FINAL REPORT

A HIGH SEASONAL PERFORMANCE FACTOR GAS HEAT PUMP FOR THE NORTH CENTRAL UNITED STATES

APPENDIX VOLUME VIII

BUSINESS POTENTIAL STUDY

Prepared By: Mechanical Technology Inc.
Prepared For: Consolidated Natural Gas Service Co., Inc.
And The U.S. Department Of Energy
Prepared Under: DOE Prime Contract EY-76-C-02-2883

January, 1980

Consolidated Natural Gas Service Company Inc.

Mechanical Technology Inc.

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Appendix Volume VIII

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Appendices to Final Report

DEMONSTRATION OF A HIGH SPF GAS HEAT PUMP
FOR THE NORTH CENTRAL UNITED STATES

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1.0 INTRODUCTION

The evaluation of the business potential of the introduction of a gas heat pump into the building climate conditioning market was conducted by Mechanical Technology, Inc. (MTI) in support of a gas heat pump development program sponsored by Consolidated Natural Gas Service Company, Inc. (CNG) and the Department of Energy (DOE). The objective of the study was to identify a business rationale under which a company currently in the climate conditioning market would invest in and introduce this revolutionary new product. The selection of a company already in this business area is based upon an assessment of the characteristics of the business and the desired end result of significant and rapid market penetration. Significant and rapid market penetration is required to meet DOE's requirement of significant energy conservation due to the intrinsic features of the product and rapid market acceptance. As the system designer and developer under contract to CNG, MTI has potential business interests in the commercialization of this gas heat pump. Therefore, MTI carried out this evaluation at no cost to the program on "ex-scope" basis. While the work is not a deliverable item, MTI views the results as being of such significant value to all parties involved in the development and commercialization of advanced energy-efficient climate control equipment that the results should be made generally available.

The business potential or venture analysis is part of an overall program to design, develop, demonstrate and commercialize a gas heat pump. The business potential analysis, therefore, must interact with other programmatic activities. Figure 1-1 illustrates the new product planning and development process which was being followed in the overall gas heat pump program. The point in the process during which this work was performed is the step termed "Business Analysis". This step has three interrelated tasks as shown in Figure 1-2. Figure 1-3 presents the details involved in each of the three tasks. The market study has the objective of defining the product requirements as viewed by the customer, specifications of the market structure and distribution, and market potential. The product requirements provide inputs such as product features, performance, and cost to the product definition task. The product features from the market study combined with the basic technology concept result in product requirements such as size of unit, control modes, distribution, efficiency, etc. These product requirements provide inputs to system and component

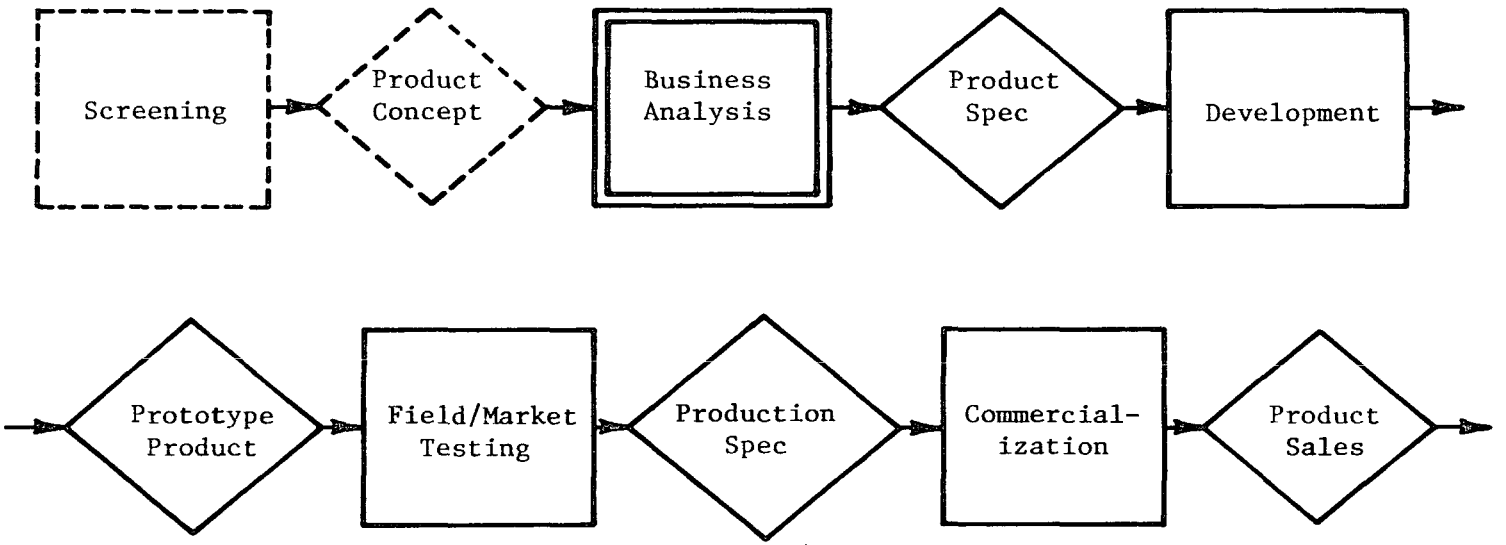

Fig. 1-1 New Product Planning and Development Process

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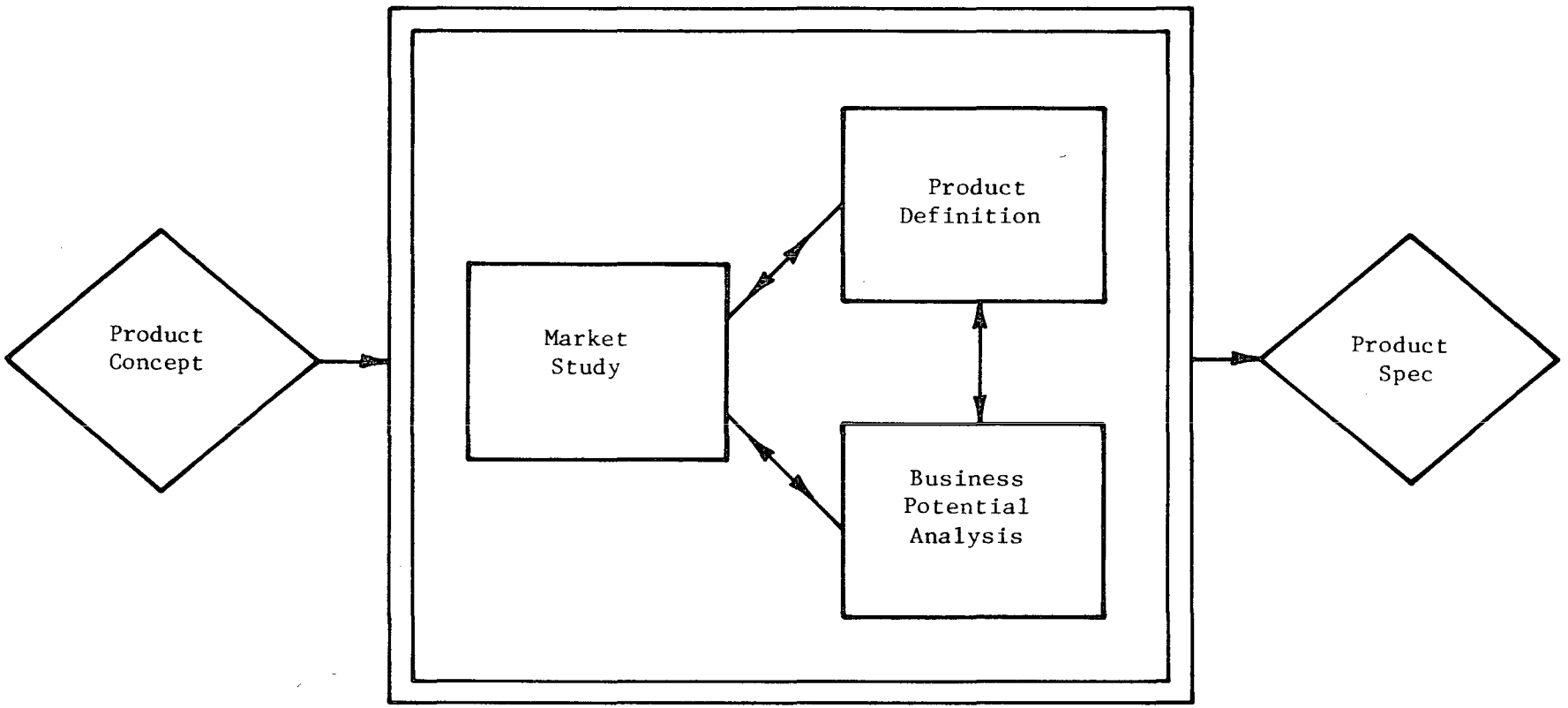

Fig. 1-2 Tasks Involved in Business Analysis

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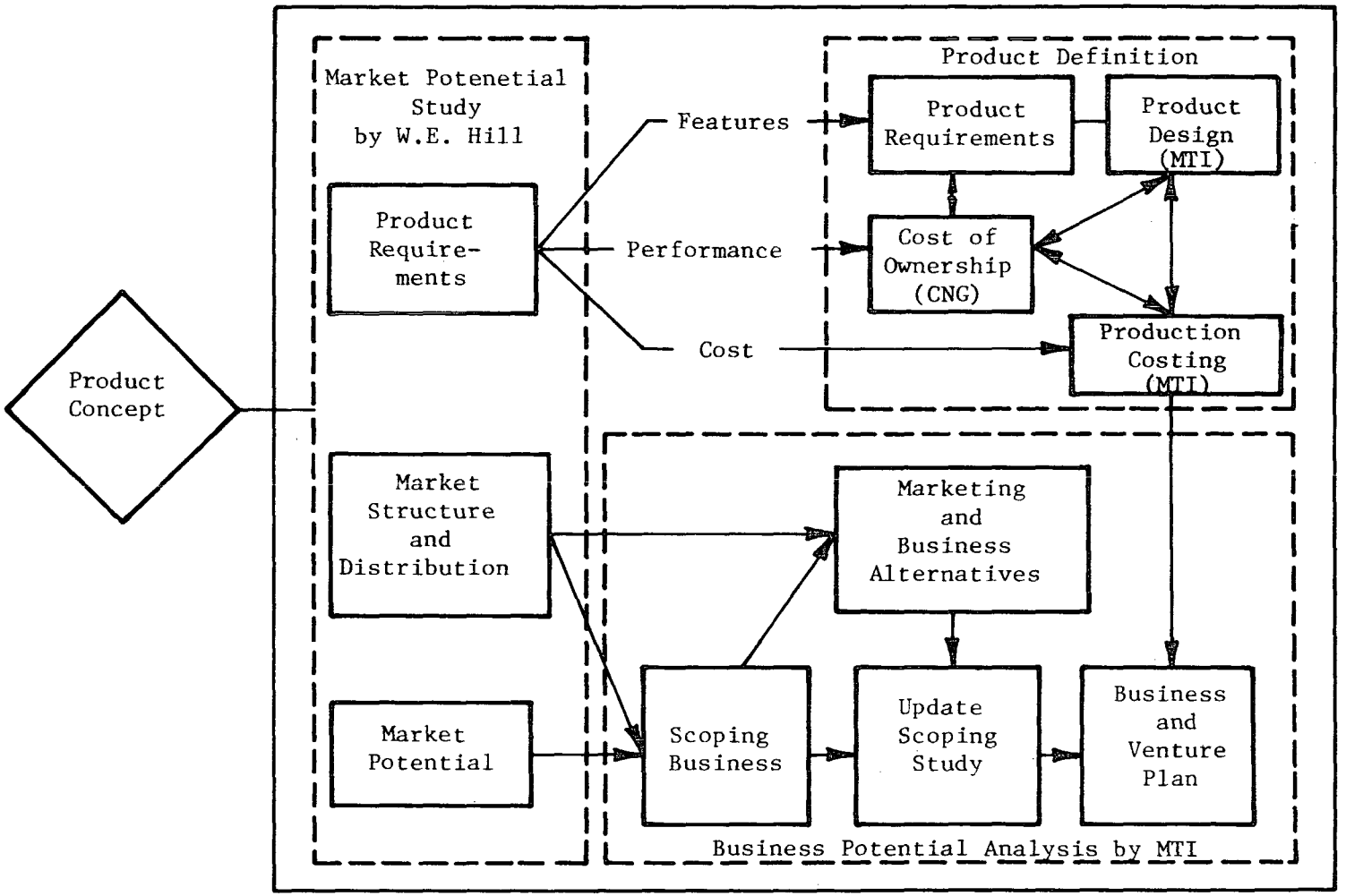

Fig. 1-3 Business Analysis Task Flow and Relationships

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design efforts and the cost-of-ownership of the device. In the product definition task, the product design is carried out only to the degree adequate to obtain a reasonable performance estimate and manufacturing cost estimate. The cost-of-ownership has the objective of defining the economic value of a gas heat pump product to the customer. The gas heat pump is viewed as being sold on the basis of the conservation money resulting from the conservation of energy. It is expected that the product will cost more than standard, higher energy consumption alternatives. A cost objective is also defined. (Interestingly, heat pump customers specified operating savings and capital costs as independent requirements). The market potential and product definition tasks provide inputs to the business potential task. The market structure places constraints on how the product is sold and, in this case, the type of companies which can best market the product. The market potential combined with the product definition, cost-of-ownership, and business structure defines a sales projection. This projection, combined with required investments and expected profitability, forms the basis for the financial returns to a company marketing this product. The market potential study was performed by William E. Hill and Associates under contract to CNG. The product and technology aspects of the product definition task were performed by MTI under contract to CNG. The cost-of-ownership study was performed by CNG. The market potential, cost-ownership and product definition tasks are reported fully in Appendices Volumes IV, V, VI and VII. The potential analysis was performed by MTI under internal funding.

