Chapter 2

The Industrial Sector: Growth, Trends, and Investment Behavior

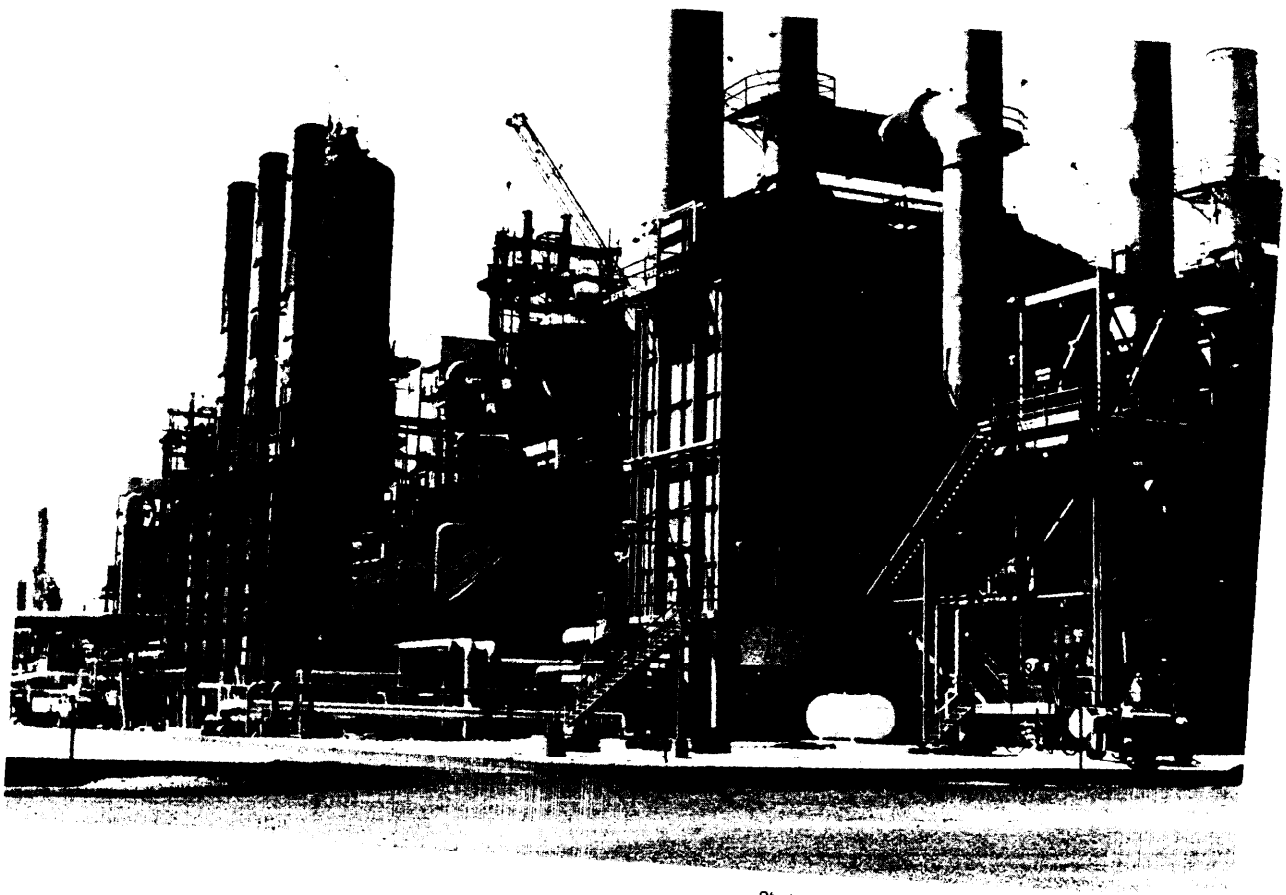

Photo credit: American Petroleum Institute and Exxon Corp.

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THE INDUSTRIAL SECTOR

As defined by the Department of Energy (DOE), the industrial sector is essentially the goods-producing part of the economy, It is largely concerned with obtaining raw materials—through extraction or through animal and plant husbandry–and with the mechanical and chemical transformation of these materials and their derivatives. The industrial sector contains agriculture (including forestry and fisheries), mining (including oil and gas extraction), construction, and manufacturing. Manufacturing is the largest of the four in dollar value of output and energy use.

These four components of the industrial sector correspond to the first four of eleven divisions in the Standard Industrial Classification (SIC) system. The SIC system defines industries and groups of industries in accordance with the composition and structure of the economy. It covers all economic activity. The Federal Government and many other organizations use the SIC framework for collecting statistical data; many businesses use it to classify customers and suppliers. Table *4* lists the SIC major manufacturing industry groups.

Table 4.—Major Manufacturing Industry Groups as Listed in the Standard Industrial Classification Manual
(1972 edition)

SIC code	Major group
20	Food and kindred products
21	Tobacco manufactures
22	Textile mill products
23	Apparel and other textile products[b]
24	Lumber and wood products
25	Furniture and fixtures
26[a]	Paper and allied products
27	Printing, publishing, and allied industries
28[a]	Chemicals and allied products
29[a]	Petroleum refining
30	Rubber and miscellaneous plastics products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33[a]	Primary metal industries
34	Fabricated metal products
35	Machinery, except electrical
36	Electrical and electronic machinery, equipment, and supplies
37	Transportation equipment
38	Instruments and related products[b]
39	Miscellaneous manufacturing industries

[a]**Industries groups examined** in detail by OTA study
[b]Shortened title.
SOURCE: *Standard Industrial* **Classification Manual, 1977** (Washington, D C Office of Management and Budget, 1977).

