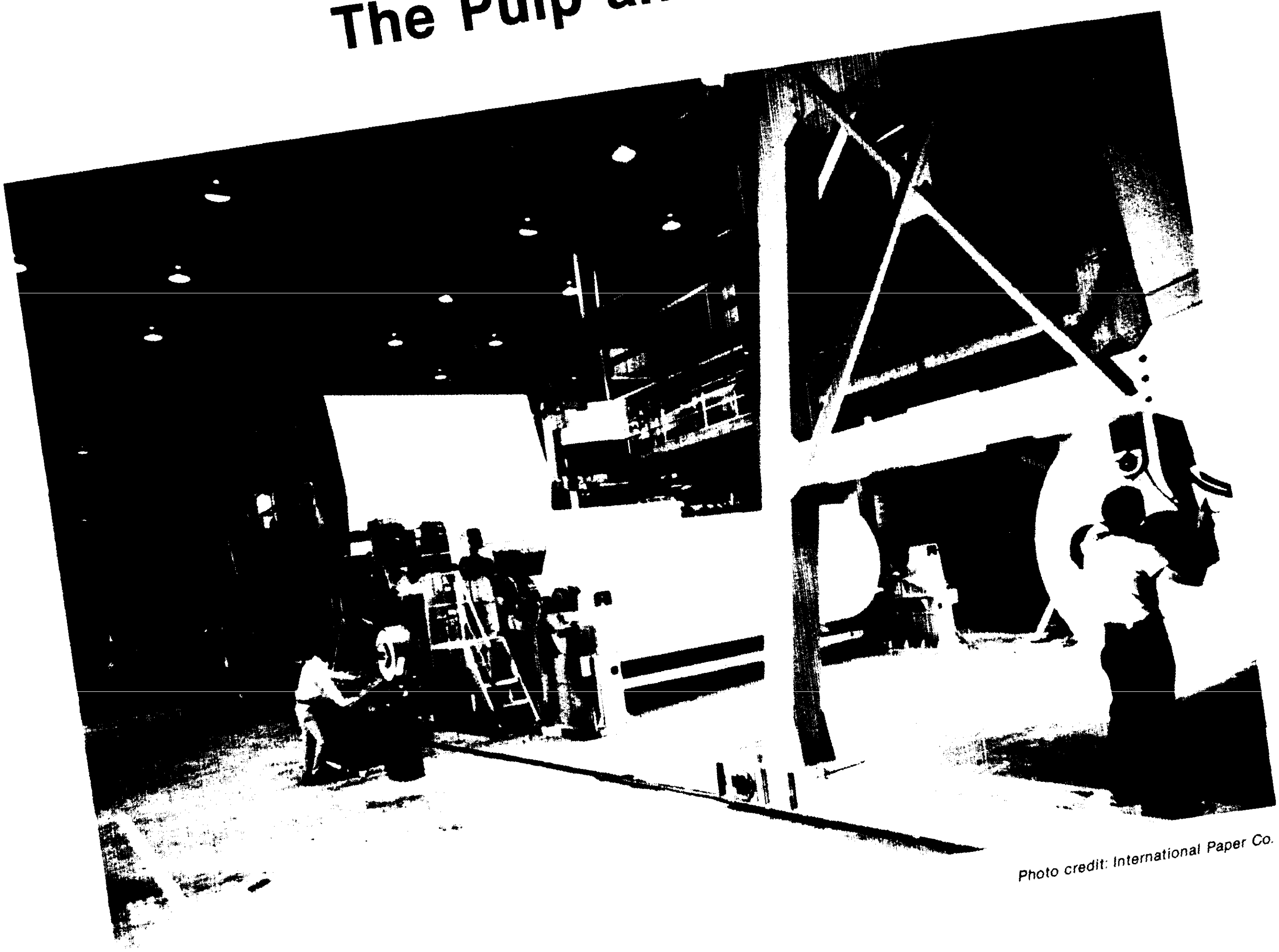

Photo credit: International Paper Co.

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Chapter 4
The Pulp and Paper Industry

INDUSTRY OVERVIEW

The pulp and paper industry is the 11th largest manufacturing industry in the U.S. industrial sector, but is the third largest energy consumer. Unlike other industries, however, the pulp and paper industry can generate a large percentage of its energy needs through the use of wood residue. As a result, the industry is in a unique position to reduce its purchased energy costs, as well as its vulnerability to fuel shortages and/or disrupt ions.

As the world's largest producer of paper and board, the U.S. paper* industry accounted for roughly 35 percent of the world's total output and produced over **62** million tons of paper and board products in 1981. The value of industry shipments in 1981 dollars totaled over $35 billion.[1] In addition, the United States has the highest per capita paper and board consumption in the world.

Industry Structure

The paper and allied products industry, classified under SIC heading 26, includes firms that produce and market pulp, paper and paperboard, packaging, and building paper and board. The subgroups of this industry are listed in table 14.

Table 14.—Definition of SIC 26—The Paper and Allied Products Industry

SIC *26* includes the manufacture of pulps from wood and other cellulose fibers and from rags; the manufacture of paper and paperboard; and the manufacture of paper and paperboard into converted products such as paper coated off the paper machine, paper bags, paper boxes, and envelopes.

SIC *26* contains the following subgroups:

SIC	Title
261	Pulpmills
262	Papermills, except building papermills
263	Paperboard mills
264	Converted paper and paperboard products except containers and boxes
265	Paperboard containers and boxes
266	Building paper and building board mills

SOURCE: **Office of Management and Budget,** *Standard Industrial Classification Manual, 1972.*

This report focuses on the three most energy-intensive industries within this SIC group: pulp, paper, and paperboard mills. Although building products and lumber are not examined further in this chapter, it is important to remember that the pulp and paper industry is closely tied to, and is becoming integrated with, these industries. Accordingly, management and investment decisions are often based on strategic business criteria that extend beyond making pulp and paper.

The paper industry is generally organized into integrated and non integrated mills. Vertical integration (i.e., producing raw materials as well as finished products) is common among the companies in the paper industry because various industry activities are often complementary. Vertical integration often begins with timber, the most common raw material, and culminates in distribution centers that assure finished product outlets. Integrated mills start with raw timber, which is processed onsite into finished paper. Nonintegrated mills either: 1) produce marketable pulp from raw timber, or 2) secure pulp from available markets and convert it into finished paper products. Based on the 1977 Census *of Manufactures* data, about 80 percent of U.S. market pulp originates in nonintegrated mills and about 20 percent in integrated mills,[2]

Currently in the United States, 400 companies operate more than 1,000 papermills and pulpmills.[3] Since World War 11, the U.S. paper industry's primary productive capacity has been progressively concentrated in large new mills located in the South: roughly 65 percent of pulping capacity and 50 percent of papermaking capacity are now below the Mason-Dixon line. The secondary or converting sectors of the industry,

*The word 1'paper " is used as shorthand for "pulp and paper' throughout this report. Also, the term "ton" is shorthand for the more precise, "air r-dryed ton. "

[1] U .S. Department of Commerce, U.S. *Industrial Outlook 1982,* p. 45,

[2] I bid., p. 40.

[3] *Directory of the Paper* **and** *Allied Products Industry,* Lockwood Publishing Co., 1981.

on the other hand, locate plants close to large metropolitan markets throughout the United States.[4,5]

The paper industry has a relatively low level of concentration. No company has captured more than 10 percent of the market. Efficient production of paper can be done at a mill throughput of 300 tons per day. (The largest mill, Union Camp, located in Savannah, Ga., produces 3,000 tons per day.) This wide range of efficient production is one of the reasons the industry remains fragmented. Table 15 lists a number of corporations that earned over $1 billion and used at least 1 trillion Btu of energy for the production of pulp, paper, or paper products in 1981.

Product Mix

The products of the paper industry are extremely varied. While paper has retained its traditional uses throughout the centuries—newsprint, writing papers, tissues, etc.— new uses and applications are continually evolving. The growth of the industry during the past few decades has been due largely to new applications and uses of paper and paper-based materials.