The principal objective of the study is:

- To define a business scenario based upon an exclusive licensing agreement with a large national firm already serving the climate conditioning market to maximize market penetration and unit sales.

The requirements for a maximizing market potential and a firm already in the climate conditioning market were briefly discussed previously. The requirement for an exclusive agreement was felt to be necessary to protect the firm's investment and to permit an acceptable return on that investment. Given the requirement that this study would be used to convince a firm of the wisdom in

investing in the gas heat pump product, the financial conditions typical of firms in the business (and hopefully the firms who would be the most desirable licensees) were used in the analysis. These financial conditions were derived from annual reports and SEC Form 10-K, as will be discussed in detail later. Since the business potential analysis and the product definition task were being conducted concurrently, there was no information available which could be uniquely associated with the gas heat pump product. Therefore, a generalized advanced climate conditioning product was assumed which could serve the same market as the gas heat pump. This generalized product was assumed to have costs, profits and investments in the same ratio to sales revenue as the average product of each of the companies investigated. In this respect, the results and conclusions of the market potential analysis are not unique to a gas heat pump, but are typical of any new product in the climate conditioning business.

The financial characteristics of the companies were combined with the market potential. These data were then combined with a simplified financial model of the firm to evaluate the economic returns of developing and introducing the gas heat pump product. The evaluations also considered variations in the input parameter of sales growth and fixed investment per dollar of sales.

The results of the evaluation indicate that the financial characteristics of the heating and air conditioning industry are not conducive to product innovation. With the use of the historic financial characteristics of four specific companies in this industry, it was not possible to justify revolutionary product innovation on the basis of a quantitative business potential analysis. This analysis clearly shows that if significant product innovations are to occur in this industry, one or some combination of the following conditions must occur:

- The decision is made on the basis other than a quantitative financial analysis;
- The financial characteristics of the industry in general must improve;
- The product has unique features that make it more profitable to the industry than the current product line;

- Incentives and/or subsidies are provided to support the product development and sales.

The means of achieving these conditions and their impact are discussed later in the report.

It is important to note that although this study focused upon the introduction of a gas heat pump, the results are applicable to any advanced climate control product.

2.0 PRODUCT DEFINITION

The product is defined as a heating, ventilating and air conditioning (HVAC) product for commercial applications. The limitation of commercial applications is basically one of size of the unit. Typically, the commercial market is defined as being served with units in excess of 7-1/2 tons of capacity. While equipment in the 3 to 5 ton class is frequently used in commercial applications, they are usually considered as residential units. HVAC products for commercial applications are segmented further as either unitary or built-up systems. The unitary systems are systems in which all the product functions of heating, ventilating, air conditioning, and by-product heat rejection are fully assembled and packaged in the factory. The built-up systems are systems in which each of the functions is fabricated separately at the factory, often by different manufacturers, and assembled at the site of use. The specific market or product segment that is addressed in this business potential study is the large tonnage (50 to 400 tons), built-up market. This market segment was identified as the result of the W. E. Hill market potential study (see Appendix Volume VI). The smaller tonnage unitary market had previously been dismissed due to the extremely high first cost premium. The large tonnage unitary market was dismissed due to lack of market potential. The very large tonnage (over 400 tons) built-up systems were also dismissed due to lack of adequate market potential. Therefore, the product concept examined is the nominal 125-ton large size model (LSM) High Seasonal Performance Factor (HSPF) built-up system which would represent a product line serving the built-up system market in the 50 to 400 ton range.

The basic technological concept is the use of a steam-Rankine power system driving a standard organic heat pump system plus auxiliary power functions. The steam-Rankine power system is fueled by natural gas in the basic concept, but can be fueled by other fossil fuels such as oil, coal, and coal derived fuels; by waste derived fuels; and by biomass derived fuels. The basic technological concept is shown in schematic form in Figure 2-1. The technological concept was implemented through the use of turbomachinery components in order to achieve the high system efficiency, high system reliability, low system maintenance, and low system cost needed for a HVAC product.

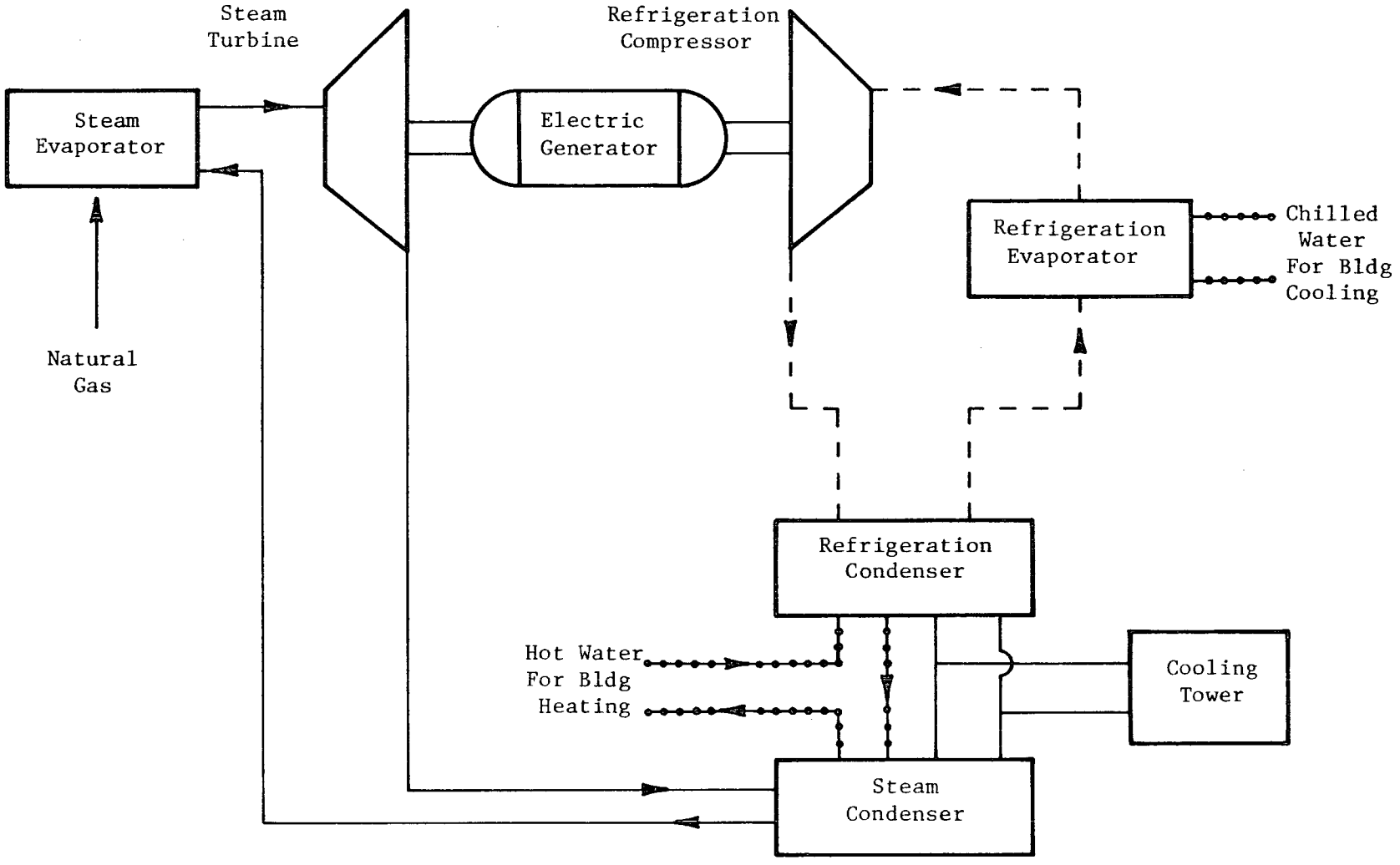

Fig. 2-1 Product Concept Schematic - Built-up Market

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The design of a system needed to meet the technology concept and the market performance, feature, and cost objectives is fully described in Appendices Volumes I and V. The results of the effort is a design that provided heating, cooling, and electricity to the building shown schematically in Figure 2-2. The operating-cost/first-cost trade-off study indicated that the steam-Rankine power cycle should be sized to be able to supply half of the power required to provide the maximum cooling load and that the steam-Rankine power cycle be base loaded. This means that at low cooling loads, the LSM would be able to provide electricity to offset the normal building electrical load. (No provision was made for export of electricity beyond the building.) At high cooling loads, the LSM would require electric power from the local electric utility. This is shown in Figure 2-3. During the heating season, the generation of electric power for the building offers a significant operating economic advantage. During the cooling season, the generation of electric power offers an economic advantage but not as great as during the heating season.

The most significant operational advantage of the gas heat pump occurs in the heating mode. The amount of energy used for heating, relative to cooling, is a function of geography, building type and building design. In general, it may be stated that buildings using built-up systems will have a lower heating load to cooling load ratio than buildings using unitary equipment. Therefore, the product concept does not offer its highest performance advantage in the market segment identified. Although it was expected and later confirmed by the cost-of-ownership study (Appendices Volumes III and VII) that the product concept would not be able to serve all geographic regions or building types in the market segment, this study did not consider a restriction of the market segment. (Attachment A does cover this and shows that basic conclusions are not affected.)

The product was expected to compete against the state-of-the-art energy-conservative option, namely the electric-compression chiller with an internal heat source heat pumping capability (i.e., the double-bundle chiller) and electric boiler. The double-bundle chiller has a price premium relative to standard chillers. The LSM was expected to have a price premium relative to the double-bundle chiller. During this study, specific information as to the price premium of the LSM was not available. Therefore, a sensitivity to price