Size and Growth of the Industrial Sector

The industrial sector accounts for nearly one-third of the gross national product (GNP). As revealed in figure s, output (discounted for inflation) by the industrial sector has grown at a respectable rate since the end of World War II. Real industrial gross product increased 167 percent, or an average of 3 percent per year, between 1947 and 1980 (latest data available).

The industrial sector's proportion of overall U.S. economic activity has been decreasing, however, owing to two factors. First, service-type activities have grown more rapidly than goods-producing activities, a situation typical of highly industrialized economies. Gross product originating* in nonindustrial divisions increased *243* percent between 1947 and 1980, or 3.8 percent per year on average, compared with 3 percent on average for the industrial sector. In 1980, gross product originating in the industrial sector represented 31.6 percent of the real GNP, a drop from 37.2 percent in 1947.

Second, among goods-producing activities, there has been a historical shift toward higher degrees of fabrication and more technologically advanced products. For example, gross product originating in the nonelectrical machinery, elec-

*Gross product originating in a division or Industry is that part of the GNP attributable to the output *of* establishments in that division or industry. It is the sum of the factor costs of production (wages, salaries, profits, net Interest, and so forth) and nonfactor costs, such as depreciation and Indirect business taxes,

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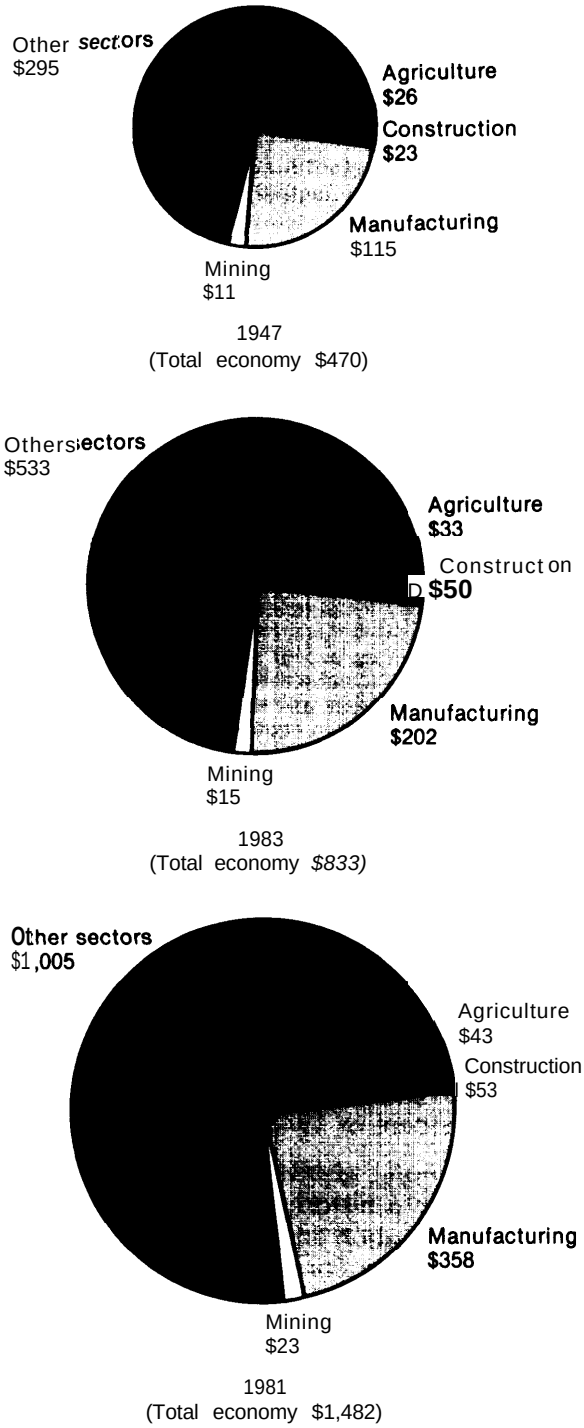
Figure 5.—Output in the Industrial Sector (billions of 1972 dollars)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analyses

tric and electronic equipment, and instrument and related products industry groups, combined, accounted for more than **6** percent of the GNP in 1981, compared to about 3.5 percent in the mid-l950's. in contrast, the combined share of the GNP accounted for by the primary metals and fabricated metal products industry groups fell from over 4.5 percent to less than 3 percent for the same period. *

Both the faster output growth of nonindustrial divisions and the shift to higher degrees of fabrication and more technologically advanced products have an important bearing on the level of energy use in relation to output in the industrial sector.

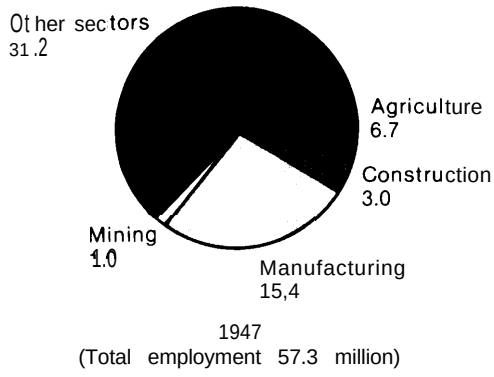
The industrial sector employs about 30 million people, or about 30 percent of the total employment in the U.S. economy (see fig. 6). This percentage is slightly higher (31 percent) when employment is figured according to the full-time equivalent of workers rather than by the number of full- and part-time workers. There are relatively more part-time workers in the nonindustrial divisions, particularly in trade and services. (Unpaid family workers, mostly in farming, are not included in this analysis.) Employment in the industrial sector has increased about 15 percent since 1947, while employment in the rest of the economy has more than doubled. Despite relatively low nominal wages in agriculture, employee wages in the industrial sector as a whole are about 1s percent higher than those in the economy as a whole.