Economics of Paper Products Production

Product Demand

Because the paper industry has a wide spectrum of end products, its growth patterns closely resemble those of the general economy. While some sectors of the product mix are more closely related to changes in industrial activity, others are more directly affected by changes in levels of personal income or by demographic factors. Combined overall consumption of paper and board has closely tracked the changes in the gross national product (GNP).[6,7]

Table 15.—Paper Corporations Earning More Than $1 Billion in 1981

Corporation	Revenues (in billions)	Employees
Georgia Pacific	$5.02	44,000
International Paper	5.00	46,000
Weyerhaeuser	4.53	49,000
Champion International	3.75	42,300
Crown-Zellerbach	3.07	32,000
Mead Corp.	2.71	25,000
St. Regis	2.71	29,700
Kimberly-Clark Corp.	2.60	31,200
Scott	2.08	20,800
Union Camp	1.57	16,097

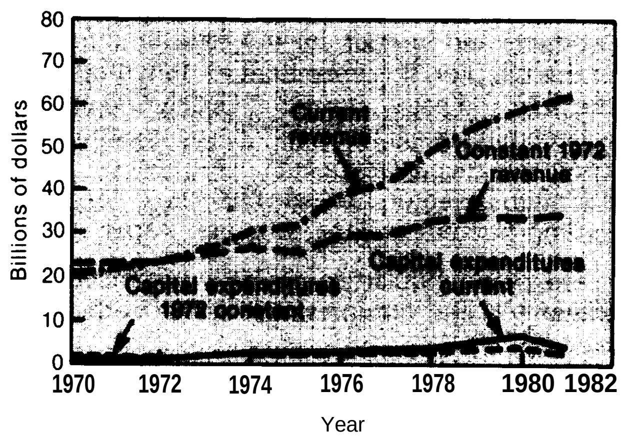
SOURCE: Standard and Poor's Register of Corporations, Directors and Executives, vol. 1, 1983.

Capital Investment

Sales, profits, and retained earnings were high in the 1970's when the industry operated close to a supply/demand balance, an important factor in the performance of a capital-intensive industry. This approach led the industry to invest substantial and increasing amounts of its revenue in new capital, an amount that rose from 8 percent in 1970 to over 11 percent in 1980. However, in the face of high interest rates, a depressed timber market resulting from few housing starts, and the like, this ratio has declined slightly (fig. 11),

Like other manufacturing industries, the paper industry is very sensitive to environmental regulations on air and water quality. Between 1973 and

Figure 11.—Paper Industry Revenue and Capital Expenditures, 1970-82



SOURCE: American Paper Institute,

[4] *U. S. Industrial Outlook, 1982,* op. cit., p. 39,

[5] H. N. Hersh, *Energy and Material Flows in the Production of Pulp and Paper,* Argonne National Laboratory Publication ANL/CNSV-10, February 1981.

[6] *U.S. Industrial Outlook 1982,* op. cit., p. 40.

[7] *U. S. Industrial Outlook 1982,* op. cit., p. 39.

1981, the industry reportedly spent a total of $37.6 billion to comply with these regulations. The added capital requirements for new pollution abatement facilities, mainly centered in pulping activities, increased the capital-intensive character of the industry. B

Imports and Exports

In 1981, the U.S. paper industry, a major exporter of pulp and paper products, exported some 3.7 million tons of pulp valued at $1.8 billion (current), and an estimated 4.43 million tons of paper and board valued at $2.18 billion (current).[9] In the same year, the United States also imported almost 10 million tons of pulp and paper products, relying heavily on newsprint and pulp imported from Canada. In the past 2 years, however, the margin of the U.S. paper industry trade deficit has narrowed because of relatively larger export volumes and an upgraded export product mix.[10]

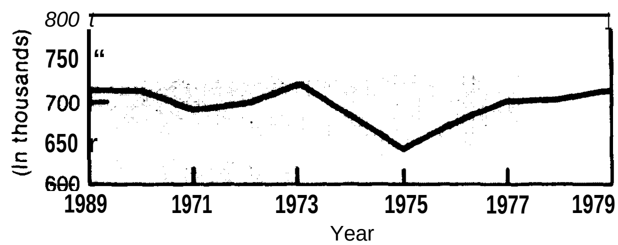
High prices for energy and raw materials have forced Western European and Japanese producers to cut their production capacity. Japanese producers, for example, plan to phase out 1.1 million tons of paper industry capacity by 1985 because of huge increases in the prices of wood chips imported from the United States and of oil imported from Indonesia and the Middle East. This decline in foreign production capacity has opened up new export markets for U.S. papermakers, thereby providing a cushion against domestic demand fluctuations.

[8] *U.S. Industrial Outlook 1982,* op. cit., p. 45.
[9] *U.S. Industrial Outlook 1982,* op., cit., p. 39.
[10] U.S Industrial Outlook 1982, op. cit., p. 44.

Employment

Employment in the paper industry has been very steady over the last 10 years. Both sales and tonnage have risen during this time, so the flat employment profile can be attributed to automation of the mills with its corresponding increases in worker productivity (see fig. 12).

Figure 12.—Paper Industry Employment, 1969-79



SOURCE: Argonne National Laboratory, *Energy* **and** *Materials Flows in the Production of Pulp and Paper,* **May 1981**

ENERGY AND TECHNOLOGY

Production Processes

Paper is made by separating the cellulosic fibers in wood and then removing the lignin that binds the fibers (pulping). The cellulose fibers are usually further conditioned–often by bleaching and refining—before being interlaced in sheets. Finally, water is removed from the sheets by mechanical pressing and the application of heat, leaving the final product, paper (see fig. 13). Many small companies use purchased pulp to begin their paper forming process.

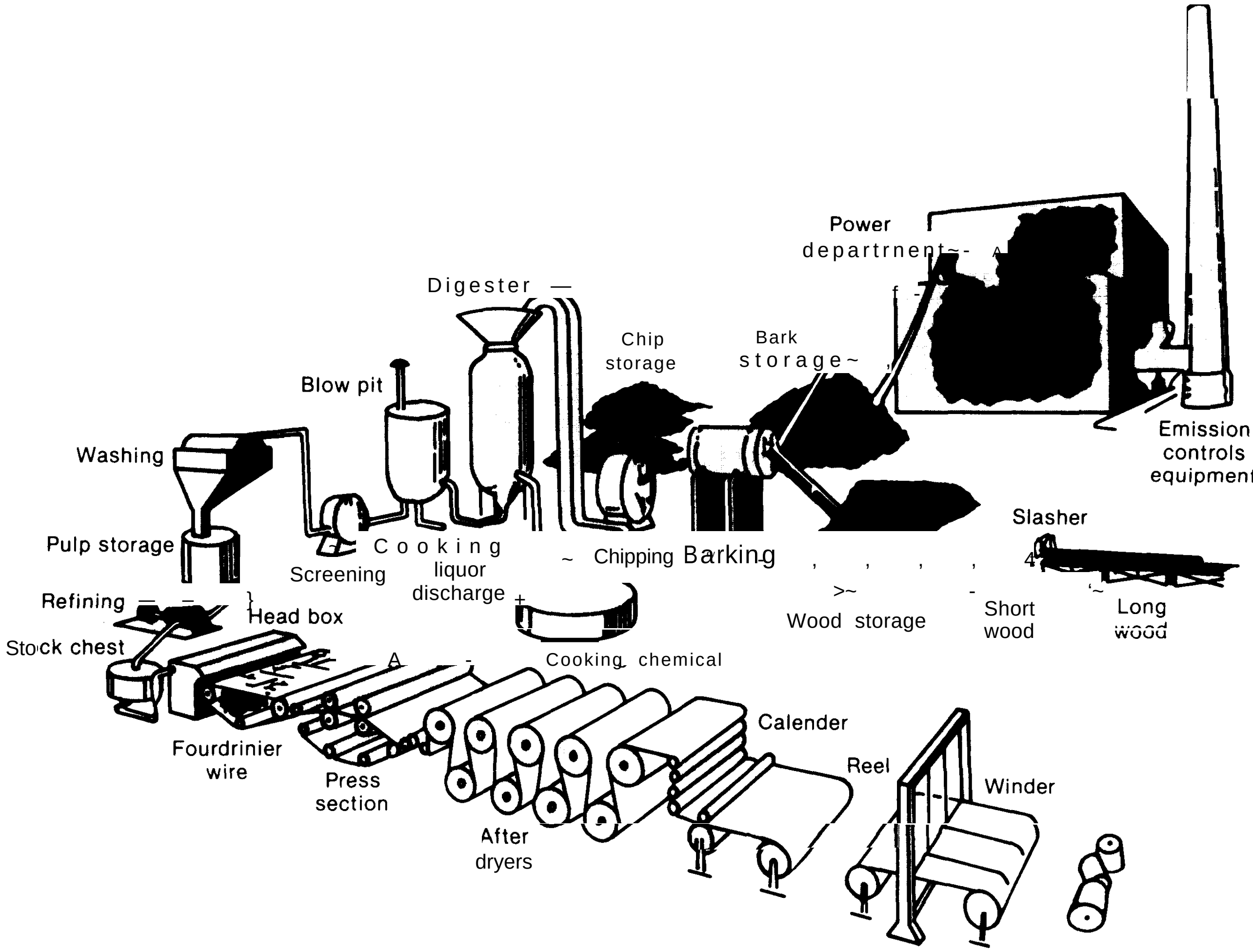
The following is a brief description of the major processes in the paper manufacturing process, including energy's role. It should be noted that process control is included under its own heading because it covers all phases.