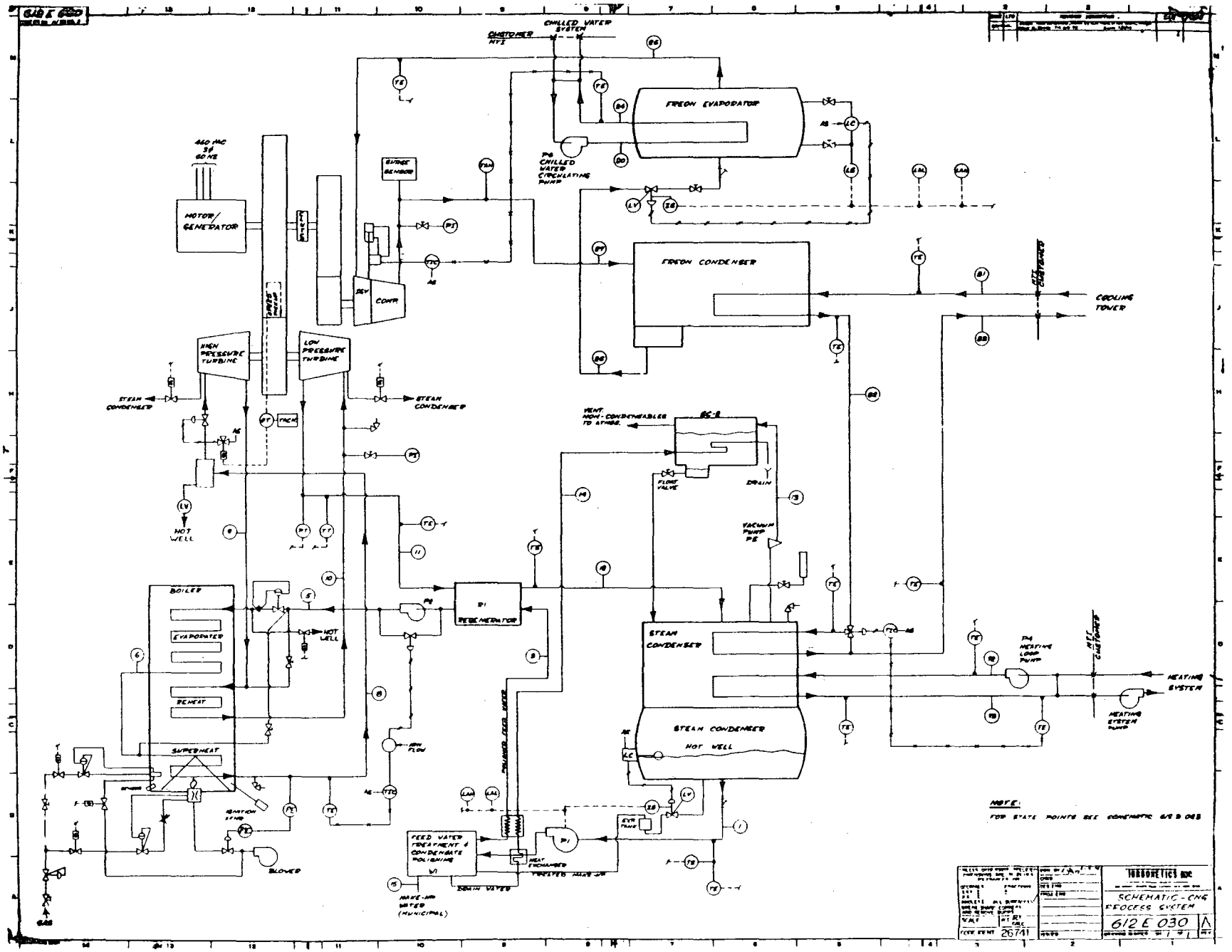

Fig. 2-2 Large Size Model 125-ton System Schematic

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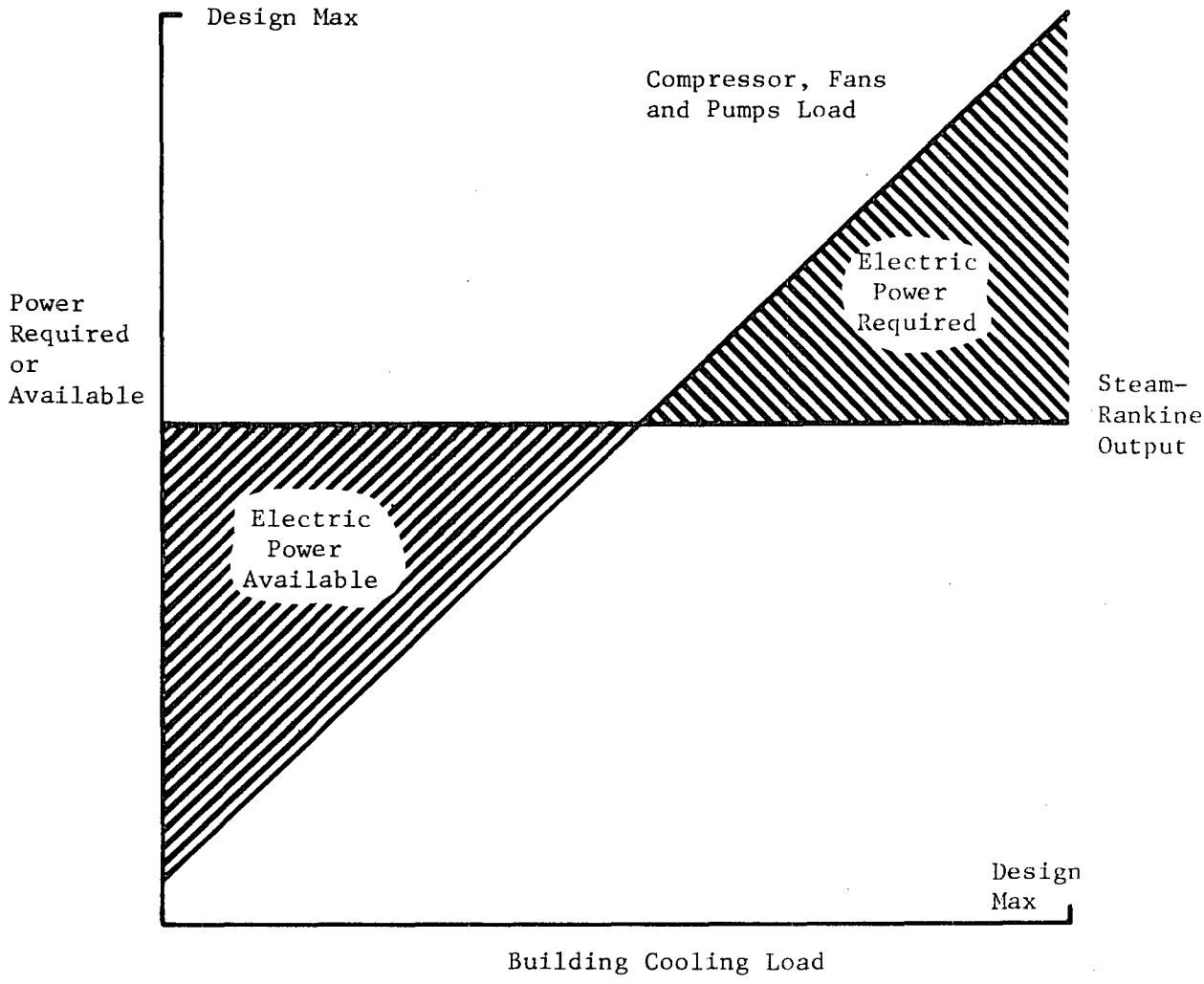

Fig. 2-3 Illustration of Power Availability and Requirements for LSM Product Design

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premiums relative to the double-bundle chiller of 0% and 50% was evaluated. Data available for the values of the competitive equipment were $276/ton for a standard chiller with a gas boiler, and $338/ton for a double-bundle boiler with a gas boiler. This study was conducted under the assumption that the standard equipment cost was $300/ton. The LSM was valued at $300/ton (0% price premium) and $450/ton (50% price premium).

No information was available as to the manufacturing investment required for the LSM. An assumption incorporated into this study was that the ratio of fixed investment to sales revenue of the companies evaluated would be characteristic of the LSM. The working capital requirements were similarily incorporated as assumptions. These assumptions are discussed further in Section 5.0.

The product concept is based on a natural gas fueled heat-cool unit with electric power generation capability serving the 50 to 400 ton built-up market. While the product is viewed as serving a specific market segment, the financial characteristics of the product are characteristic of the average HVAC product the companies considered.

3.0 MARKET CHARACTERISTICS

The heating, ventilating and air conditioning (HVAC) industry is a large, diverse and segmented market. While MTI is concerned with only one product segment of the HVAC industry, it is necessary to understand the entire industry including product manufacturing, distribution, selection, and use. A detailed analysis of the industry was made by W. E. Hill and is reported in Appendices Volumes II and VI of the report. A brief discussion is presented here to identify those factors relating to the business potential analysis.

Figure 3-1 presents the generalized structure of the large tonnage HVAC industry from manufacturer through end user. The flow of goods from manufacture to end use tends to follow a vertical path as shown in Figure 3-1. However, virtually any combination of manufacture, distribution, service, specification, purchase and end use is possible and occurs. A general observation is that the integrated manufacturers have the largest market shares, often around 30%. Integrated manufacturers have a more extensive product line within any product classification (such as central chillers), have national coverage, extensive supporting products (such as terminal units), and an acceptable reputation with the specifiers. The integrated manufacturers account for a large percentage of the shipments of any given product line. In general, three or four integrated manufacturers account for over 60% of shipments. In the large tonnage, built-up product line, three integrated manufacturers account for over 80% of shipments. In order to optimize their production capacity, the integrated manufacturers usually buy some of their components from component Original Equipment Manufacturers (OEM) suppliers. Production economics limit the number of OEM suppliers. Thus, there is even more concentration in some HVAC component lines than there is in the HVAC product business. The existence of these component suppliers enables the assemblers to exist. None of the assemblers has adequate market share to attain production economics on key components. The component suppliers provide these components to the assemblers. The assemblers can then package these components with limited capital investment and with production operations which are relatively insensitive to the volume of production. With lower capital investment, administrative and selling burdens, and limited market objectives, the assemblers can meet or even beat the prices offered by the integrated manufacturers. The existence

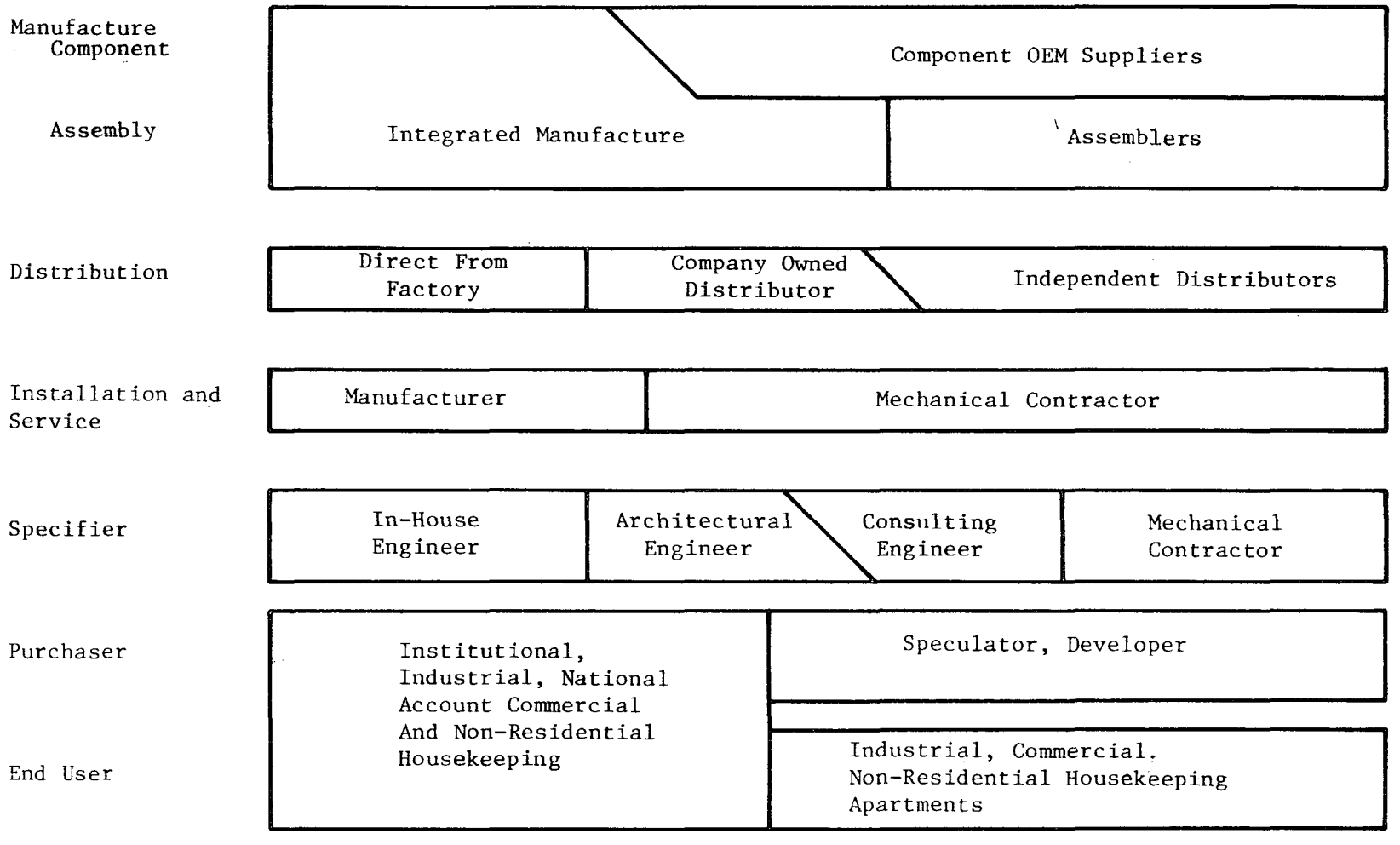

Fig. 3-1 Generalized Structure of the Large Tonnage Air-Conditioning Industry

of the component suppliers enables the assemblers to easily enter the market and exert price pressure on the integrated manufacturers. Entry into the component business is very difficult. However, competition among the component suppliers and the internal manufacturing capability of the integrated manufacturers keeps a price and profit lid on the component suppliers.

Viewed from the vantage point of an end user or purchaser, the HVAC products are virtually undifferentiated. A 100-ton chiller will provide the required 100 tons of cooling at the rating point. Since operating costs were usually not a significant factor, the selection of equipment was made on a first cost basis and the reputation of the manufacturer for reliable equipment and service. The use of first cost as the principal purchasing criterion tends to put severe pressure on HVAC profitability. This resistance to the price premiums, even for features, inhibits innovations.