Industrial Productivity

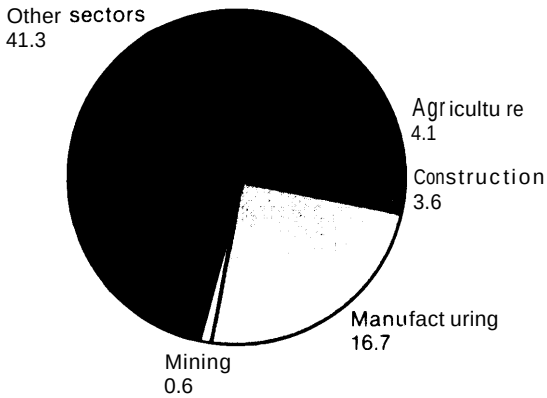
Industrial labor productivity, as measured by the amount of output produced per hour of labor used, has dramatically increased since World War II. Production per person-hour in manufacturing (which accounts for three-fourths of industrial sector output) grew at an average rate of 2.6 percent per year between 1947 and 1981, In

*Data on gross product originating by detailed industry group may contain considerable errors and are not published by the estimating agency–the Bureau of Economic Analysis (BEA) of the Department of Commerce. BEA strongly recommends that the figures be used with caution.

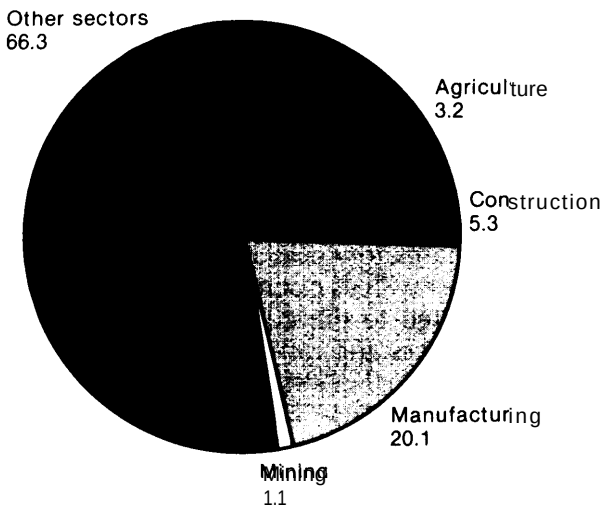
Figure 6.—Distribution of Employment in the Industrial Sector



1947
(Total employment 57.3 million)



1963
(Total employment 66.3 million)



1981
(Total employment 96.0 million)

SOURCE U S Department of Commerce, Bureau of Economic Analysts

comparison, labor productivity in the private nonfarm economy as a whole increased 2.1 percent per year on average during the same period. This contrast reflects the more rapid gains in labor productivity in goods production than in the production of services. Part of the substantial rise in labor productivity in the industrial sector has come about through the use of more energy. Yet, at the same time, the other factors contributing to higher labor productivity–improvements and/or increases in technology, physical capital, and the skills and education of the labor force—have also combined to actually decrease the amount of energy used per unit of output.

INDUSTRIAL INVESTMENT DECISIONMAKING

The significance of industrial energy demand in overall U.S. energy use has focused considerable attention on means of encouraging more rapid improvements in industrial energy productivity. A business decision to invest in new plant and equipment or in retrofits of old equipment for the purpose of cutting energy use (and thereby reducing costs) is made, however, in the context of many other competing criteria. An understanding of this decision making process is an important goal of this study.

The fiduciary duties and responsibilities of management are well known. In a modern society these responsibilities can be said to range from protecting shareholders' interests to assuring employee welfare and safeguarding the environment. These fiduciary obligations play a major role in the company's decision making process, ensuring that investments are prudent and that they protect the company's assets.

A well-managed company that wishes to expand its operations has many avenues open to it for raising capital and does not have to rely entirely on the current profits generated. These avenues range from selling company stock, to issuing interest-bearing paper—i e., debentures, to borrowing the required amount of money and paying interest to a lending institution.

Management responsibilities in these areas are directed at ensuring that debts arising from borrowing or the issuance of stock do not overdilute or undermine the asset value of the company. It is this fiduciary responsibility, with its inherent emphasis on prudent management, that gives rise to financial planning and investment policies that are incorporated into a strategic plan. Decisions regarding all investments, including those related to energy, are made within this area of strategic planning.

Uses of Capital

Corporate funds can be used to pay the debt and debt service on existing loans; to pay dividends to stockholders, for such payments often serve to keep up the price of the stock so more stock can be issued; and to pay for the working capital—i. e., everything from the company's inventory to the cost of raw materials. For many companies, working capital is the largest dollar expenditure but is allocated only after the first three items have been satisfied.

Once a company knows the size of its capital pool, it must decide how to allocate it. Certain projects are considered mandatory–e.g., pollution control equipment, equipment required for health and safety, and projects agreed to in collective bargaining. Also, some capital projects, especially those in the capacity expansion category, obligate a company to spend in certain ways to support a major project. Once a decision has been made to build a new pulpmill or a new blast furnace, completing a number of projects related to that decision becomes mandatory. Such things as purchasing additional transportation equipment for the new product would be in this category.

plants in the primary manufacturing industries are often very large. To take advantage of critical economies of scale, major expansion of industrial capacity in these plants involves large blocks of financial resources and delayed returns on investment during lengthy construction periods. To justify such investments, project lifetimes must be predictably long term. Such long-term forecasts are exceedingly difficult to make, especially during periods of economic instability. Consequently, at present, primary manufacturers requiring long-term investment commitments involve greater apparent risks than do industries that offer shorter term investment opportunities.

After all mandatory allocations are made, a company is left with its discretionary capital pool that is subjected to the corporation's strategic planning process for ranking investments. In some corporations, investment decision making is a very formal process. The company invests in only its most productive product lines and plants. In other firms, decisionmaking seems less formalized, but still subject to the perceptions of managers on growth potential of a product, market and technological competition, and use of

capital, labor, and materials. I n no case has OTA identified companies that accord energy projects special status. All firms regard energy efficiency as one more item in which they could invest and not as a series of projects that differ from other potential investments. The economic incentive to save energy because of its high cost is counterbalanced by high capital and labor costs and increasingly costly raw materials.