Pulping

Pulping is energy-intensive, using about 4.5 million Btu per ton (MMBtu/ton) of paper. Commercial pulping operations are of three principal types: mechanical, full chemical, and semichemical.[11] The method of pulping used by a mill depends on the input (kind of trees) and the desired output (products). Within these constraints, the

[11] McGraw.Hill Encyclopedia of Science and Technology, vol. 9. 1977, p. 609.

Figure 13.—Materials Flow in an Integrated Papermill



SOURCE: National Science Foundation

pulping processes on the basis of energy and raw material costs, as well as utilization rates, labor intensity, and ancillary costs, such as pollution control.

Mechanical pulping involves the reduction of wood to fibrous states by purely mechanical means. In the traditional stone groundwood pulping, logs are first ground into pulp by large revolving grindstones, while water is sprayed against the stone to control the temperature and carry away the resulting pulp. Except for a few water-soluble components, all the constituents of the wood remain in the pulp; thus, the yield of pulp may be nearly 95 percent of what was originally in the tree. Thermomechanical pulping (TMP), which uses pressurized disk refiners in conjunction with heat and occasionally chemicals, is replacing the standard groundwood process fairly rapidly. It requires more purchased energy, and its yields are slightly lower than with conventional groundwood pulp, but the very important property of pulp strength is nearly that of semichemical pulp. Moreover, the process can use residual chips from sawmills and plywood plants as its raw material.

Full chemical pulping employs chemicals to separate cellulose fibers from other wood components. Wood chips are cooked with chemicals in an aqueous solution, usually at elevated temperatures (1**70° C** or **350°** F) and pressures, to dissolve lignin and other compounds and leave the cellulose intact and in fibrous form. Dry pulp yields are in the range of 40 to 60 percent of wood dry weight. The kraft, or sulfate, process is the chemical pulping process most extensively employed. It uses sodium hydroxide (NaOH) and sodium sulfide (Na_2S) to solubilize the ligni n. Almost any wood species can be pulped by this process.

Semichemical pulping is relatively new. It involves softening the wood with mild chemical action and then mechanically grinding it into pulp. Semichemical pulping is employed largely, but not exclusively, on deciduous wood species.

Significant processes in pulping include TMP, alkaline-oxygen pulping, and continuous digesters. Although TMP requires more energy to produce a ton of pulp than does the conventional groundwood method, it is likely to be used by the industry because it produces higher product quality and lower overall cost. On the other hand, alkaline-oxygen pulping uses only about half the energy as the conventional pulping and bleaching process and has the advantage of less sewage waste and the potential to recover more of the chemicals used. Unfortunately, it produces a weaker pulp than does the standard kraft process.

The continuous digester uses approximately 60 percent of the steam required by batch digesting systems. Because it also produces a higher quality, uniform pulp, its adoption within the industry is spreading. Its only disadvantage is its high cost of maintenance.

Bleaching

Pulp must be bleached if it is used to make white paper. The object of bleaching is to render the pulp white without degrading the cellulose, Some grades of paper need not be bleached at all (such as corrugated cardboard boxes), while others (newsprint) are given only light bleaching. Better grades of printing and writing papers require bleaching.[12]

Almost all bleaching is carried out with chlorine or chlorine compounds, leaving an effluent containing high levels of chemicals that must be

[12]Ibid

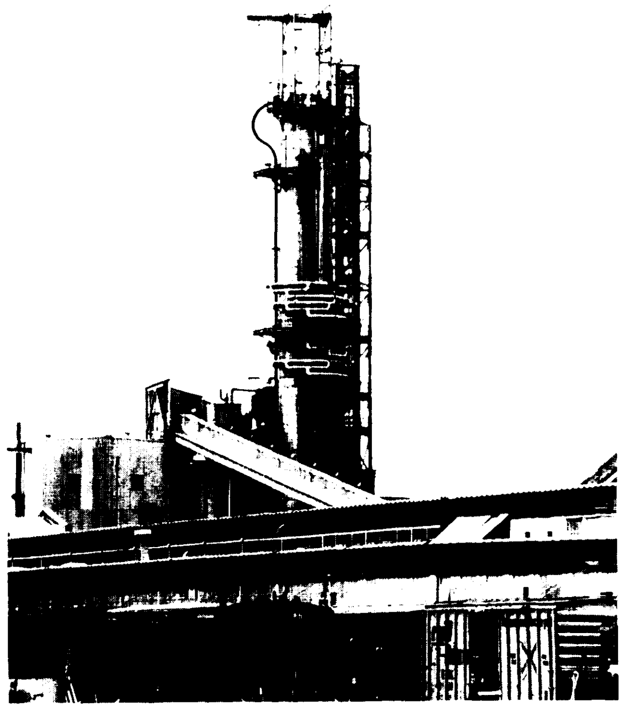


Photo credit International Paper Co.

Wood chips and chemicals are cooked in continuous digesters which break down the wood fiber so that it can be made into pulp and paper

biologically degraded at a sewage treatment plant. In addition, bleaching is an energy-intensive step that requires 5 MMBtu/ton of paper and increases the energy intensity of papermaking by 20 percent. Accordingly, mills have become attentive to ways to reduce energy and chemical losses in the bleach plant.

A number of new bleaching technologies are available to the industry, and some others are under development. Again, as with pulping, these new technologies have both advantages and disadvantages that have to be weighed before their adoption. Most of the new bleaching methods (e.g., the Rapson process, displacement bleaching, and compact bleaching) all appear to have the advantages of reduced energy consumption, and some have the added advantage of using less chemicals. On the other hand, some of these technologies suffer from deficiencies such as extremely high maintenance costs and corrosion. Some have not yet been proven in the American marketplace.

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Refining and Repulping

The refining process is the stage of stock preparation that occurs after bleaching but before papermaking. During this stage the proper mixture of pulp types is blended. Recycled wastepaper also enters the paper stream at this stage for repulping. During refining, the unmodified cellulose fibers (obtained from pulping) are separated, crushed, frayed, fibrillated, and cut. They imbibe water and swell, becoming more flexible and more pliable.

The major energy source in the refining and repulping operations is electricity, which is used to operate motors. The primary way to conserve energy would therefore be to install newer and more highly efficient electrical motors.

Papermaking

In forming paper, up to 95 percent of the water has to be removed from the cellulose mixture. This process is the single most energy-intensive process in the entire papermaking operation, requiring up to *40* percent of the total energy used. Paper sheets are made by depositing a cellulose mixture, with a consistency of less than 1 percent cellulose solids suspended in water, on a continuously moving screen and subjecting it to one of the following three methods for removing the water: the Fourdrinier process, the cylinder machine, and the twin-wire former. [13]

In the Fourdrinier process, a dilute (water content of 99 percent or higher) suspension of cellulose fibers is sprayed under pressure onto a moving wire screen. As the slurry travels away from the spraying point, it passes over several suction devices that cause water to drain through the screen. As water is removed, a wet sheet is formed. The wet sheet is transferred to a supporting felt, which carries it through a series of press rolls. There, water is squeezed out and the sheet progresses to the dryer section. The remaining water is removed by evaporation as the sheet passes over a series of steam-heated cylindrical dryers which expose alternate sides of the sheet to hot dryer surfaces.