Due to all the factors involved in both supply and demand, profitability in the HVAC industry is at or below the average for all manufacturing. To illustrate this point, an analysis of variance of 92 companies listed in the 1979 Forbes annual directory of industry indicates that there is at least a 99% probability that firms in the HVAC industry have lower cash flows per dollar of sales than the average of six other industry categories. These categories include insurance, food production, chemicals, banks, petroleum refining, and public utilities. Of the six categories, only food production had a lower cash flow than HVAC. The capital investment requirements seem higher than industry averages also. These factors inhibit innovation in the HVAC industry. The objective of this analysis is to determine what method of introduction of introduction of an innovation into the HVAC industry would overcome these negative factors and yield an acceptable rate of return for the innovating company.

The paths for bringing an innovation into the HVAC industry are dependent upon the innovation. In Section 2.0, the innovation was described as a built-up, steam powered heating-cooling device. The technology of the innovation is such that the key innovative components are the steam generator and the turbo-machinery package. These innovative components could be assembled into the overall built-up device by an integrated manufacturer or an assembler. This

technology would then allow six different paths into the marketplace with the innovation as shown in Table 3-1. Each approach presents some problems. The integrated approaches could result in a market limitation, due to the fact that only a single manufacturer would supply the product. The component approach could maximize the market penetration since all firms could offer the innovation for sale. The problem with the component approach is to get any assembler to take the risks of introducing the product without an assured method of protecting his investment. If an exclusive arrangement is made between the component supplier and the assembler, cases 5 and 6 would become equivalent to cases 1 through 4 (Table 3-1). There is a serious question if any non-HVAC company could enter the market as an integrated company. An example of this would be a corporate owner of an innovation acquiring an HVAC company in order to bring the innovation to market. This option was not available in this analysis and, if it were, the result would be identical to the first approach in Table 3-1.

This business potential study focused upon the first four commercialization approaches as given in Table 3-1. These approaches would be consistent with the characteristics of the market and the recommendations of W.E. Hill (see Appendices Volumes II and VI).

TABLE 3-1

COMMERCIALIZATION PATHS FOR LSM PRODUCT INNOVATION

APPROACH NUMBER	MANUFACTURE OF INNOVATIVE COMPONENTS	ASSEMBLY AND DISTRIBUTION	COMMENT
1	Integrated HVAC Manufacturer		Integrated Approach
2	HVAC Component Supplier Integrating Foreward to Assembly		
3	HVAC Assembler Integrating Backward to Component Manufacture		
4	Non-HVAC Company Becoming an Integrated HVAC Manufacturer		
5	HVAC Component Supplier	Integrated Manufacturers and Assemblers	Component Approach
6	Non-HVAC Company	Integrated Manufacturers and Assemblers	

4.0 MARKET POTENTIAL

Projecting the market potential of any new product is a complicated task requiring a thorough evaluation of the market and the product. Actual sales penetration into the projected market potential will be affected by the commercialization path and marketing approach. Additional factors involved are the general business environment, market attitudes towards life cycle costing, fuel costs, fuel availability, public policy and others. The intent of this section is to develop a sales forecast upon which the business potential of the product can be assessed. An assumption made is that the maximization of market potential, sales penetration, and sales is necessary and desirable to achieve the commercialization objectives of CNG and MTI and the energy conservation objectives of DOE.

The market potential projection starts with the historic sales data for HVAC products. The basic market potential projections were made by W.E. Hill as reported in Appendices Volumes II and VI. To facilitate the market potential projections, Hill segmented the market data by geographic regions, unit size, unit type, type of construction, and building type. Four basic geographic regions were considered. These regions are too broad to have a climatic factor for equipment performance. Unit sizes were considered from 5 tons and up. The two basic unit types were unitary and built-up. The type of construction was segmented to consider the demand factors imposed by new construction, major remodeling, replacement and energy retrofits. Two broad classes of buildings exist, residential and nonresidential. Since the product concept is directed toward the large tonnage market, only the nonresidential building type was considered. This includes all applications except single family and mobile homes.

Geographic and demographic construction patterns and weather conditions affect the demand for HVAC equipment in terms of quantity, types and future growth. The market analysis considered the demand growth potential by deducing regional demand from new construction projections from sources such as F.W. Dodge. The effect of climatological factors on the demand were not considered during the market projection or business potential analysis. Subsequently, it was determined from the cost-of-ownership study that the LSM is cost effective in buildings with a high heating load relative to cooling load. While this ratio

is a function of building type and design, the climatic region of the country that has more than 6000 heating days would be considered the prime market area. This region is shown in Figure 4-1. The effect on the business potential of limiting the geographic market is discussed in Attachment A.

Historic sales data are available by unit size of equipment sold. This information is important since the economic unit size range of the LSM is limited. In its studies, W.E. Hill considered equipment size ranges from 5 tons and up. Within this broad range, W.E. Hill identified the size segment of 50 to 400 tons as having the best market potential for the LSM. Therefore, only the 50- to 400-ton range is considered in this business potential analysis with a nominal size of 125 tons.

The two basic types of equipment are unitary and built-up. The unitary is a factory packaged unit which includes all the heating, air conditioning and ventilating functions. This unit would include air distribution to the building, the air conditioning as heat pumping equipment, heating equipment, and equipment to reject building heat to or extract heat from the environment. The built-up unit consists basically of a field assembly of the major heating, air conditioning and ventilating equipment functions. This unit would normally include a boiler, a chiller (air conditioning unit), a cooling tower, (to reject building heat), various water circulating pumps, water piping, ventilating fans, and terminal cool air and warm air units. The LSM product combines the function of the boiler and chiller into a single package. All other built-up system components would consist of conventionally available equipment. While the market study examined both the unitary and built-up markets, only the market historically associated with built-up equipment was considered in the business potential analysis.

As noted previously, there are four basic types of construction that impact upon the market potential analysis. Each type of construction affects the basic demand for HVAC equipment. New construction is very sensitive to the general economy and is very cyclic. For example, a building boom in the early 1970s created a peak demand for HVAC equipment. Only now, six to seven years later, is that demand being equaled by current shipments. Large buildings that are in the market for large tonnage built-up equipment have a long planning and

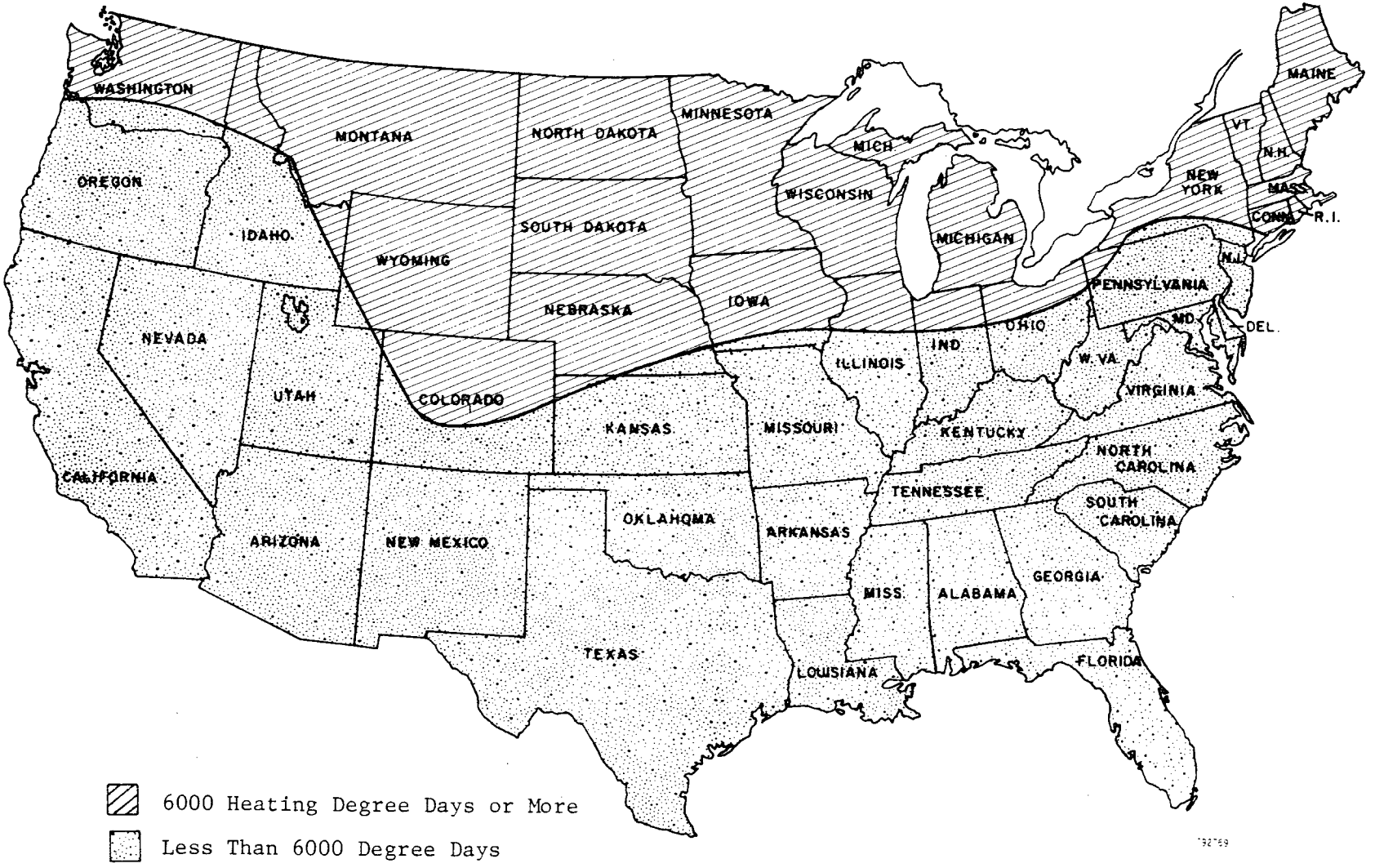

Fig. 4-1 Geographic Regions Having More Than 6000 Heating Degree Days

building cycle. Fairly accurate projections of new construction for one to two years are available. These estimates of new construction by building type and geographic area were used in defining the market potential.

The nonresidential building type classification is further segmented into five major subtypes as follows:

- Commercial - includes retail stores, shopping centers, restaurants and offices, commerical warehouses, garages and other miscellaneous commerical buildings.
- Industrial - includes plants, manufacturer warehouses and labs, and other industrial buildings.
- Institutional - includes secondary schools, colleges, hospitals medical clinics and various types of public buildings.
- Apartments - include low-rise and high-rise apartment buildings.
- Hotels/Motels - includes high- and low-rise hotels, attached restaurants, meeting rooms, etc.

The commercial classification was further segmented to consider high-rise and low-rise banks and offices and all other commercial buildings. The institutional classification was segmented to include educational and science buildings, hospitals and health treatment centers, public buildings, religious buildings, and all others.

The results of the market potential estimation are presented in Table 4-1. These results are for the entire potential market in 1981. The next steps are to define what the market size will be like with time and what share of the market potential will be realized as sales for the LSM.

The estimation of growth in the HVAC industry is very difficult since the bulk of the demand is from new construction. The data in Table 4-2 show that there are often wide swings in new construction activity. The extremes would be essentially no growth in market in a given year to a growth rate of 6.4% per year. The projections by Hill showed an overall growth rate of 5.2% from 1976

TABLE 4-1

PROJECTED MARKET FOR 50 TO 400 TON EQUIPMENT IN 1981

Building Type Market Segment	1981 Market (thousands of tons)		
	Unitary	Built-up	Total
Commercial			
Banks and Offices			
High Rise	0.0	84.0	84.0
Low Rise	24.1	113.3	142.4
Stores and Other	60.4	102.0	162.4
Industrial	28.5	90.6	119.1
Institutional			
Education and Science	29.9	65.9	105.8
Hospital and Healt Treatment	11.2	110.1	121.3
Public Buildings	7.2	35.8	43.0
Religious	1.9	9.0	10.9
Other	8.4	42.6	51.0
Apartments	2.1	108.4	110.5
Non-Housekeeping Residential	1.0	32.1	42.1
TOTAL	179.9	793.8	973.7

Source: W. E. Hill

TABLE 4-2

U.S. CONSTRUCTION GROWTH RATES(1) BY MARKET SEGMENT

Market Segments	Average Annual Rate of Growth				
	Historical Growth			Projected Growth	
	1967-76	1967-73	1973-76	1967-81	1976-81
Commercial:					
Office buildings	(2.5%)	6.3%	(20.0%)	0.5%	16.4%
Stores and other	1.5	8.0	(14.3)	1.4	3.7
Industrial	(5.7)	(3.3)	(21.5)	0.1	15.9
Institutional and Misc.	(2.2)	(2.8)	(4.2)	(0.8)	3.3
Apartments	(3.1)	16.1	(27.7)	(0.8)	2.8
Nonhousekeeping Residential	(7.8)	4.3	(31.1)	(2.5)	18.3)
Total	(2.3%)	6.0%	(18.3%)	(0.2%)	6.4%

(1) Average annual physical rate of growth - millions of square feet of floor space added annually.