To be effective in the marketplace, management must have a strategic plan. The approval process in developing the plan and its projects tends to be complex and the project analysis, exhaustive. Technical decisions tend to be separate from and subservient to financial decisions. The corporate engineering staff performs detailed technical analysis, estimating such factors as construction costs, potential energy, labor or material savings, and project lifetime. A return on investment is then calculated. I n multi plant firms, proposals for capital projects are then submitted to the plant manager, who may approve certain areas and not others. This package is then sent on to the corporate staff for consideration with proposals from other plants. This capital fund request summary would be reviewed by senior corporate management, and only at this time would funding source, tax credits, and the like be discussed.

As shown previously in table 1 energy efficiency improvements are generally classified into four categories: housekeeping, equipment retrofit, new plant construction or capacity replacement, and product shift.

Housekeeping

Housekeeping refers to the substitution of labor and management inputs for energy. It includes: 1) closer monitoring of process streams and greater coordination of products in process in order to minimize delays and reject rates, 2) more frequent equipment repairs to increase average energy efficiencies, and 3) improved job skill training and motivation to minimize human errors. Because many of these alternatives are not expensive and involve a very large return for little effort, they are often the first actions taken by a company. The consensus of energy managers and corporate investment analysts i n the four industries studied by OTA is that most firms have done their housekeeping–that those things that can be readily adjusted, insulated, turned down, or turned off, have been.

Equipment Retrofit

Most existing equipment was installed when energy costs were expected to be much lower than they are today. Replacement with new equipment would offer the greatest improvement in energy efficiency and the greatest reduction in fuel costs (via fuel switching). However, since replacement is most expensive and a great deal of capital in place may not have been amortized, replacement would be tantamount to accepting large, lump-sum losses. The alternative is to retrofit existing equipment—e. g., by adding pipe insulation, combustion controls, more efficient motors, and heat exchangers to heaters and boilers in order to achieve their maximum design efficiencies; by adding computer controls to process streams in order to minimize deviations from optimum temperatures and pressures; and by adding or replacing a multitude of other process components whenever such installations do not significantly increase downtime.

Most important energy-saving retrofit alternatives involve well-proven technology. Several firms contacted used a lower hurdle rate for energy conservation projects because they were considered to be of low technical risk. On the other hand, while there are a multitude of retrofit project alternatives at any major industrial facility, the actual energy savings for a particular project may be severely constrained, or the investment outlays may be excessively large, because of the existing plant configuration.

New Plant Construction or Capacity Replacement

The most costly investment strategy (at least in initial capital outlay) is to build entirely new facilities that embody the latest energy-efficient technology or any technology that lowers cost and improves product quality. This alternative is frequently the most attractive to growing industries. However, in the four subject industries, this

choice is less attractive because a new plant must replace an old plant, with all the attendant losses of jobs, established ways of doing things, and even capital writeoffs if the old plant has not been fully depreciated. Curiously, new construction is attractive in the steel industry, which is experiencing the greatest overall decline in total domestic output. It occurs there at the initiative of relatively new minim ill firms that reprocess scrap metal. These new firms are growing at the expense of older, established steelmaker.

Product Shift

Product shifts are unique to a given corporation and quite idiosyncratic. Whether the managers of a company choose to invest in maintaining their existing capital stock, add new capacity, or invest in entirely new product lines depends on how those managers view their industry. Parts of an industry may be more susceptible to competition than others, or have higher costs or lower returns compared to other product lines in which a firm could choose to invest.

Of all the factors that enter into a firm's decision to invest, those that influence the two categories of new capacity or product switching are the most difficult about which to generalize. The managers of one firm may decide to stay with a product line or with an industry, while another group of managers may decide to expand to another product line or industry. Once a firm makes this type of evaluation, it locks itself into a particular kind of capital spending pattern. For instance, a paper firm that decides to build a new pulpmill commits itself to 3 to 5 years of capital expenditures before a single dollar in increased sales or increased net profits attributable to that investment is realized. This situation dramatically affects the size of the capital pool available for other projects.

STRATEGIC PLANNING

There are as many strategic plans as there are corporations because each corporation has its own procedures for strategic planning. For the purpose of this report, simple generalizations are given to illustrate commonalities.

Strategic plans tend to have a framework of 5 to 10 years, but are revised annually. Often, the chief executive officer devotes most of his attention to strategic planning. Such plans invariably identify the markets and the products that are most important to the company and direct management's attention to strengthening the most promising of these.

In a simplified strategic plan, business sectors are ranked, and often individual factories within a corporation are ranked. Most of management's interest, and most of the money for new investment, goes into highly ranked factories in highly ranked business sectors. A facility ranked low on both scales has little hope of acquiring new investment capital.

Strategic plans are based primarily on the assumption that a firm is operating in a normal business environment and is not prone to drastic fluctuations in commodity and raw material prices, labor, interest rates, or other precipitous changes that cannot be anticipated. Therefore, in order for the strategic plan to work, the environment must be relatively stable. Although managements go to great pains to attempt to forecast disturbances in a worldwide environment, where factors ranging from political unrest to large changes in government policies take place, sometimes firms are surprised by unforeseen events and strategic plans break down. For example, overnight, the U.S. car industry became extremely vulnerable to the Japanese small-car import, a situation almost entirely due to events that took place in Iran in 1979 and to the subsequent 300- to 40()-percent increase in world oil prices. The American car industry obviously could not have planned in the mid-l 970's for the revolution in Iran.