A second papermaking technique involves use of a cylinder machine to make multilayer paperboard. It differs from the Fourdrinier process only in the forming. In place of the moving screen are one or more rotary cylindrical filters. Each screen-covered cylinder is mounted in a vat where it operates partially submerged in the dilute papermaking slurry being supplied to it. As the cylinder revolves, water drains through the screen to the interior of the cylinder and a wet sheet is formed. The sheet is removed at the top of the cylinder and may be joined to other wet sheets from adjacent cylinders to form a thicker, laminated sheet or board. The press section and dryer processes are essentially the same as those following the Fourdrinier process.

The third major sheet-forming device is the twin-wire former, which is an outgrowth of the Fourdrinier process. Here the sheet travels vertically between wire screens that contact both sides of the sheet, forcing water out in both directions.

It is far more expensive to remove water thermally in the dryer section than physically in the press section or screen, because evaporation is much more energy-intensive. New techniques to increase moisture removal include such items as twin-wire forming and extended nip presses, where savings of up to 0.5 MMBtu/ton, or more, are possible. However, in some instances, it is possible to damage the cellulose fibers by excessive squeezing.

Another technology being developed is the high-consistency forming of paper, where the cellulose content is raised from below 1 percent to 3 or 4 percent, consequently reducing the water that has to be evaporated. Several other technologies have been developed for facilitating the removal of moisture on the machine, including drying hoods, fans, and other devices designed to remove the evaporated moisture from the proximity of the paper so that further moisture can be evaporated. These developments notwithstanding, the basic design of the papermaking machine itself has changed little over the last 100 years.

[13] Ibid., p. 610.

Recovery Operations

Chemical pulping processes also entail a recovery cycle in which valuable chemicals are reduced and returned to the digester. After digestion of pulp, a black liquor is drained off that consists of lignin, spent chemicals, and water. In a device (unique to the paper industry) called a recovery boiler, lignin carried within the spent pulping liquor is burned as fuel to generate steam while the sodium compounds used in pulping and beaching are recovered and reused. The considerable amount of energy produced in a recovery boiler and used in the recovery cycle has motivated some new conservation technologies.

The recovery cycle of a papermill may be as simple as a bark boiler at a groundwood mill or as complex as the Rapson process in a kraft mill. In the conventional kraft mill, the centerpiece of the recovery activity is the recovery boiler, which burns the organics (mostly lignin) as a black liquor, whi le recovering the valuable sodium chemicals.

Unfortunately, the black liquor, with its high water content (85 percent), will not burn. In order to reduce the water content in the black liquor, multieffect evaporation systems, with their high inherent coefficients of performance, have been adopted. Vapor recompression is starting to make inroads, although this technology is highly dependent on the cost of the electricity required to drive the system.

Process Control

Process control is a computerized monitoring and control of process variables that can save energy and materials and improve efficiency in almost every aspect of the paper industry. For example, either batch or continuous digesters are installed with a computerized process control system as standard equipment, and in the bleach plant, a process control system can increase uniformity of the bleached pulp. Moreover, process controls improve the throughput of the papermaking machine and have saved 1 to 2 percent of the total drying energy as well.

However, process control applications in paper are limited because the most important measurement points are often in harsh or inaccessible environments. For this reason, cooking rates in the digester (which contains a mixture of wood chips, chemicals, and steam) have been very difficult to measure, but research among instrument manufacturers continues to focus on this. optimum cooking rates would produce higher quality pulp with minimum expenditure of energy and time. For other control tasks where the necessary measurements have been achieved, productivity has risen in every case.

Unified control, which coordinates and schedu les component processes, is now catching the attention of the paper industry. Its chief advantage is the reduction of overall production costs. Although this system is now available from control system vendors, the introduction of full mill control is progressing only gradually because of its large cost.

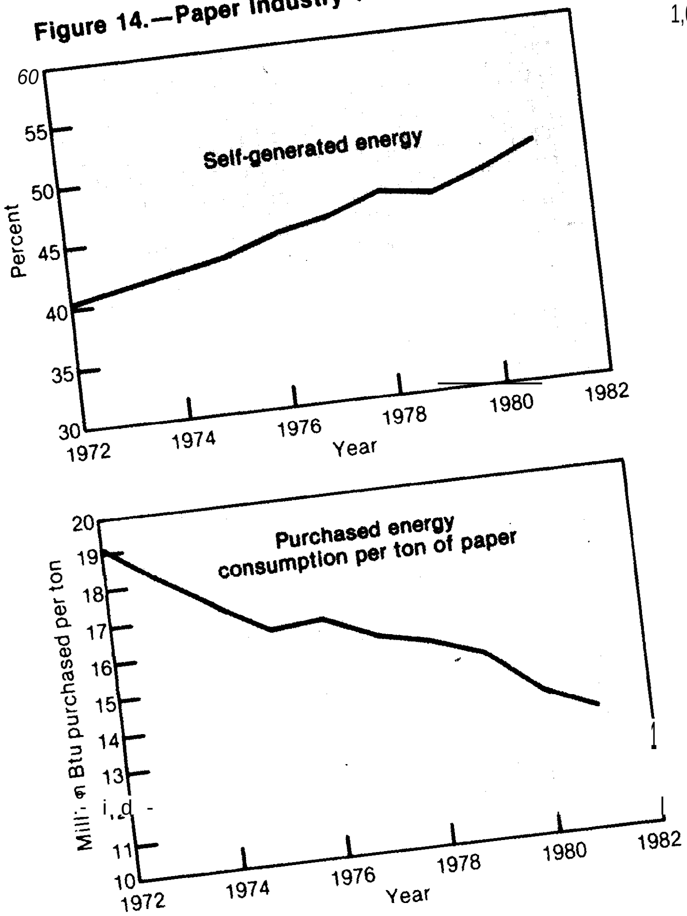
Energy Consumption

Energy consumption in the paper industry varies from year to year and from region to region. The total energy consumed in any given year is determined by a variety of factors, including availability and price of fuel, product mix, and capacity utilization. In 1981, the pulp and paper industry consumed 2.15 Quads of energy, one-half of which was internally generated from wood residues.

According to the American Paper Industry (API), during the period 1972-81 the paper industry's percentage of internally generated energy rose from 40.5 to 50 percent. Figure 14 shows this improvement clearly. As fossil fuel prices continue to escalate, more waste recovery programs will be introduced or expanded, and the industry will likely become even more self-sufficient. Already, many paper companies now find it economical to use the bark of the logs at the mill for fuel. Likewise, more and more sawdust is used as fuel,

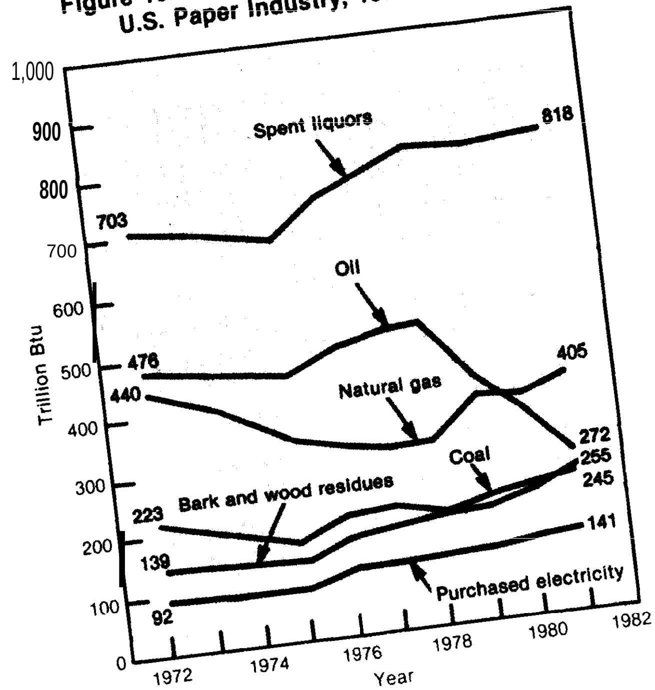
The amount of energy purchases from utilities or other fuel suppliers is down by 6 MM Btu/ton from the 1972 levels, also shown in figure 14. Total purchased energy for 1981 was about 1.06 Quads. The latest API figures show that natural gas is the leading purchased fuel, followed by coal and residual oil (see fig. 15). The fuel used

Figure 14.—Paper Industry Trends, 1972-81



SOURCE: American Paper Institute.