Source: W. E. Hill and F. W. Dodge Construction Data.

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to 1981. These projections included new construction and all types of remodeling. The effect of the two growth rates on market potential is shown in Figure 4-2.

No segmentation of the market potential was made beyond the specification of a 50- to 400-ton built-up market. There is good rationale to differentiate the next steps of market penetration by building type, based upon the historic approach to the specification of equipment for each type of building. Also, the geographic impact on economic viability of the product and the new building activity was not considered. The optimisic and pessimistic market potential in Figure 4-2 forms the baseline for the market penetration estimates.

The projection of actual sales penetration is very difficult and is often highly subjective. There are, however, some objective data about the sales penetration into the HVAC market. Specifically, data are available showing the rate of penetration of the electric residential heat pump, the electric warm air furnace and the commercial unitary year-round air conditioner (YAC). The normalized sales penetration for these three products is shown in Figure 4-3. The heat pump has the lowest penetration rate due to early product quality problems and virtual market rejection. The warm air furnace has the highest penetration rate due to the heavy promotional efforts of the electric utilities and the universal availability of the product. The YAC has the middle or nominal penetration rate and might be typical of the penetration of an evolutionary product in the HVAC industry. The YAC was offered by all manufacturers. While the YAC offered no new technology, no operational advantage, nor first cost advantage, it did offer easier installation and better reliability since the product was totally factory assembled and tested. The assumption was made that the LSM would experience a market penetration that would be between the nominal and accelerated penetrations shown in Figure 4-3 and Table 4-3.

The combination of the high and low growth rate of total market potential and the high and low rates of market penetration would result in four possible sales projections as shown in Figure 4-2. These penetration projections were averaged to find a mean sales forecast or base market penetration projection

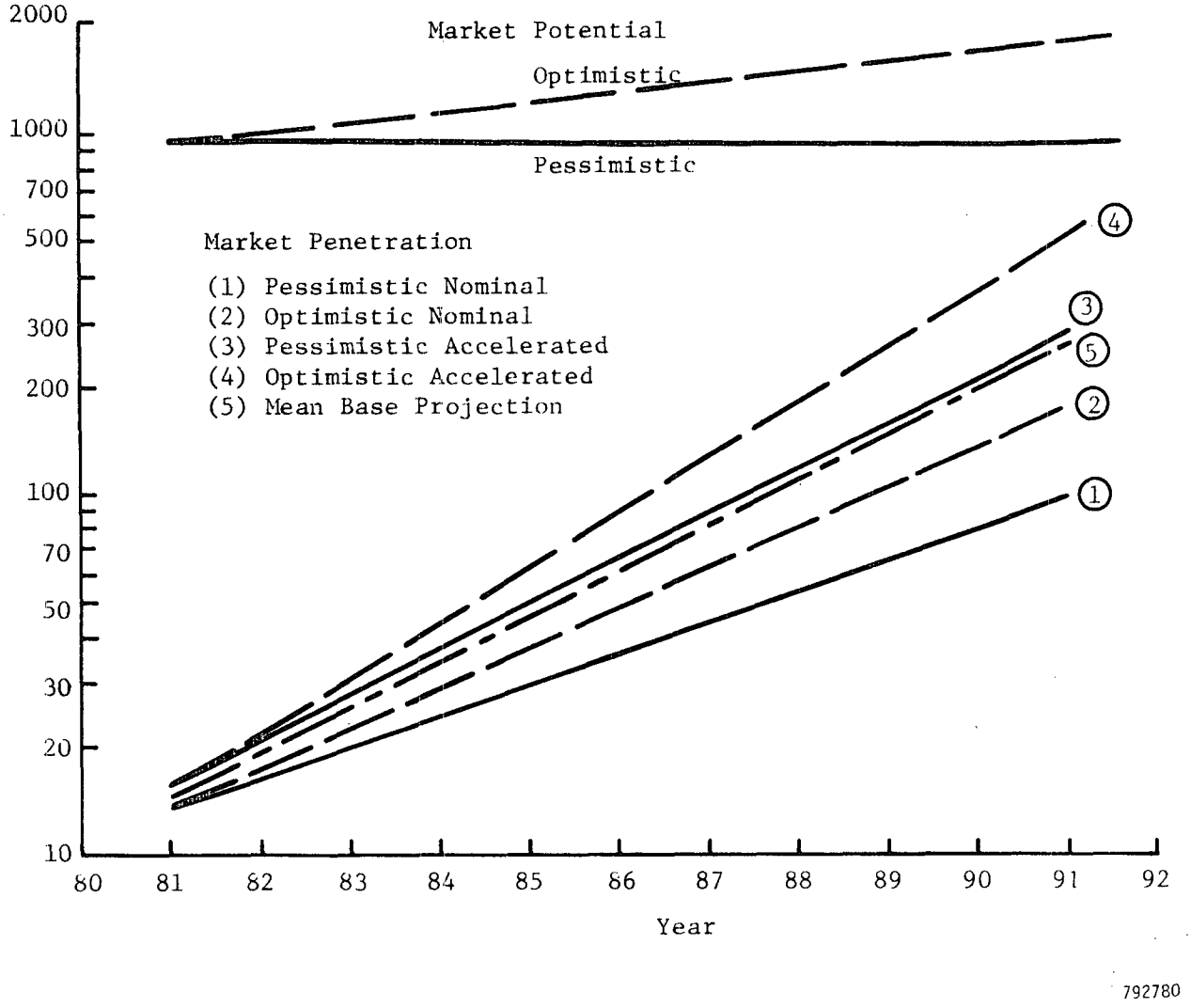

Fig. 4-2 Market Potential and Penetration Projections

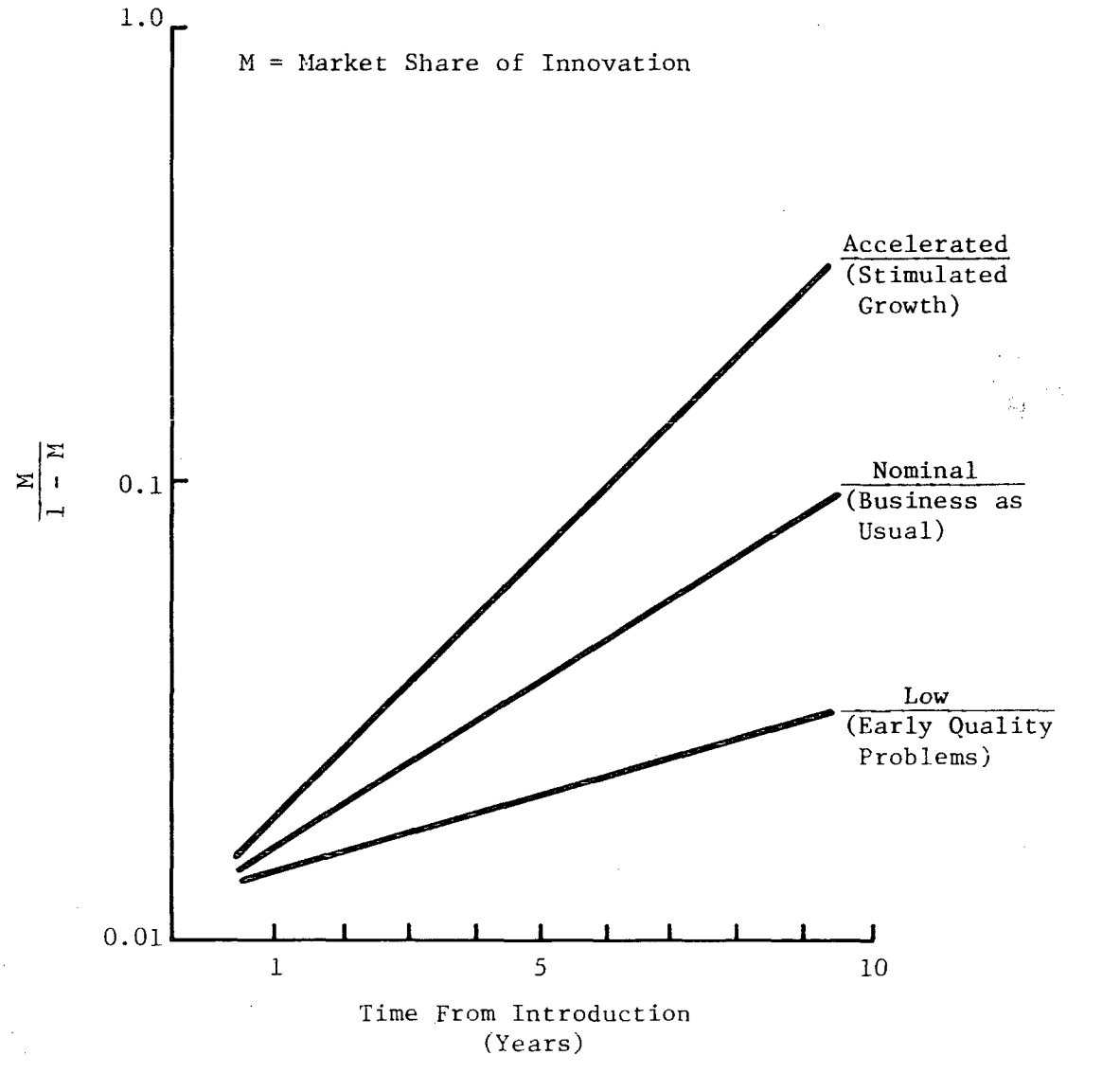

Fig. 4-3 Alternative Gas Heat Pump Market Penetration Rates

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TABLE 4-3

SALES PENETRATION FOR LSM HEAT PUMP

Year From Introduction	Percent of Market Penetration	
	Normal Growth	Accelerated Growth
1	1.4	1.6
2	1.7	2.2
3	2.1	3.0
4	2.5	3.9
5	3.0	5.3
6	3.8	6.8
7	4.6	9.2
8	5.6	12.3
9	6.8	16.3
10	8.2	21.9
11	10.2	29.2
12	12.4	38.8
13	15.3	51.8

Source: AGA Data

for the market potential analysis. This mean base projection is shown in Figure 4-2 and Table 4-4. This sales projection results in an average annual growth rate of 34.4%. The projection in Table 4-4 is the baseline projection for an evolutionary product in the large tonnage (50-400) built-up HVAC market. The influence of price and performance must be taken into account.