Similarly, the whole infrastructure of the housing industry, from the basic forest products industry to the savings and loan bank mechanisms that finance it, has matured and grown on the basis of relatively low interest rates. The dramatic rise in interest rates in the late 1970's caused vast

dislocations to the market that could not possibly have been foreseen by the strategic planner of a forest products company planting trees 20 years ago, or by a mortgage broker planning his loan strategies in the 1960's.

Factors That Influence Investment Decisions

Fiduciary responsibilities strongly influence management thinking. The first and possibly the most overriding factor when dealing with investments is management confidence. In this context, the word "confidence" does not describe management's own view of its abilities, but describes instead management's perspective of all the relevant factors that make up and influence its enterprise.

Management must be confident, for example, that its investments are going to bear fruit. it is more likely to invest when it is confident that the market for its company's products is growing, or that the company can capture a larger share of the market, or that the general economic climate is improving. This confidence has a major impact on how management views the risks associated with an investment. As the confidence factor grows, the impact of a risk factor is minimized.

Furthermore, management must demonstrate to the financial marketplace that the company is financially sound and that its investment strategies and policies are well thought out. [t is not uncommon for the chief executive officer and/or his designated appointees to expend time and effort explaining these plans and strategies, not only to their immediate bankers, but also to Wall Street analysts, brokerage houses, and others in order to assure the decision makers in capital markets that money raised and investments made are prudently managed.

The four industries examined for this report identified five factors that affect their strategic decisionmaking: product demand, competition, cost of capital and size of capital pool, cost of materials and labor, and general economic environment and Government policy.

Product Demand

Demand for primary industrial commodities depends on the general level of economic activity–i.e., the GNP. When the economy is growing steadily and existing capacity is fully operating, profits that depend critically on capacity factors are generally high, investment capital is generated internally, and new energy technologies can be adopted as soon as they become profitable. On the other hand, when the economy is stagnant or depressed, low-capacity utilization leads to low profits and curtailed investment. So even if energy-related profits have calculated a return on investment well in excess of normal corporate hurdle rates, they may not be implemented.

The generally accepted opinion seems to be that market opportunities for U.S. suppliers of basic industrial commodities are below average. Despite many uncertainties, analysis suggests that the advanced industrial economy is gradually saturating markets for durable manufactures and construction and moving into higher and softer areas of technology, such as semiconductor-based computation and communication. For example, in the steel and petroleum refining industries, more production capacity is now in place than is required for the next 5 years. In 1982, the steel industry used less than half its capacity. As long as the economy is sluggish from high interest rates, unemployment, and inflation, the steel industry will not use much of that excess production capability. In addition, with the recent U.S. recession, fewer durable goods, such as refrigerators and washing machines, are being sold, and some goods that are sold tend to be made of less steel.

The overcapacity (almost 30 percent) of petroleum refining in the United States, is due in part to the high market price of the fuels produced–which has in turn led to fuel conservation, the use of more fuel-efficient autos, and the switch from fuel oil to natural gas in residential heating. In both the steel and petroleum refining industries, then, it is clear that major new capacity expansions will not be undertaken. The existing capacity, although not as efficient as it could be,

will provide sufficient steel, petroleum, and associated products to meet anticipated growth.

In the paper industry, demand is forecasted to grow at 2.5 percent per year, given a GNP growth rate of about the same percentage. This anticipated growth is sufficient to encourage managers to plan for new capacity, although it would not be the only factor they would consider.

The chemicals industry expects product demand growth that exceeds that of paper and a continued ability to export products outside the United States. Because the chemicals industry has more product flexibility than do the other industries discussed so far, it can be expected to add new capacity on the basis of anticipated market growth, although, again, this would not be the only factor considered.

Competition

Perception of competition also exerts an influence on investment decisions. There are two types of competition: a technological one within an industry and market competition, both local and foreign. Although it is beyond the scope of this report to examine the competitive quality of products made by the four subject industries, the report does identify within each of the industry-specific chapters, new technologies in which these industries will most likely invest in the next two decades to help maintain or improve their competitive positions.

Two of the subject industries face severe market competition from foreign companies. The steel industry has initiated suits with the International Trade Commission, alleging that foreign producers make steel that is subsidized by their respective state governments. The "subsidized" steel is then sold in the United States at prices lower than that of domestic steel. The U.S. producers feel that an unfair advantage is accorded East Asian and Western European manufacturers by their governments in order to sell steel in the U.S. market. The reasons for the alleged subsidization seem clear: the desire for high employment and the need to develop or maintain a heavy industrial base by each country. Such subsidization raises major questions about U.S. dependence on foreign sources for basic industrial materials.

In the chemicals industry, the United States faces external competition, but of a different type. Chemical manufacturers in the United States already have a large share of the overseas chemicals market. Foreign producers claim that the United States subsidizes chemicals production by artificially keeping feedstock (specifically, natural gas) prices low through controlled prices. As natural gas prices are decontrolled in the United States, the $12 billion balance-of-payments surplus generated by the chemicals industry in 1981 will be reduced as foreign producers take away foreign markets formerly dominated by the United States.

The paper industry does not appear to face imminent foreign market competition, except perhaps from Canada. Petroleum refining should also be free of competition. In both cases, transportation costs should limit intrusion by foreign producers.

In general, exports of primary industrial commodities are unlikely to sustain U.S. industry growth because developing nations typically emphasize relatively low-technology industries first, making such commodities highly competitive in international trade.

Cost of Capital and Size of Capital Pool

Money to be used for capital expenditures can arise from several different sources. The major sources are debt, equity, and retained earnings. Corporation managers view their money as a resource that could be invested in any of the four project categories (e.g., equipment retrofits) or in some type of revenue-earning account. Any returns from capital investment, in theory, must exceed the interest return of possible bank deposits. The more funds a corporation must borrow from commercial sources to finance its capital projects, the more profitable a project must be.