Figure 15.—Changing Fuel Mix in the U.S. Paper Industry, 1972-81



SOURCE American Paper Institute

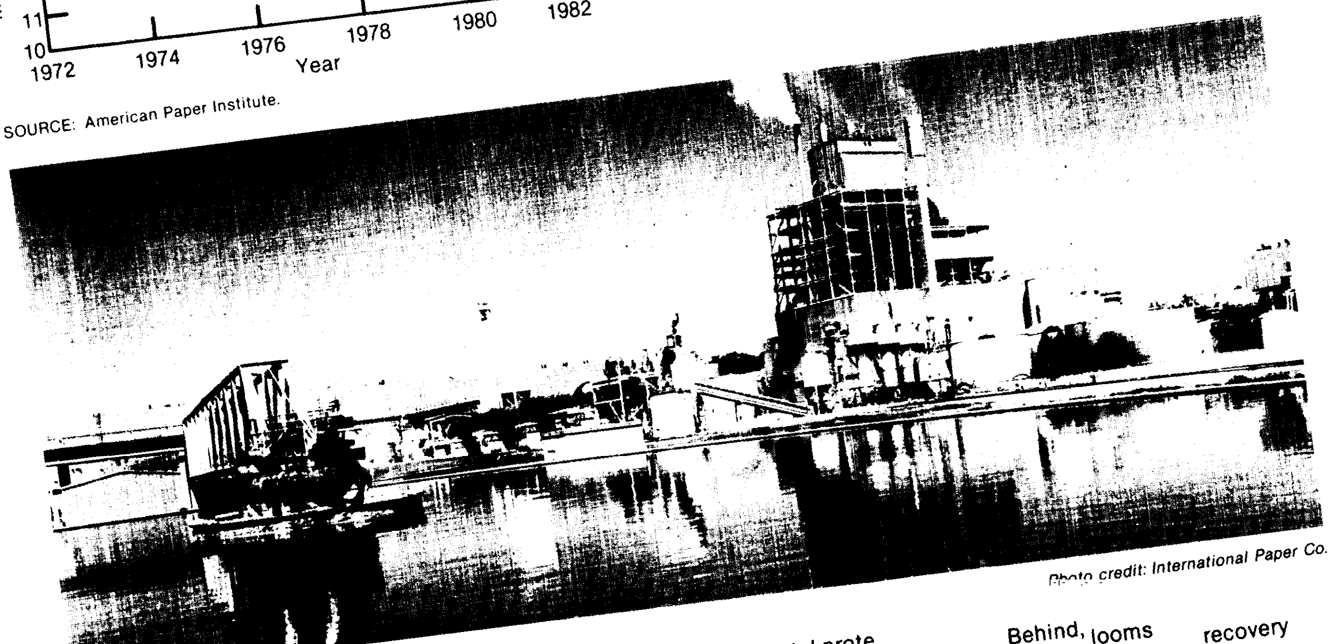


Photo credit: International Paper Co.

'end in the foreground is part of the mill's environmental prote Ction ɪy Stem" Behind, looms 'he recovery boiler, which can meet a significant portion of a mill's energy needs by burning waste 'rem 'he ''"ping' recess in a particular mill is determined by the availability and cost of energy in a region.

Fuels are used by pulpmills and papermills to generate steam or electricity, large quantities of which are used to produce paper. The amount of energy needed to produce a ton of paper from wood averages about 30 MMBtu. This figure can be broken down more precisely by process and by product. The most energy-intensive step in papermaking is the drying process, followed by pulping and bleaching.

Not surprisingly, many mills have the capacity to cogenerate electricity. The paper industry has in place approximately 3.5 billion watts of cogeneration capacity, virtually all of which is in the form of steam turbine generators.[14]

Energy Conservation

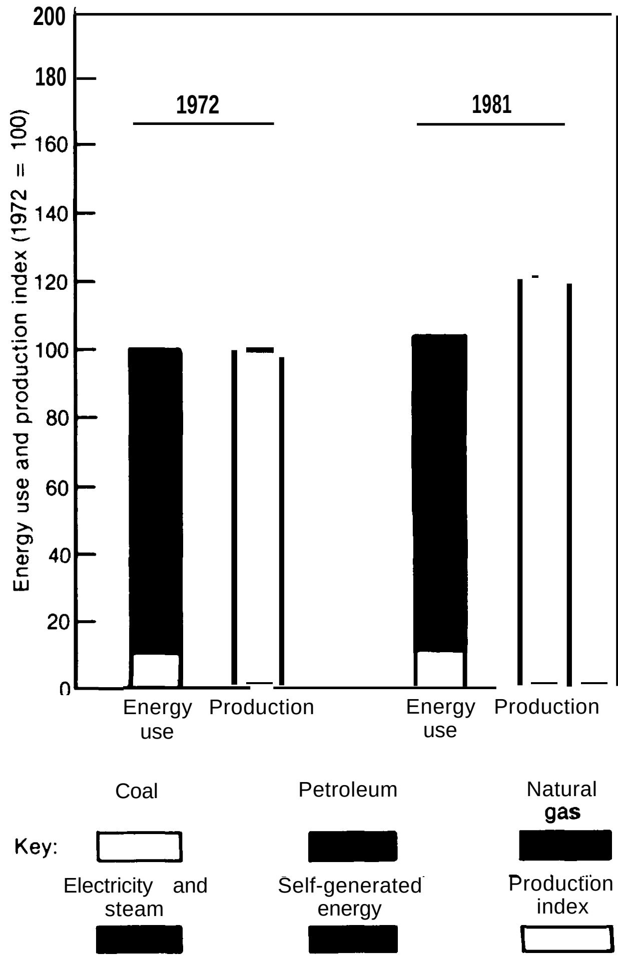
As part of the Department of Energy's Office of Industrial Programs effort, the paper industry adopted a voluntary goal of 20-percent reduction in energy consumed per ton of product by 1980. According to API, by 1981, the industry was using 23.3 percent less purchased energy, while at the same time, productivity had increased by almost 20 percent. This is shown clearly in figure 16.

Many of the new pulp and papermaking processes and their associated equipment offer great potential for saving even more energy. Because new processes and equipment require large capital outlays, the rate at which conservation technologies are deployed will be largely dependent on the paper industry's ability to raise capital.

Given the steep fuel price rises of the 1970's, and their maintenance or escalation in the 1980's, it is safe to assume that energy conservation will continue to play a major role in the paper industry. Perhaps the greatest potential for reducing

[14] Ibid., p. 609.

Figure 16.—Comparison of Paper Industry Energy Use and Production Output, 1972 and 1981



SOURCE: American Paper Institute

oil and gas consumption in the paper industry lies in increasing the industry's use of wood residue as fuel for the integrated producers. For those firms that produce paper from purchased pulp, such fuel sources do not exist. Instead, their improvements will come from more efficient production.

INVESTMENT CHOICES FOR THE PAPER INDUSTRY

In general business operations, the paper industry is similar to other industries. It strives to maintain reasonable cash flow, and its investment strategies are designed to preserve the company and maintain or improve its profitability to its shareholders. It attempts to preserve its asset values, maintain creditworthy balance sheets, and, of course, produce profits. However, although the individual paper companies are basically dependent on the same raw material inputs, their end products and markets are extremely diverse. These products can range from heavy linerboards to fine writing papers to tissue paper. This diversity further increases divergent subjective and objective opinions of management, for the marketplace of one major forest products company could be completely different from the marketplace of another.

In one respect, the paper industry could be considered slightly different from other industries. The major pieces of equipment used in this industry have exceedingly long lifetimes. Fifty years is considered a reasonable retirement age for a lime kiln, and some parts of paper machines running now are over 100 years old. Therefore, investment decisions in the paper industry are often viewed over much larger horizons of time than in other industries.