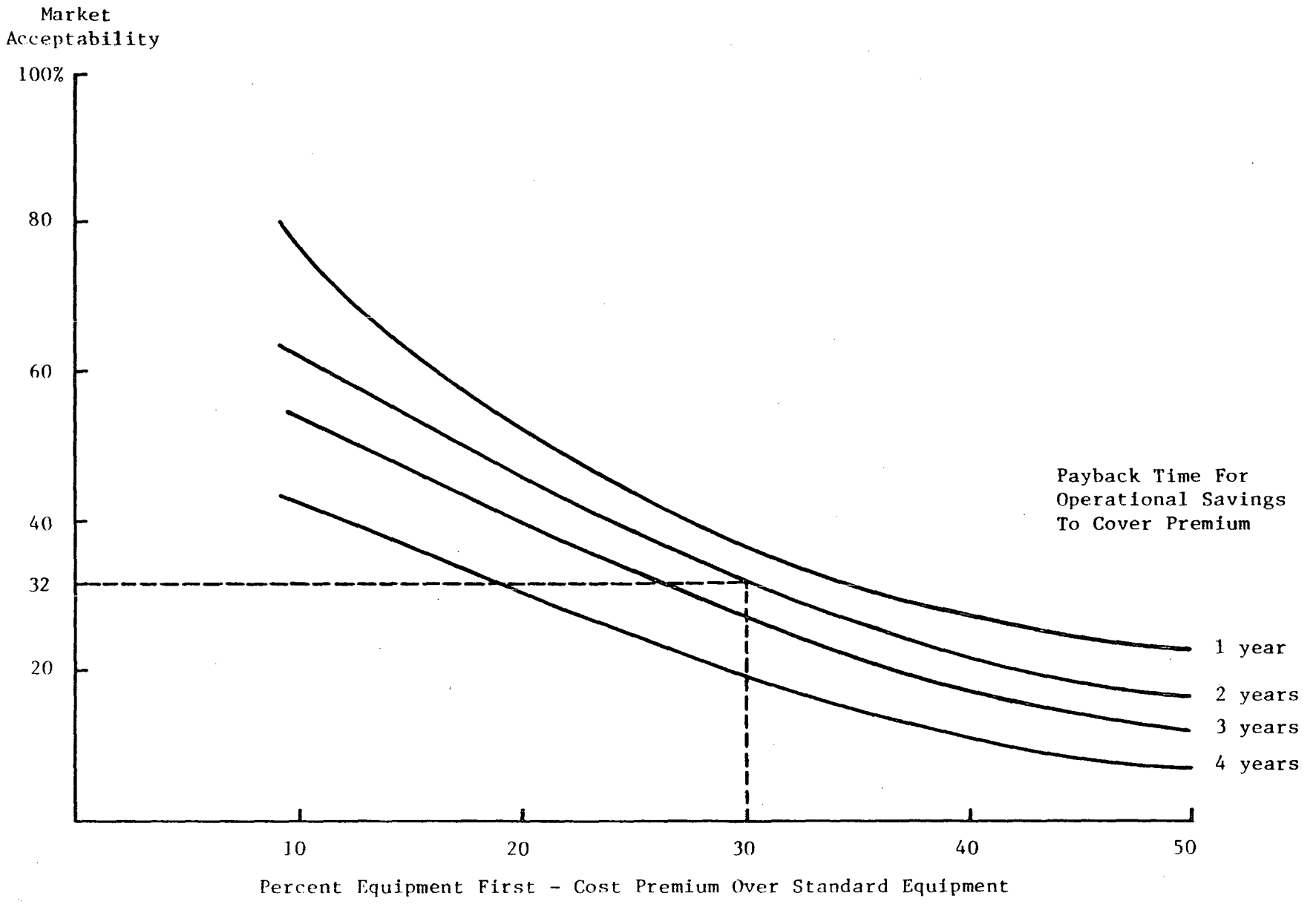
The results of the market studies show a definite buyer resistance to first price premiums in the HVAC market. This is illustrated by Figure 4-4 which shows the percent of the market potential that would buy (or consider buying) a premium-priced product as a function of the operational savings reflected in terms of a simple payback. For example, if the product has a first price premium of 30% and shows that that 30% premium can be returned by operating savings in two years, only 32% of the customers that will consider buying equipment on this basis will still be in the market. However, not all customers will consider buying HVAC products on a life-cycle basis. Hill's study showed that currently, only 40% to 50% of all customers will even consider life-cycle analysis in the buying decision. Not all of these customers use the analysis as the principal buying criterion. The impact of life-cycle sensitive customers and those customers' willingness to buy as a function of price premium and payback is shown in Figure 4-5. This figure shows that, with the expected market conditions in 1981 of 60% of the market being life-cycle sensitive, only 20% of the market potential will consider buying a product with a 50% premium and a two-year payback. Thus, the sales projections for a zero premium are as shown in Table 4-4 and for a 50% premium and a two-year payback is 20% of the values shown in Table 4-4. These are the sales projections used in the business potential analysis.

There are many uncertainties as to how the future market conditions will evolve. The factor which creates the most uncertainty and the most impact is government policy. The absence of a national energy policy results in a condition of market uncertainty, where the most conservative action by industry would be to do nothing. However, government is acting in regards to equipment performance standards, building design standards and even operating temperature for buildings. These actions, combined with various tax and grant incentives, will have a great effect upon the HVAC market. The deregulation of natural gas prices

TABLE 4-4

MEAN BASE MARKET PENETRATION PROJECTION

Year	Sale Projection (thousands of tons)	Growth Rate (%)
1981	14.6	-
1982	19.6	34.2
1983	26.5	35.2
1984	34.4	29.8
1985	46.1	34.0
1986	60.9	32.1
1987	82.3	35.1
1988	110.8	34.6
1989	148.6	34.1
1990	201.2	35.4
1991	274.3	36.3
1992	371.3	35.4
1993	507.3	36.6
	Average Annual Rate of Growth	34.4%



(1) Of total large tonnage equipment (unitary; built up) customers.
Source: W.E. Hill

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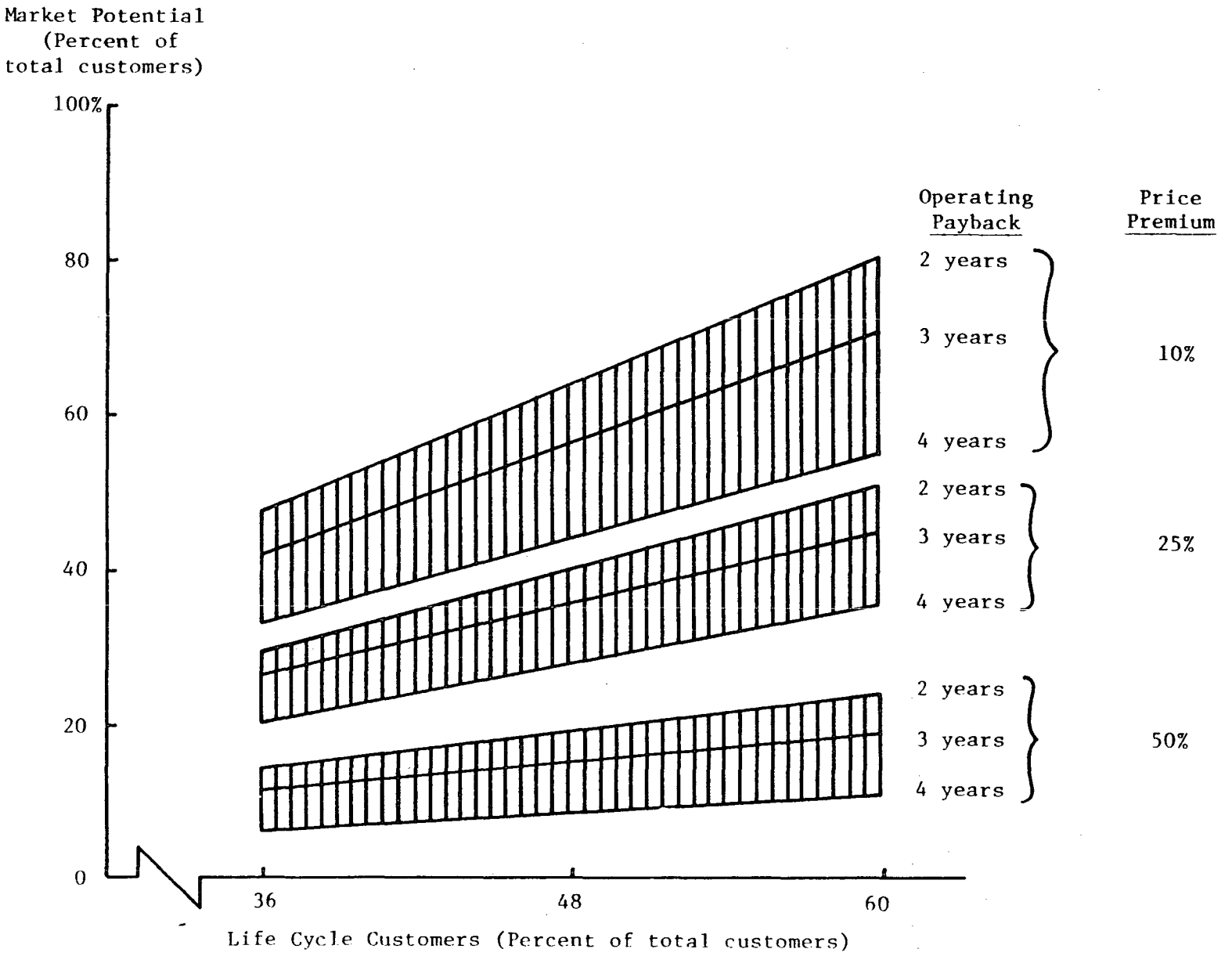
Fig. 4-4 Market Acceptance of Operating Cost Sensitive Customer to Price Premium and Payback - 1977 Survey(1)



Source: W.E. Hill

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Fig. 4-5 Market Potential Among Premium/Payback Customers - Large Tonnage Equipment 1977 Survey

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and the discovery of the so-called "gas bubble" will impact the marketability of natural gas in the commercial sectors. All these environmental factors will affect the general market for HVAC equipment.

An environmental factor that can affect the LSM system directly is the evolution and innovation of standard HVAC products. All of the environmental factors noted above will provide an impetus to accelerate conventional product improvements. These improvements can be made with little technical or market risk and minimal investment. There is a limitation as to how far standard products can be improved by evolution. Any innovation in conventional HVAC products will face the same business potential hurdles as faced by the LSM.

The limitations of making the sales projections are clearly understood. However, it is felt that the baseline market penetration presented in Table 4-4 is representative of the "most probable" sales scenario with a reasonable degree of optimism.

5.0 BUSINESS POTENTIAL METHODOLOGY

The basic approach to the business potential analysis was to use a simplified model of the firm to project profitability, cash flows, and investment levels over an evaluation period through 1990 using the baseline market penetration projection developed in Section 4.0. This model was applied using financial data from four firms in the HVAC industry: two integrated manufacturers (referred to as companies A and B), a component supplier (company C), and an assembler (company D). The financial data on these companies were derived from their 1978 annual reports and SEC Form 10-K. In applying the financial data, two principal assumptions were made: 1) a simple linear relationship between gross sales, profitability and investments exists, and 2) the historic financial data for a whole line of business for a company, as reported under SEC rules, is characteristic for a single new product innovation. The first assumption is a standard business planning and analysis assumption and is usually very acceptable. For the four companies selected, their ten-year financial data show a high degree of correlation with sales, as will be shown later. The second assumption may not be as accurate. The desired approach would be either to use a specific product that is identical in function or to build up a product financial picture for the innovation. The former approach is not feasible since specific product line financial data are highly proprietary. The latter approach is not feasible due to the lack of specificity of the product innovation at the point in time this analysis was performed. The only approach that would be accurate to any degree and that would give an indication of the impact of different approaches to the business was to define an "average HVAC product" as characterized by the overall financial position for a line of business. These average HVAC product financial characteristics give the results of this analysis applicability to the HVAC industry in general.

Figure 5-1 presents the flow of information in the model of the firm used in the analysis. The market potential, market penetration, baseline sales projection, sales price consideration, and the impact on market acceptability of the price premium have all been discussed in previous sections. The other factors will be discussed in detail in the following pages. Three factors are derived from the financial reports of the four companies considered.