Corporations derive their funds for capital from a number of internal and external sources. Internal sources include: retained earnings or money

remaining after the costs of production are paid, the delay in paying corporate taxes, and the claiming of tax credits. External sources include borrowing money and paying interest, or equity, and selling ownership (stock) in the company.

Many firms try to mantain a specific debt-equity ratio in order to avail themselves of particular financial sources. If a firm is already at or near its desired debt-equity limit (usually about 35 percent), borrowing ability can be severely constrained. The only way to alleviate this problem would be to issue more stock. However, if the company cannot purchase the stock at an adequate price, because of poor returns, the size of the company capital pool cannot be expanded.

In the steel industry, with its low capital return and its need to finance from debt sources, high interest costs of capital restrict the ability to invest in energy saving or any other kinds of projects. The other three industries also find themselves constrained by the cost of capital, but for them it is but one of the capital allocation decision factors.

interest rates also impact these industries in other ways. When interest rates are high, consumer sales are restricted; then, consumer goods that use products from the chemicals, steel, and wood products industries do not sell rapidly. Thus, firms may not invest in many technologies that would save energy, either because they do not expect sales volumes large enough to return a profit on the new outlays or because they simply cannot raise the money, no matter how profitable an investment might be. High interest rates also give firms that have traditionally produced primary commodities at least a strong positive incentive to diversify. Diversification can occur by vertical integration downstream into more finished products that generally offer larger profit margins. Also, a firm might engage in an entirely different industry by acquiring another company.

Cost of Materials and Labor

Individual firms in particular industries compete with one another to purchase raw materials and energy at the lowest levels of cost possible, a goal that affects both day-to-day operations and strategic planning. Management can compete by investing in projects that minimize the cost of production by minimizing labor or by substituting one material for another (or using it more efficiently). process controls and automation can offer a company significant cost savings through improved quality control–i,e., more efficient use of material—and labor savings. Such changes place more demand on corporation managers to use their employees more productively and often require employee retraining.

From a raw materials standpoint, apart from the price of the raw materials, large and mature companies in the industries discussed also see security of supply as a major problem that could affect both their fiduciary responsibilities and their competitiveness in the marketplace. If, for example, during the time of a fuel embargo, a company has to tell its customers that it cannot supply them because its plants are shut down from lack of energy, it might very well lose those customers forever to a company that can supply them. Therefore, it is not unusual for firms to couple these two factors, price and security of supply, into one strategic decision. For instance, a steel company may choose to own iron ore and coal resources or a paper products company may choose to own forests and timberland.

General Economic Environment and Government Policy

Obviously, management is concerned not only with the immediate environment within its own company and industry, but also within the general economic environment. In the large, multinational firms, this concern has both national and international ramifications. The factors that affect economic outlook are therefore very important to management and vitally affect investment decisions, including the obvious criteria —i. e., interest rates, inflation rates, GNP, and the like.

In the larger corporations, such factors could include international trade agreements, Eurodollar and Japanese interest rates, and international labor rates. It must also be considered that the international competitor could, in fact, be government owned and subsidized in terms of interest rates, research and developing backing, subsidized pricing of the product, and so forth.

Such backing may be carried out in the "national interest" to the extent that the fiduciary responsibility to operate the company at a profit is greatly diminished.

Government regulations or taxes that unnaturally tip the balance of the marketplace are considered extremely detrimental by industry. For example, if a Btu tax were applied to oil, the nonintegrated papermill would be at a severe disadvantage with an integrated papermill because the integrated papermill can use wood waste, black liquor, and other materials to meet its fuel requirements. These resources are unavailable to the nonintegrated mill.

Conversely, pollution legislation that applies equally to all companies can be viewed by industry as a pass-through that does not alter the company's competitive position. However, in today's marketplace, pollution legislation that is applied in the United States, but not equally applied in other industrialized countries, could be considered detrimental to U.S. manufacturers because it upsets the competition balance of the worldwide marketplace.

Finally, the perception of Government policy affects strategic planning. Changing policies, indefinite policies, and policies whose provisions take a long time to effect can play havoc with an industry's strategic planning. For instance, one problem with energy investment tax credits is that it often takes **6** months to 1 year to determine if a project will qualify for the credit. The suggestion heard time and again in case study visits and workshops was to avoid changing policy. With respect to natural gas deregulation, managers said that, by far, the best policy for the Government to pursue was to fix a definite date for deregulation (as has been done) and then to allow sufficient time for the corporation to react to the anticipated price increase.

Levels of Decisionmaking

The responsibility for assessing and minimizing risks falls on all levels throughout the corporation. In most major corporations, those responsibilities are clearly defined. Examples of the provinces of risk decision making are given below. However, it must be emphasized that each individual corporation would have its own criteria and decision making levels that may be different from those given.

Senior Management

Ensuring the security of energy, material, and labor supplies in a strategic plan is a pivotal aspect of risk reduction for senior management. For example, often the site of a new plant is chosen because of the perception that it will ensure a secure labor or materials supply. In addition, efforts invested in better employee/management relations make a major contribution to risk minimization by avoiding potential strikes in which losses of both profits and wages would be high.

Upper/Middle Management

Upper and middle management play an extremely detailed and comprehensive role in risk management. At this level proposed investments that are compatible with the corporation's strategic plan are reviewed and selected for approval before the commitment of funds is made.

Innovations in new energy-saving processes face a series of hurdles pertaining to risk. One of the greatest of these is skepticism about whether they will actually work as well as they are supposed to. Most companies are reluctant to be the first to try out a new idea. * The manager who accepts an unproven innovation and commits his production line to it reaches for a possible incremental gain on the upside, but may face a total shutdown on the downside. The manager of another mill, who waits to see how his competitor fares, suffers none of the costs of debugging a new idea and generally loses less than a year in catching up if the new idea works. In fast-moving fields like genetics, pharmaceuticals, and computers, a year can be devastating; but in paper, steel, or energy-intensive chemicals, it makes little difference.