There are a number of possible investment opportunities in energy conservation and other areas for the paper industry that appear financially attractive (see table 16). OTA reviewed eight such investments, ranging from those made specifically to save energy, to those with the secondary benefit of saving energy, and finally to those that do not save energy and, in fact, compete with energy-saving technology for corporate investment dollars. Furthermore, the opportunities examined provide examples of discretionary expenditures to satisfy very short-term problems and to remove bottlenecks, as well as capital expenditures to install new machinery or to initiate a research and development project to increase market share.

Table 16.—Pulp and Paper Industry Projects To Be Analyzed for Internal Rate of Return (IRR) Values

1. Inventory control-A computerized system can keep track of product item availability, location, age, and the like. In addition, these systems can be used to forecast product demand on a seasonal basis. The overall effect is to lower inventory, yet maintain the ability to ship products to customers with little or no delay. In typical installations, working capital costs are dramatically reduced.
   Project life—5 years.
   Capital and installation cost–$560,000.
   Energy savings—O directly, but working capital could be reduced by $1.2 million.
2. ***Electrlc motors.*** —The primary use of electric motors i n the paper industry is in paper machine operations. In this analysis, OTA has assumed that five aging electric motors will be replaced with newer, high efficiency ones.
   Project life—10 years.
   Capital cost and installation cost–$35,000.
   Energy savings–$16,000 per year at 4¢/kWh.
3. ***Lime kiln replacement***—Replacement of an aging unit which thermally converts calcium carbonate waste chemical back to chemical oxide (lime) suitable for further chemical processing of pulping liquors.
   Project life—20 years.
   Capital and installation cost—$11 million.
   Energy saving—$1 million in first year.
4. ***R&D*** project. -A hypothetical research effort to develop **a** new paper-coating process.
   Project life—3 years.
   R&D costs—$1.4 million.
   Plant construction cost at end of 3 years of development—$57 million.
   Energy savings—O directly but new market could generate $50 million per year in increased profits.
5. ***Pulpmill cogeneration*** pro]ect.—Installation of a turbogenerator unit to recover electrical power from steam production facility. Superheated steam is produced at 600 psi and then passed through a mechanical turbine to generate electricity. The turbine exhaust, which is 175 psi steam, is used then for normal plant production.
   Project life—10 years.
   Capital and installation cost–$231,000.
   Energy savings—$72,300 per year,
6. ***Continuous digester.*** —Equipment for new, innovative process for generating pulp.
   Project life—20 years.
   Capital and installation cost—$27 million.
   Energy savings—$3.7 million in first year.
7. ***Computerized process control*** —The most common retrofit purchases being made for industrial systems are measuring gauges, controlling activators and computer processors. The main accomplishment of such a process control system is to enhance the throughput and quality of a chemical production plant with only materials and small energy inputs.
   Project life—7 years.
   Capital and installation costs–$500,000.
   Profit savings—$150,000 per year.
8. New ***papermaking*** *machine.—A* **new** pulp processing, papermaking facility including buildings, machinery, and installation.
   Project life—20 years.
   Capital and installation costs—$350 million.
   Energy savings—O directly, but profits could be increased by $60 million per year.

NOTE: All projects are assumed to be financed from equity. Fuel is assumed to rise in cost slightly faster than inflation. Depreciation follows the ACRS schedule, and there is a 10 percent general investment tax credit, but no energy tax credit.

SOURCE: Office of Technology Assessment.

These projects can be ranked according to several criteria, among which are the internal rates of return (IRRs). As shown in the reference case column of table 17, the project with the highest rate of return, 90 percent, is inventory control. Project IRR values descend thereafter to a low of 13 percent with the new papermaking machine. Thus, if one were to invest purely on the basis of maximizing returned moneys to a corporation and its shareholders, the inventory control project would be the first one undertaken. However, there are other criteria by which projects can be ranked. For instance, the project that saves the greatest amount of energy per dollar invested is the replacement of the electric motors. And if one were to rank the projects based on the total energy saved, the continuous digester would come out on top, with a savings in energy equivalent to over 80,000 barrels of oil per year. However, its $11 million cost is by no means insignificant and illustrates the point that those projects that save large amounts of energy have large costs associated with them as well.

Table 17.—Effects of Policy Options on IRR Values of Paper Industry Projects

		IRR with policy option		
Project	Reference case	ACRS removed	10-percent EITC	$1/MMBtu tax on natural gas and petroleum products
Inventory control	**90**	90	***90***	90
Electric motors	**47**	47	52	**50**
Lime kiln	**31**	28	34	**32**
R&D (no R&D credit)	***28***	26	28	**28**
Continuous digester	21	20	21	**25**
Process control	20	20	25	**22**
Cogeneration	15	13	18	**15**
Paper machine	13	12	15	**13**

NOTE: All projects are assumed to be financed from equity.

SOURCE: Office of Technology Assessment

IMPACT OF POLICY OPTIONS ON THE PAPER INDUSTRY

This section of the report describes the projected impact of each of the legislative options described in chapter 1. Although the projections for total fuel use and overall energy efficiency in the pulp and paper industry are included, the goal of this section is to present comparisons of each policy option with a reference case. The reference case projections are predicated on a series of product growth-rate assumptions and energy price assumptions, previously shown in tables 2 and 3 of chapter 1. The basic premise is that industrial electricity prices will remain constant for the last 15 years of this century, while petroleum and natural gas prices will rise at an overall rate of approximately 2.1 percent per year.

The Reference Case

OTA's model projection of the volume of shipments and energy demand in the pulp and paper industry is shown in table 18. There are several interesting points to be noted on the table. First, total energy is projected to rise at about 1 percent per year from its 1980 level of 2,180 trillion Btu to approximately 2,620 trillion Btu in the year 2000. Purchased energy will decline slightly from 52 to 47 percent, owing primarily to the increased use of coal and electricity. However, purchased fuel use per ton of paper will likely decline from its 1980 level of 20 MMBtu/ton to a level of 11.6 MMBtu/ton by 2000, as shown in the last column of table 18.

Within the paper industry the three major means of pulping wood (i.e., chemical, semichemical, and mechanical) were projected to maintain the approximate pulping percentages they now enjoy. However, recycled pulp is expected to grow from its 1980 level of 23 percent of total pulp production to 25 percent by 2000,

Table 18.—Overall Production and Energy Demand Trends in the Paper Industry (Reference Case)

Year	Paper shipments (million tons)	Total energy (trillion Btu)	Purchased energy (trillion Btu)	Purchased/ total energy (percent)	Total MMBtu/ton of output	Purchased MMBtu/ton of output
1980	63.8	2,180	1,130	52	34.2	20.1
1985	71.2	2,150	1,100	51	30.2	15.4
1990	82.0	2,280	1,140	50	27.8	13.9
2000	106.1	2,620	1,230	47	24.7	11.6
Average growth rate, 1980-2000 percent per year	2.54	0.92	0.42			

SOURCE: Office of Technology Assessment

since the supply of virgin pulpwood appears to be unconstrained.

The mix of products produced in 1980 in the paper industry is shown in table 19, along with the products' anticipated growth rates. Comparing the 1980 (actual) and 2000 (projected) product slates indicates that printing and writing papers will increase their percentage, while construction, paperboard, and packaging percentages will decline. This is a trend seen in other industries that have a higher growth in the more value-added products and a fall-off in production of basic commodity products.

OTA analysis of the impact of each legislative option is illustrated with the data on IRR calculations shown in the legislative option columns of table 17. In this exercise, IRR calculations are initially made for each project in the series, assuming reference case conditions of equity financing, accelerated cost recovery system (ACRS) depreciation, etc. Then IRR values are recalculated under the conditions of the legislative options. Several points should be noted about the projects listed and the numbers calculated.

First of all, the IRR fails to consider the other questions that go into making a decision about each project. For instance, notwithstanding the tremendous savings in energy efficiency that would come about in the lime kiln replacement, there is no way in which an energy saving of $1 million a year can, by itself, justify a $11 million expenditure. However, in this instance (based on a real case), the firm was faced with expenditures of $4. o million to overcome pollution problems and a cost of $1.0 million necessary for repair of the existing kiln facility. While energy savings certainly increased the attractiveness of the new kiln, the about-to-be-imposed Federal environmental restrictions on the existing facility were felt by management to be the main motivating factors.