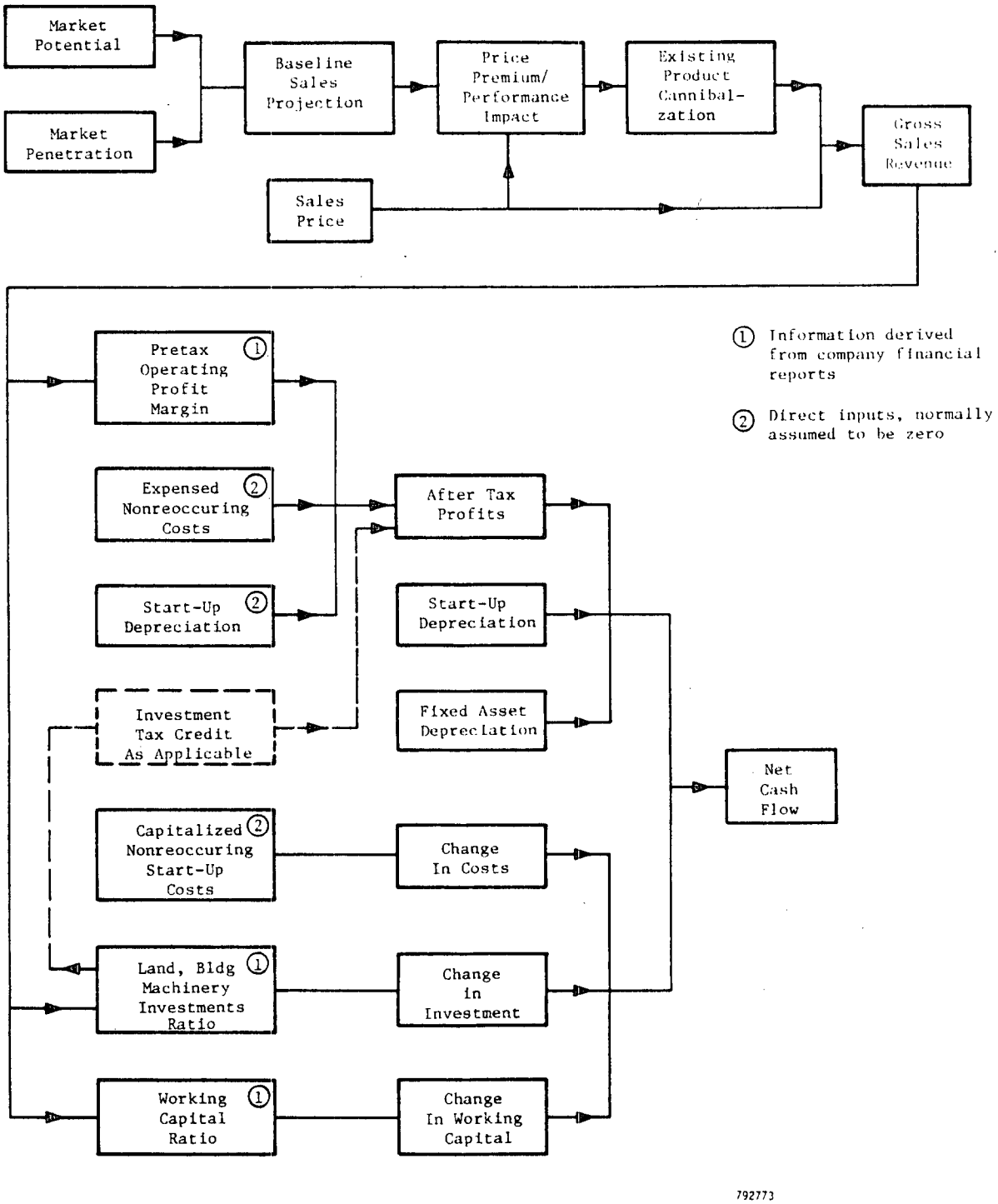

Fig. 5-1 Schematic Flow of Simplified Model of the Firm

For the bulk of the analysis, the nonreoccurring costs were considered as zero. The implications of this assumption are that there are no development costs, no introductory advertising or promotional costs, no manufacturing dislocations, no royalty expense, or no other costs normally experienced in the development and introduction of a new product. These implications make the analysis very optimistic in that if a business decision cannot be justified on this basis, it could never be justified.

At this point, it is necessary to recall that the objective of this analysis is to determine if it is financially justifiable for a company to enter into an exclusive license to produce and sell an innovative product. The company's option is to continue to sell its current products. Therefore, the analysis must implicitly or explicitly consider the "do-nothing" alternative. This alternative is considered through the use of the "cannibalization" factor. An assumption is made that a company is now in the HVAC business, commands a given market share and expects to maintain that share. As the market potential expands, the company will increase its revenue in the same proportion as the market expansion. If the company introduces a new product which successfully competes against its old product line, and if the company continues to maintain its market share of the old product, it will experience a different revenue growth. The difference between the two alternatives is:

Sales with new product - sales without new product.

The"sales without the new product"is simply

(Market potential) x (Market share) x (Price)

The"sales with the new product"is

(Market Potential) x (Market penetration) x (Price) x (Premium)
+ (Market potential) x [1-(Market penetration)] x (Market share)
x (Price)

The net impact on sales revenue of the new product is then

$$[(\text{Market potential}) \times (\text{Market penetration})] \times \left[1 - \frac{(\text{Market share})}{(\text{Price premium})}\right] \times [(\text{Price}) \times (\text{Price premium})]$$

The first term is the market penetration projection in Section 4.0. The last term is the selling price of the product innovation. The middle term is the impact of cannibalizing the market for the existing product. Figure 5-2 presents the value of this cannibalization factor for various market shares

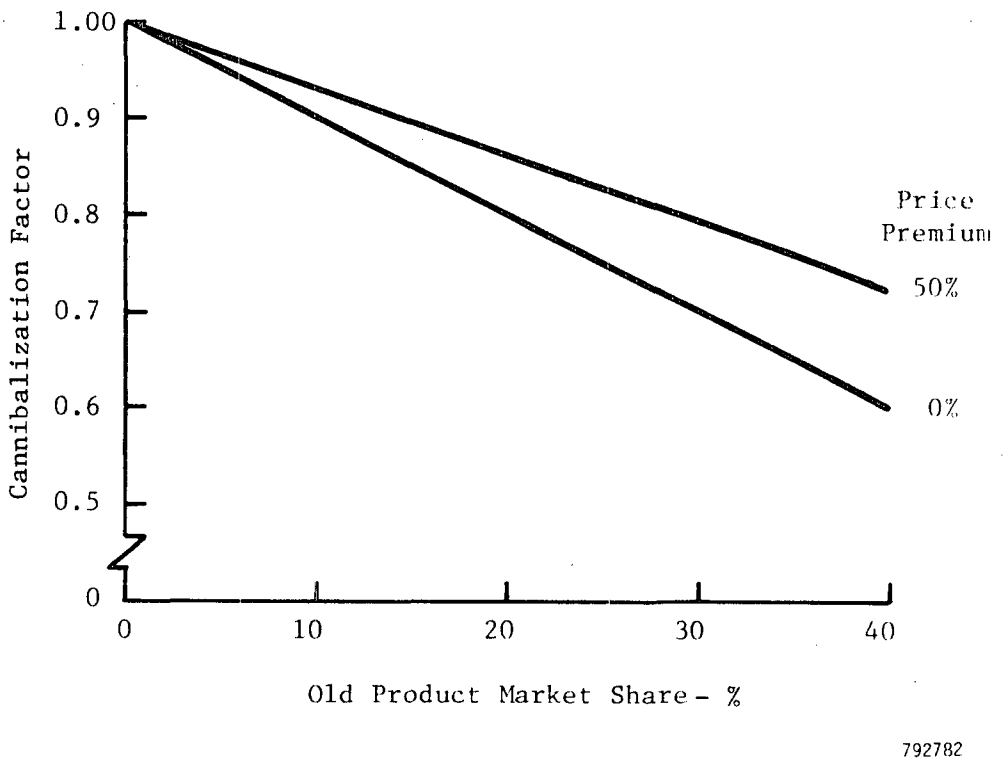

Fig. 5-2 Impact of Cannibalization of Existing Product Lines

and price premiums. This factor adjusts the gross revenue figure to be truly reflective of the incremental sales revenue impact of the new product.

The financial data for the four companies was correlated to sales through the use of a linear regression or least-squares fit. The correlation of those financial data which are normally present in the ten-year financial summary (i.e. cost of goods, net operating margin, working capital, and net plant) correlated very well. Typical regression correlation values (i.e. r^2) were around 0.99 and always over 0.97. A perfect linear correlation would have a correlation value of 1.0. Therefore, a great deal of confidence is placed in the assumption of a linear relation with sales. For those values of interest which have only a two-year data base, (i.e. gross investment in land, buildings and equipment), a simple ratio to sales was determined. The specific quantities that were selected to be inputted in the model were the gross operating margin, the working capital, the gross investment in land, the gross investment in buildings and the gross investment in equipment. The results of the data correlation for those quantities for the four companies are shown in Table 5-1.

The operating margins were readily determined for three of the four companies since operational sales and expenses were clearly separated from other income and expenses. Integrated manufacturer B did not have the other income called out. The result reflects an interesting anomaly; that at zero sales manufacturer B would have $18,000,000 in operating profit, as shown in Table 5-1. The intercept in the relations in Table 5-1 for operating profit is what is usually considered as fixed costs. For three of the manufacturers the fixed cost is a cost. For manufacturer B, however, the fixed cost is an income. This anomaly is illustrated in Figure 5-3. The operating cost is plotted as a function of sales volume for companies B and C, which have about the same sale revenues. Also, the slope of the curve for company B is significantly different from the point valuation of the gross margin based on the average of the last two years of sales data. (The point valuation assumes a zero intercept). The other companies show a resonable relationship between the curve fit slope and the point evaluations for gross margin. Therefore, for manufacturer B, the point evaluation was used for gross margin. Since the analysis basically compares the status quo with a new venture, the values of the intercepts do not enter into the model calculations.

TABLE 5-1

COMPANY FINANCIAL DATA USED FOR MODELLING

	Integrated Manufacturers		Component Supplier	Assembler
	Company A	Company B	Company C	Company D
Operating Profit	Sales * 0.1001 -25726	Sales * 0.0527 +18923	Sales * 0.1289 -7197	Sales * 0.1054 -2453
Working Capital	Sales * 0.3652 +26230	Sales * 0.2936 +25534	Sales * 0.1515 +4285	Sales * 0.2189 +2727
Fixed Assets				
Land	Sales * 0.0091	Sales * 0.0071	Sales * 0.0069	Sales * 0.0057
Buildings	Sales * 0.0976	Sales * 0.1563	Sales * 0.0620	Sales * 0.0802
Equipment	Sales * 0.2362	Sales * 0.1853	Sales * 0.1920	Sales * 0.1897
Operating Profit Margin (average of two year's of data)	0.0906	0.1053	0.1161	.0893

Note: Sales are expressed in thousands of dollars

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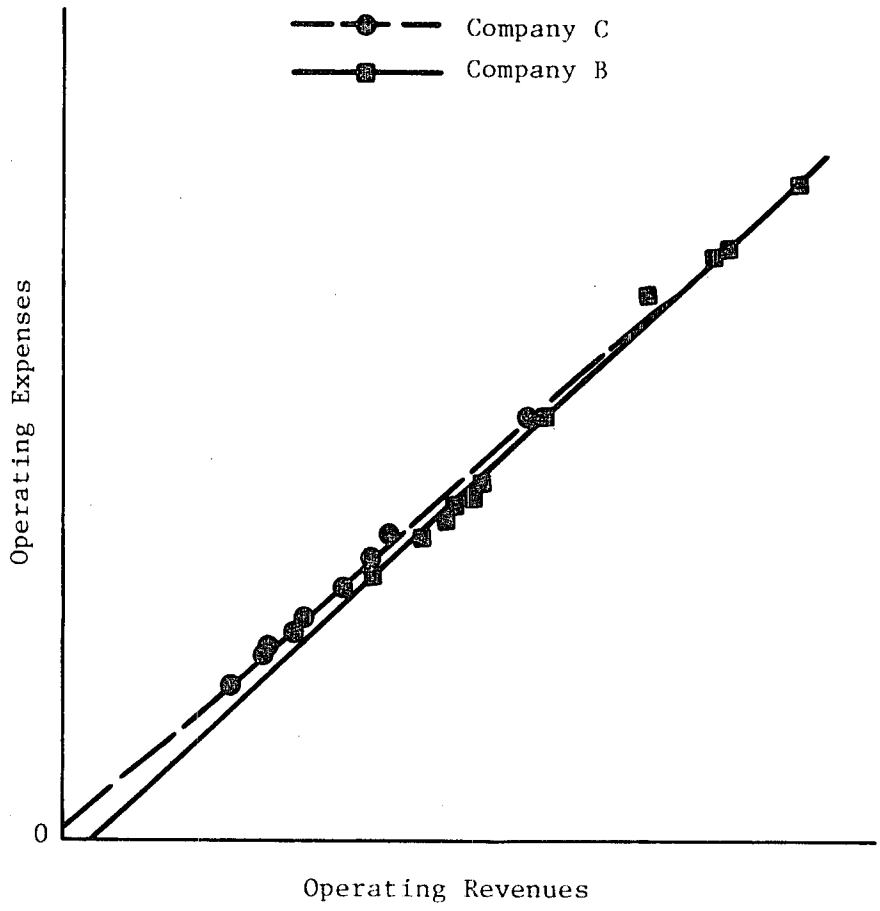

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Fig. 5-3 Operating Cost Comparison with Operating Revenues Showing Actual Data and Computed Linear Regression Curve Fit

The values for working capital and fixed assets shown in Table 5-1 were used in the model.

The overall financial data were adjusted to reflect the "air conditioning" line of business for companies A, B, and D. The line of business data presented in the annual reports and 10-K forms permitted a direct adjustment to gross margins and an implied adjustment to the fixed asset ratios. The line-of-business information presents only the total assets applied to a line of business. It was assumed that each of the asset items of interest would vary directly with the total assets applied.

The fixed asset investments were determined in the model on the basis of estimated sales and the historic ratio between fixed assets and sales. The acquisition of land was made on the basis of projected sales three years in the future. The acquisition of buildings was made on the basis of projected sales two years in the future. The acquisition of equipment was made on the basis of projected sales one year in the future. The annual incremental investment thus computed was used to compute the depreciation contribution to cash flow. This new incremental investment was depreciated on the basis of a sum-of-the-years-digits schedule. The buildings were depreciated over a 30-year life, the equipment over a 10-year life. The costs associated with the depreciation cash flow are assumed to be included in the operating costs as determined above. The use of this methodology poses two problems. First, historical costs were used to determine equipment requirements. This process will result in an underestimation of the fixed asset investment requirements. An analysis of replacement costing by one of the integrated manufacturers, as reported in their 10-K form, shows that replacement costs are almost 2.5 times historic costs. Second, even with the use of historic costing for the fixed assets, the contribution of depreciation to cost of goods may be understated by using the historic gross margins. Both of these problems will contribute to a more favorable financial picture than might actually be realized.