*This reluctance on the part of business leaders was recognized by the Energy Research and Development Administration (predecessor to **DOE)** in 1976. Subsequently, the Office of Industrial Programs within DOE focused its industrial energy conservation program on full-scale demonstrations of new technologies.

Plant Management

The day-to-day operations of risk management and risk planning that affect plant production are usually dealt with by plant management at the corporate and plant engineering levels. In a multiproduct, multi plant company, individual managers know their performance is graded, among other criteria, on the quantity and quality of products produced. An innovation installed on one machine, even when parallel machines are functioning properly, increases a manager's perceived risk, Vendors of process equipment compete not only on price, but also with guarantees of minimum installation time and debugging periods. Furthermore, certain key components (e.g., the recovery boiler in a papermill) have no backup unit, so that something as simple as retrofitting a new combustion sensor could be seen as carrying enormous risk because it jeopardizes the entire unit.

Even in negotiating a new contract with a supplier, the risk of delivery failures and the penalties for such failures are of great concern. To cushion against such risks, some companies hold inventories of raw materials many times the size of inventories of finished products held in the warehouse. The magnitude of possible losses owing to downtime (labor, idle capital, and so forth) warrants this precaution.

Industry managers are also sensitized to regulatory pitfalls that may accompany new technology. A new process or a variation of an old process may come under new Occupational Safety and Health Administration rules, and a new combustion method or new byproduct may require an Environmental Impact Statement. In the recent history of major industries, regulatory requirements have delayed the implementation of certain innovations and cut into profits.

A new technology can best penetrate an industry, therefore, if it has established a record of simple, safe, and rapid installation and startup. Also if the manager can establish checkpoints at which to decide whether to continue with the project, the project stands a better chance of being accepted quickly. The history of process control equipment is an example of this. The steps toward computer control were first to install stand-alone gauges (in the 1950's), then to add simple analog control systems requiring constant surveillance (in the 1960's), and finally, in the 1970's and 1980's, to introduce fully computerized production lines, including robotics, to replace or augment manual labor.

Elements of a Strategic Plan

The strategic plan that gives rise to investment must, of necessity, incorporate sophisticated methodologies and techniques to analyze risks and attempt to minimize them. Some of these techniques follow.

Time Concepts Within the Strategic Plan

Time considerations not only apply to risk perception, they also play a major role in every facet of the business. Making payroll, paying critical suppliers, repairing critical items of a plant are short-term considerations that fall under the fiduciary responsibility of management. A company must be able to generate the cash to meet its obligations. Obviously, in times when interest rates are high, borrowing money for these purposes can be a critical strain on a company's resources, particularly if sales and profit margins are being eroded. Thus, under some circumstances, even if an excellent long-term investment opportunity arises, it must defer to the short-term obligation. Many energy conservation opportunities are either deferred or not even considered, for just this reason.

A short-term consideration at another level would be the delaying of investments intended to increase future market shares through the modernization and/or expansion of capacity. This decision can have a critical effect on energy efficiency, for the introduction of new technologies associated with modernization and/or increasing capacity invariably lead to increased energy efficiency.

An example of an intermediate-term consideration would be the investment in dual-fired boiler capabilities to protect against and minimize the risks associated with fuel supply interruptions and resultant plant closures. This type of investment would not have a calculable return, for the plant

may never be closed. It is, instead, insurance undertaken purely to meet fiduciary responsibility and reduce risk. Of course, if an interruption does take place, the investment becomes very worthwhile indeed.

Finally, an example of a long-term consideration would be a forest products company buying woodlands or planting trees, or a steel company purchasing iron ore mines and ore-bearing rights. Again, there is a fiduciary responsibility associated with this type of investment, together with the minimization of risk that comes from protecting raw material supplies into the future. However, such long-term investments would take second place to short-term considerations associated with cash flow.

Investment Levels Within the Strategic Plan

Investments can be considered as falling into two broad levels of priorities. In the first level are short-term demands that enable the company to meet its fiduciary responsibilities on a day-to-day basis, for example, meeting payroll. Although these investments can be categorized as "mandatory, " decisions associated with them are still very much part of the strategic plan and involve discrete management judgments. For example, a decision to reduce a skilled labor force or accept a small market share by shedding marginal operations in order to protect cash flow in the short term could seriously jeopardize the company's growth in the future if its market position improved. The company may not be able to recapture easily the skilled labor force or the market share it lost.

The second level of investments, categorized as "discretionary," are made after mandatory investments. They are chosen from a list of alternatives and are subjected to various criteria of evaluation, from technical scrutiny to rigorous financial analysis. Investments in energy conservation fall into this category when they are part of the overall strategic plan, most often under the discretionary investments associated with cost cutting.

The importance of cost cutting within a plan depends on the overall economic climate and health of the company. In general, cost cutting that does not involve capital outlay is always welcome. Energy conservation that often falls in the subcategory of cost cutting is housekeeping.

Cost cutting is usually a very low, if not the lowest, level of priority within the overall plan, particularly when capital outlays are involved. Therefore, Government tax policies–e.g., directed energy investment tax credits that attempt to influence the outcome of industrial investment analysis—only come into play at the lowest level of corporate strategy. The major decisions associated with an investment are based on other aspects which, from management's point of view, are infinitely more important.