IRR calculations also fail to show the magnitude of the risk associated with the new papermaking machine. A new facility costing $350 million, no matter how high its IRR value, would be closely scrutinized from a strategic standpoint. The economics of this type of project depends highly on such factors as the perception of market demand and product competition. The cost of energy plays a secondary role.

Table 19.—Projected Product Mix Changes in the Paper Industry

	1980 product ion (million tons)	Relative growth rate (0/0 per annum)	Product mix (0/0) 1980	Product mix (0/0) 2000
Newsprint[a]	4.67	–0.5	7	7
Printing and writing[b]	15.60	1.3	24	31
Packaging	5.54	– 1.4	9	7
Tissue	4.30	–0.2	7	7
Paperboard	30.95	–0.3	49	45
Total	63.62		100	100

[a]The growth in domestic production incorporates a correction for relatively declining imports.
[b]Coated papers are about 30 percent of this category.

SOURCE: Office of Technology Assessment.

Strictly speaking, cogeneration falls in the category of discretionary investment and can be viewed as a technology installed entirely to reduce energy costs, although if the electricity network is poor in an area, it could also carry some economic value in security of supply. Compared to a discretionary investment with a lower rate of return (e.g., the continuous digester), it does not necessarily follow that the cogeneration facility would take preference. Much depends on the marketplace and whether bottlenecks in production are more important to management than is a reduction in energy costs. Here again, the highest return on investment may not necessarily attract the corporate dollar.

In the case of the process controller on a paper machine, different functions are involved. Process controllers may be designed either to increase machine speeds and therefore output or to produce a uniform quality, saleable product, thereby reducing waste and increasing output. A reduction in energy use inevitably occurs when a process control system is installed—e. g., if less waste were produced, the energy input per ton of saleable output would also be reduced,

The case of the electric motors illustrate an important point concerning replacement of existing equipment. If a motor must be purchased, and the choice is between a standard model or a high-efficiency one, the investment in the latter produces an IRR of 46.6 percent. However, if the existing motors need not be scrapped, and replacement is to be justified purely on energy savings, the return on investment would drop to 14.6 percent, which includes the targeted tax credit favoring the high-efficiency motors. Even if the existing motors were to be replaced in 5 years, the IRR would reach only 18 percent, which includes the investment tax credit of 10 percent. All economic justification for this type of project must thus be realized from the savings in electrical energy.

It is obvious from this example that energy savings alone cannot overcome the financial realities associated with prematurely scrapping equipment. Therefore, even though the energy savings per dollar invested are the highest of all the technologies discussed in this section of this report, it is unlikely that replacement of existing motors would be high on the list of any paper company's discretionary spending investments.

The point here is not to discount IRR calculations, but to illustrate that other factors besides the return can enter into the decision whether or not to undertake a project.

Projected Effects of Policy Options

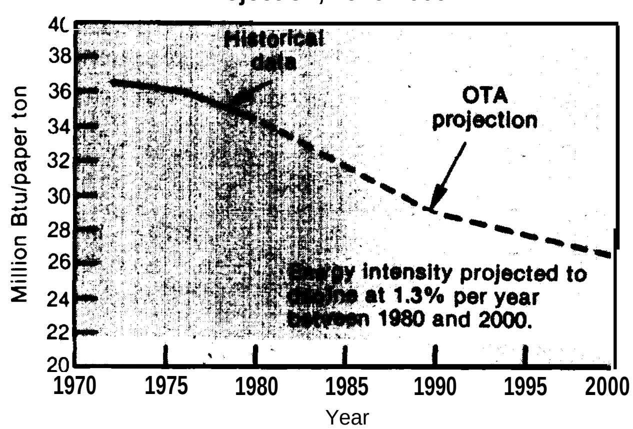
The following sections illustrate the projected effects of the four policy options in comparison with changes in energy demand and energy intensity in the reference case. Figures 17 and 18 present a graphical overview of the impact of these policies.

Two things are immediately apparent in the diagrams. First, as shown in figure 17, the average energy intensity for the paper industry (in million Btu per ton) is projected to decline from its present level of about 35 to a level of 26 in 2000. And, as shown in figure 18, the amount of fuel used is expected to increase to 2,620 trillion Btu over the same time period. That is, the trend of the industry, assuming the fuel prices originally shown in table 2, will be toward more efficient production of paper.

Option 1: Removal of Accelerated Depreciation

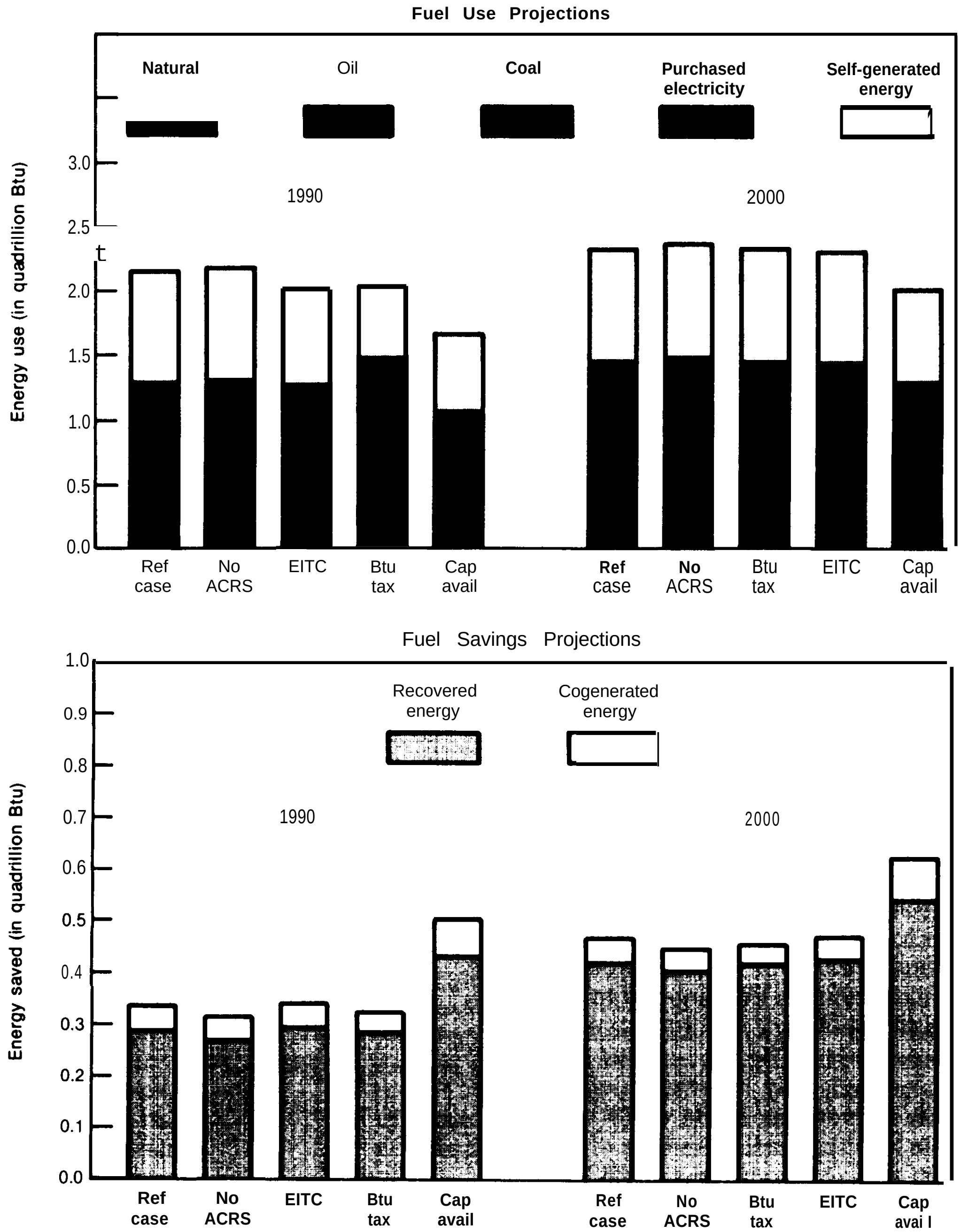
The passage of Public Law 97-34 in August 1981 brought several significant benefits to industry.