Financial Analysis

All corporations have extremely sophisticated methods for carrying out financial analyses, using certain accepted financial and accounting practices. Each corporation has its own criteria that reflect its basic management style and philosophy. Once a decision to proceed on an investment has been made, a detailed investment analysis, including returns on investment, discounted cash flow, and tax and depreciation implications is undertaken. Although these implications were considered in the formative stages of planning, their specific importance was not quantified in detail until the decision to proceed was made. However, and most important, these implications are not expected to make any material difference to the decision. For example, an energy tax credit on a very small percentage of a multimillion dollar investment would have negligible impact on the decision to undertake the project. A change in depreciation rates that alters cash flow would play a larger role, but again would be unlikely to reverse the decision. However, a large increase in interest rates or a perceived downturn in the market could abort the project immediately.

Any capital investment requires money to be spent at the front and before any revenue stream can be generated from the investment. Because these investments generate returns over long periods of time, methodologies have been developed to calculate accurately the returns on investment, from a project's conception to the end of its useful life. These methodologies consider

inflation rates, depreciation rates, cost of money, and so forth, and produce calculations that attempt to predict cash flow and the returns on investment over the lifetime of the project.

Methodologies of varying complexity are often used within a corporation when evaluating investments. These methodologies calculate such parameters as simple payback period, net present value, internal rate of return, equivalent rate of return, and profitability index. In choosing which parameter to calculate, corporations reflect both the management style and accounting practices that are compatible with the operation of their business. Each parameter is described briefly below.

SIMPLE PAYBACK PERIOD

The simplest estimate of profitability is obtained by taking the initial capital cost and dividing it by the positive cash flow in the first full year of operation. For typical projects, this gives a number between 1 and 10, which is called the "simple payback period." For example, a $1.2 million investment which returns $400,000 per year "pays back" the original investment in 3 years.

NET PRESENT VALUE

When the sophistication of the analysis is increased, two steps are taken. First, the impact of depreciation and taxes are included because after-tax dollars are important factors in determining corporate cash flow. Second, future streams of income are discounted to recognize the greater value of a present over a future dollar.

The effect of the resultant net present value calculation is to produce a number that reflects the dollar value of the specific project to a company, compared to the value of the money used to undertake that same project if that money were invested.

INTERNAL RATE OF RETURN

For most projects where the cash flow is negative at first and positive later, there exists a discount or interest rate such that net present value is zero—e.g., such that the initial capital outlays exactly balance the later profits, The interest rate at that point, called the "internal rate of return" (IRR), can be looked on as the interest rate at which money is returned to the company for the dollars invested in the capital project.

PROFITABILITY INDEX

One indication of the profitability of a project is made by comparing the capital outlay of money to a project and the revenue stream of money from a project, discounted back to the present. The ratio of the two dollar values is the profitability index.

Comparison of Methods

These sophisticated analysis techniques and the wide variety of capital formation opportunities open to industry are designed both to assess accurately the profitability of the investments and to facilitate their financing. By varying the different parameters, some of the risk involved can be assessed, that is, various interest rates or inflation rates could be examined in order to ascertain the potential vulnerability of the investments to changes in external factors.

The choice of methods used to calculate the value of a capital investment reflects the management style of and within a corporation. It is not unusual for the energy engineering department to assess a project in simple payback terms while the finance department takes the engineering calculations and applies the more sophisticated techniques used by the corporation.

For the purposes of this study, OTA has selected the IRR method for most of its calculations. IRR has the advantage that it lets each project stand alone, unencumbered by the choice of corporate discount rate within any firm. The industry-specific and general investment opportunities discussed in later chapters are evaluated quantitatively using the IRR. The impact of the legislative options on investment decisions concerning specific projects can be seen quite well using the IRR.

The financial assessment is not the final assessment undertaken, however, particularly where major projects are concerned. Sensitivity analysis, which takes into account all other factors—from R&D to final market potential—can also have major impacts on the success of investments,

Sensitivity Analysis and Its Effects

A number of hypothetical investments were carried out by OTA and shown to industrial managers at case study firms in each of the four industries. Upon seeing the results, they cautioned OTA not to take return on investment calculations too seriously. The fact that an initial 10-percent tax credit changed the after-tax IRR by 6 percentage points was not considered persuasive enough to induce investment in a project.

In order to understand this position more fully, further calculations were carried out, incorporating parameters that could be considered uncontrollable by a corporation. This simple sensitivity analysis was applied to a process control system project using five simple variations, including:

1. negotiating a small change in the vendor's centract,
2. incurring unexpected repair costs equivalent to 10 percent of the investment,
3. experiencing a recession during the lifetime of the project,
4. achieving a performance rate of only 90 percent of what was expected, and
5. having prices held down by competition, as shown in table 5.

The results of these analyses, compared to the effect of a 10-percent energy investment tax credit (EITC), indicate that external factors such as those listed above can have as dramatic an effect on the potential profit derived from a capital project as that of a 10-percent EITC. OTA calculations show that a mild recession can cause a capital project IRR to shift 3 percentage points—i. e., to fall from 16.4 to 13.1 percent. On the other hand, a 10-percent EITC would cause the IRR to shift upward by only 5 points; for example, from 16.4 to **21.5** percent, which may in part explain why aversion of risk and anticipated energy prices drive project decisionmaking more than do tax credits and other Government policies.

Table 5.—Sensitivity Analysis of Internal Rate of Return (IRR) Under Different Scenarios[a] for Computer Process Control System

Condition	After-tax IRR
1. Base Case.	16.4
2. Vendor escalates service contract	15.3
3. Unexpected repair cost in year 4	14.8
4. Recession in midlife of project	13.1
5. Profits only 900/0 of expectations.	12.3
6. Prices held down by competition	10.4
7. Addition of a IO% EITC	21.5

[a]**Invariant conditions:**
Project: Installation of Computer Process Control System
Project lifetime = 7 years
Inflation rate = 6 percent
10 percent Investment tax credit
ACRS depreciation schedule

SOURCE Office of Technology Assessment