Figure 17.—Paper Industry Energy Intensity Projection, 1970-2000



SOURCE. Office of Technology Assessment

Figure 18.—Paper Industry Projections of Fuel Use and Energy Savings, 1990 and 2000



SOURCE. Office of Technology Assessment.

For the paper industry, the new rules put buildings into a 10-year depreciation lifetime category, and all pulping and papermaking equipment into a 5-year category. This is in contrast to the previous situation wherein this equipment would be in the 15- to 20-year lifetime.

If the ACRS were removed, OTA analysis indicates that the effect on energy use would be minimal. Total energy use would increase from a projected level of 2,820 trillion to 2,840 trillion Btu, an overall change of 0.7 percent. This would occur because ACRS allows a corporation to defer its tax liability, but does not remove the obligation.

Table 17 illustrates the effect of this policy option on the IRR of the eight paper industry projects described previously. OTA analysis using these IRR calculations indicates that none of the eight projects shifted their positions relative to the other projects. Each project changed the I RR value only 1 to 3 percentage points. Overall, removal of ACRS would make slightly less money available for corporate use, but that the effect on paper industry energy intensity would be negligible.

Option 2: Energy Investment Tax Credits

The second policy option, a targeted energy investment tax credit (EITC), would be used by corporations to offset a part of their Federal income tax. In the paper industry, the items benefiting most from such tax credits would be cogeneration systems and computer control systems for either steam boilers or paper production. Large units such as digesters, whose primary purpose is other than to save energy, will not, in all likelihood, qualify for a tax credit, The existing list of qualified equipment will also include heat recovery equipment, evaporators, and black liquor preparation systems.

In conducting its analysis, OTA found that all corporations take advantage of tax credits that are available to them, but in no instance was a tax credit found to be the deciding influence in whether or not to undertake an energy efficiency-improving project.

As illustrated in table 17, when this option is applied to the reference case, only one of the projects moves up in position. The process controller moved ahead of the continuous digester by 4 points. Investing in the continuous digester undoubtedly results in a significant increase in capacity, whereas a process controller most likely results in an increase in the efficiency with which existing equipment is used, One means making more pulp, while the other means making better pulp. The influences on the first project reflect management's perception of the demand of the market for more product, or, in the second case, for a better product. A tax credit, while not without impact, is only one factor influencing the choice between the two projects.

Previously in figure 18, OTA presented its analysis of the impact of a tax credit on total paper industry fuel use and overall energy efficiency. As shown in the EITC case compared to the reference case, there is projected a slight drop in total energy demand from 2,819 trillion to 2,809 trillion Btu in 2000. Most of that would come from decreases in natural gas use. Energy intensity of the paper industry is projected to be virtually unchanged, i.e., 24.7 MMBtu/ton in both the reference and EITC cases.

Overall, OTA analysis indicates that the influence of a small EITC on the paper industry would not be significant.

Option 3: Tax on Premium Fuels

Of the four industries examined in this study, paper uses by far the most self-generated energy. Wood residue produced **50** percent of the energy used in pulp and paper production in 1981. This trend toward self-generation of energy has been in existence for at least the past decade, which means that purchased energy now used by this industry cannot be easily supplanted by self-generated energy.

Thus, the premium fuels tax option does not have much impact on fuel use patterns. As shown in figure 18, the impact would be greatest on natural gas, where consumption is forecasted to decrease 7 to 8 percentage points. However, since natural gas accounts for only 20 percent of the fuel used by the paper industry, the impact of the natural gas decrease on total energy use is small. OTA analysis does indicate a slight decrease in cogenerated electricity production with a Btu tax, since much of the commercially available cogeneration equipment is based on natural gas use.

The use of TMP processes would be influenced by a premium fuels tax to the extent that utilities are dependent on these fuels to produce electricity, since electricity is the main source of energy for TMP processes. The Pacific Northwest has seen a dramatic rise in the price of its hydroelectricity, from $0.005 to $0.03 per kilowatt-hour. The initial impact of this energy price rise has been to make Canadian pulp more attractive.

A Btu tax on gas and oil would cost the paper industry approximately $600 million annually, which would translate to an approximately $7/ton increase. Much of this would be passed on to customers of the industry, but it is not clear that all can be.

The effect on the IRR of a fuel tax of $1 .00/MMBtu is shown in table 17. Comparison of the case with the Btu tax case shows that the largest gain was with the continuous digester, where the IRR value increased from 21 to 25 percent. However, as noted previously, many factors enter into the decision to build a continuous digester facility. The fact that the energy consumed by an existing batch digester is subject to a tax will not by itself motivate a company's managers to invest in a new continuous digester. But, if the batch system must be replaced, a tax may contribute to the decision to upgrade the system.

The overall result is that the fuel tax is not enough to reorder the priorities of this collection of projects. Although the fuel-intensive projects advanced in the I RR with a sudden increment in price, they did not advance enough to displace higher ranked projects. Of course, it would be possible to pick a different slate of projects that shows more motion, The conclusion by OTA for the paper industry is that a fuel tax of $1 .00/MMBtu will not solely be effective in motivating energy conservation investments.

Option 4: Low Cost of Capital

OTA analysis indicates that capital is constrained in the paper industry not so much by the interest rates charged by commercial institutions for loans, as by the overall economy and the ability of firms to sell their products. As discussed in chapter 2, capital for investment in energy projects or any other project comes from a combination of borrowing and net profits. There are many things that can decrease a company's capital pool size if that pool is derived mainly from internal funds. To the extent that internal funds are used for capital investment, interest rates will have no effect on whether a project is undertaken. However, in many companies the interest rate is used as the discount rate in IRR calculations, and so interest rates may affect IRR values.

In many firms, the capital pool is comprised of a combination of internal and borrowed funds. In these cases, there is the opportunity for interest rates to influence the decision of whether to invest in a project or not. However, OTA has found that even here, the decision is comprised of many factors besides energy conservation and the cost.

The eight paper industry projects illustrate quite well the small change that would be exhibited by the IRR calculations for this policy option. For these calculations, OTA assumed that the projects were financed by one-third equity moneys, and two-thirds debt funding (see table 20). The first column shows what the IRR value is when

Table 20.—Effect of Lower Interest Rates on IRR Values of Paper Industry Projects[a]
10% inflation, ACRS, 10°/0 ITC)

Proiect	Reference case IRR with 16°/0 interest rate	IRR with policy options: interest rate of 80/0
Inventory control	389	373
Electric motors	75	79
Lime kiln	47	52
Process control	33	41
R&D (with 25°/0 credit). .	34	35
Continuous digester . . .	22	23
Cogeneration.	17	20
Paper machine	13	17

[a]Projects are assumed to be two-thirds debt financed and one-third equity financed,

SOURCE: Office of Technology Assessment, the interest rate is 16 percent, while the second presents these same calculations with an **8** percent interest rate. I RR values rise by 4 to 5 points in each case, * which is in the range of uncertainty for these projects. And, not only do the projects rise only a small amount, but also none of the projects changes place.

Figure 18 shows the OTA projections on fuel use under the terms of this legislative option. Of the four options, this one is projected to have the greatest effect. Energy use would drop from 2,81 Quads in 2000 to 2.67. Much of that would result from increases in the recovered energy now being sent up stack gas flues and sent to thermal waste streams, and in cogenerated energy derived from waste fuel sources. This improved energy use comes from increased market penetration of relatively capital-intensive conservation and cogeneration technologies and is projected to cause a 15-percent drop in natural gas and petroleum use. Additionally, the growth in total electricity demand, owing to increased penetration of electrical technologies at the expense of generally less efficient, fossil fuel technologies, and the increased penetration of conservation devices cause overall energy consumption to decline while the product slate remains the same.

*Except for inventory control, which goes down because the computer control saves working capital. When interest rates drop, the carrying charges on the working capital also drop, and therefore profitability drops slightly as well.