The tax rate was taken to be 48% for combined state and federal taxes. An investment tax credit of 10% of equipment purchases was assumed.

All of the assumed inputs to the model are illustrated in Figure 5-4 which is a revision of Figure 5-1. The analysis was conducted in constant 1979 dollars and developed net cash flow, cummulative cash flow and a program internal rate of return or discounted cash flow.

This model was programmed using the Interactive Financial Planning Systems (IFPS) language as offered on time sharing by Control Data Corporation. A sample printout of the model is shown in Figure 5-5. While the objective was to evaluate the business through 1990, the program logic of determining investment from future sales required sales data to be inputted through 1993. Any data generated by the model beyond 1990 would be invalid.

Since the period of evaluation covers only 1979 through 1990, a method to determine the residual value of the business beyond 1990 was needed. One approach would be to determine a market value for the business in 1990. Theoretically the market value would be identical to the present value of future earnings of the company. The typical mode expressing a market evaluation is the price (of stock) to earnings. Under less depressed conditions, the stock market would normally value a company at a price-earnings ratio of 10. Therefore, the after-tax earnings of the new product business in 1990 were multiplied by a factor of 10 to define a proxy for the present value of the future income. The impact of such a valuation procedure is shown in Figure 5-6. A more conservative valuation would be liquidation value of the working capital and fixed assets. The former approach was chosen since it would be more reflective of an on-going business and give a more favorable financial result.

There are two financial criteria that are considered in the evaluation of the business potential of the LSM product. The first criterion is cumulative cash flow. The second criterion is discounted cash flow (DCF) or internal rate of return (IRR). Since the models used are based upon operating profits, the method of financing does not impact the analysis. This obviates return on equity as an evaluation criterion. Also, debt leveraging could give attractive returns on equity for a poor investment. Other investment criteria are felt to be of interest only if the cash flow and DCF criteria are attractive.

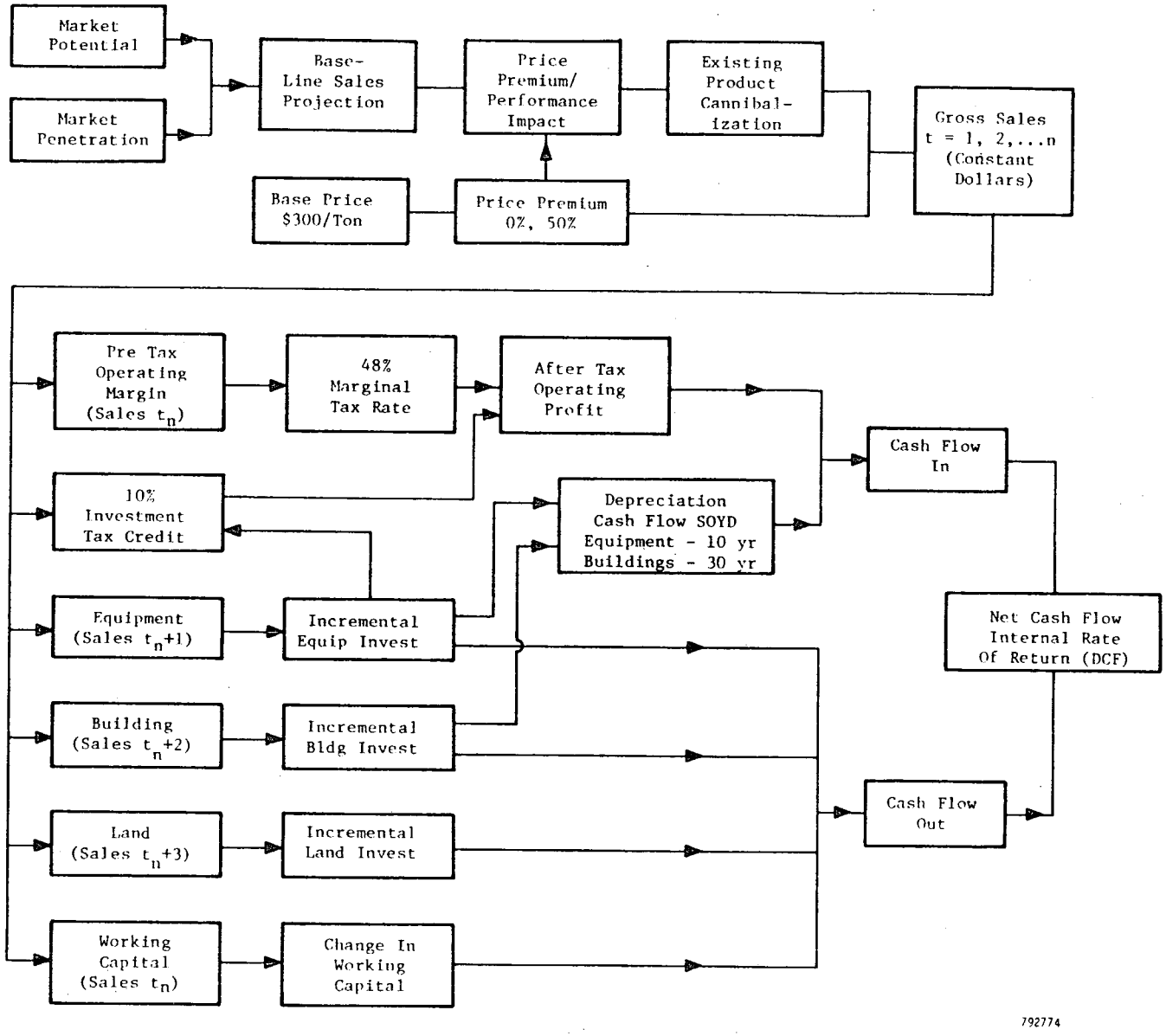

Fig. 5-4 Model of the Firm Used in the Business Potential Analysis - Flow and Assumptions

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```
MODEL VENTURE  VERSION OF  08/09/79  09:31
1 COLUMNS 1979-1993
10 TONS=0,0,14.6,19.6,26.5,34.4,46.1,60.9,82.3,110.8,148.6,201.2,274.3,371.3,507.3
11 SALES ADJ=1
12 PRICE PREMIUM=1
13 INC REV=L10*300*L12*L11*(1-L20/L12)
20 SHARE=.3
21 BT MARGIN=.1001
22 CAP RATIO=.3652
23 LAND RATIO=.0091
24 BLDG RATIO=.0976
25 EQUIP RATIO=.2362
30 OPER PROFIT=L13*L21
31 DWC=0,(L13-PREVIOUS L13)*L22
32 LAND=FUTURE 3 L13*L23
33 BLDG=FUTURE 2 L13*L24
34 EQUIP=FUTURE 1 L13*L25
35 DLAND=L32,L32-PREVIOUS L32 FOR 11,0
36 DBLDG=L33,L33-PREVIOUS L33 FOR 12,0
37 DEQUIP=L34,L34-PREVIOUS L34 FOR 3,0
38 SUM DEPR(L36,0,30,BLDGD,BOOKB,CUMBD)
39 SUM DEPR(L37,0,12,EQUPD,BOOKE,CUMED)
40 ITC=.1*L37
41 CASH IN=.52*L30+L40+BLDGD+EQUPD
42 CASH OUT=L35+L36+L37+L31
43 RATIO IN=0,0,L41/L13
44 RATIO OUT=0,0,L42/L13
45 CASH FLOW=L41-L42
46 CUM CF=L45+PREVIOUS L46
47 VALUE=0 FOR 11,5,2*L30,0
48 DCF=IRR(L41+L47,L42)
49 DCF WO VAL=IRR(L41,L42)
END OF MODEL
?
```

Fig. 5-5 IFPS Printout for Model Used in Baseline Business Analysis

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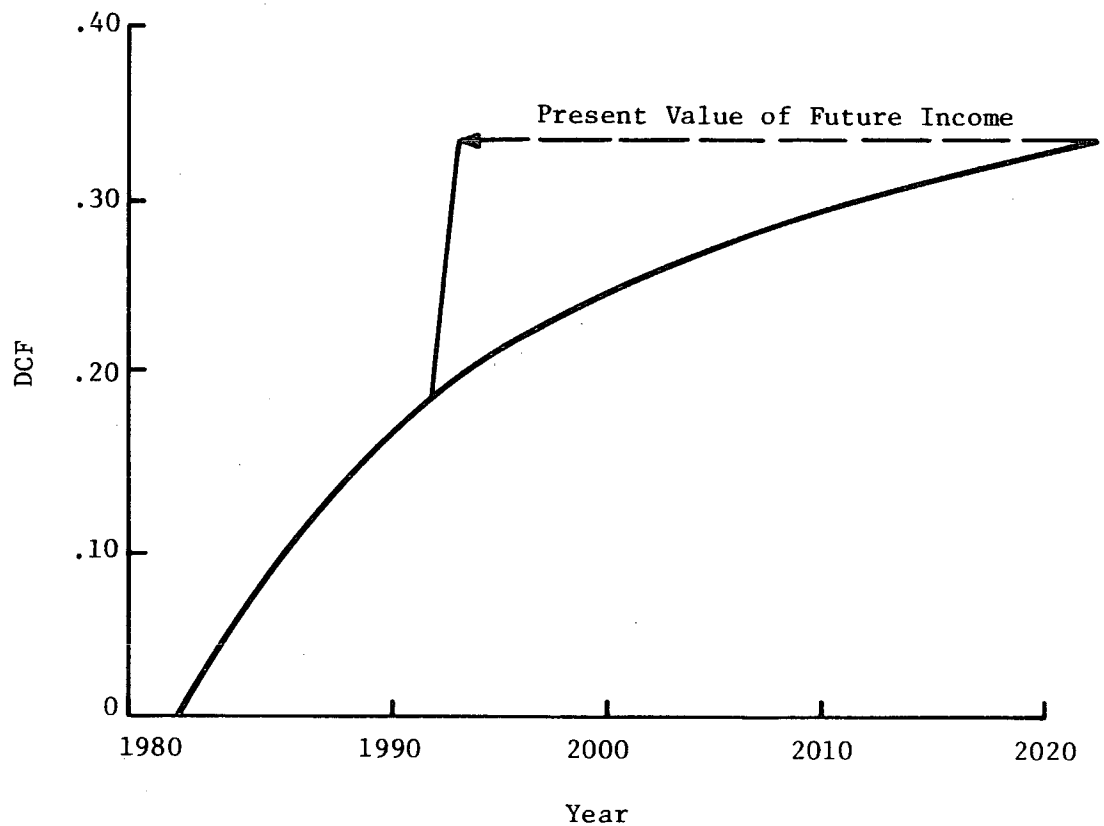

Fig. 5-6 Illustration of the Effect of a 1990 Valuation of the Future Income Upon DCF

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The evaluation does not consider nonquantitative financial factors such as overall market perspective of the company, or factors such as technical risk of current product obsolescence, government regulation, or earnings per share criteria.

Cash flow is simply the summation of all the cash generated by a company less the cash required by a company. Figure 5-4 shows the cash generators, such as operating profits, and the non-cash period expenses, such as depreciation. The cash users in normal circumstances are land, buildings, plant and working capital. Capital formation expenses, such as interest and dividends are not shown as a cash user in Figure 5-4. In a mature company, the cash generated should be adequate to cover all cash uses including interest, and an economic dividend. Some very profitable companies satisfy all the cash use requirements and still have cash available for additional investment. For a new product or business, the initial cash uses exceed the cash generation. Thus, a characteristic negative cumulative cash flow is associated with and expected for start-up situations. The reason for this "bathtub" is that investment in development, the plant, marketing, etc. occur before there are any sales or profit. This usual relation between cash use, cash generation and net cummulative cash flow is shown in Figure 5-7. The time values shown in Figure 5-7 are typical for new product innovations from the point in time the product development is started. The concerns for a company are the maximum financial exposure and the length of time to break even. Both of these quantify the degree of risk to the company. If the maximum financial exposure is comparable to the net worth of the company, the decision maker would be betting his company on the outcome. If the break-even point is far out in the future, the uncertainties of the marketplace may preclude the break-even point from occurring. The cummulative cash flow analysis is a quantitative input to a subjective evaluation by the decision maker.

The Discounted Cash Flow produces a single value quantitative measure of merit of a program, venture, or investment. This value is an effective interest rate that the investor or decision maker can relate to a risk-free simple bond or other investment opportunities. The DCF can be evaluated on a quantitative basis as is shown by the typical DCF investment thresholds in Table 5-2.

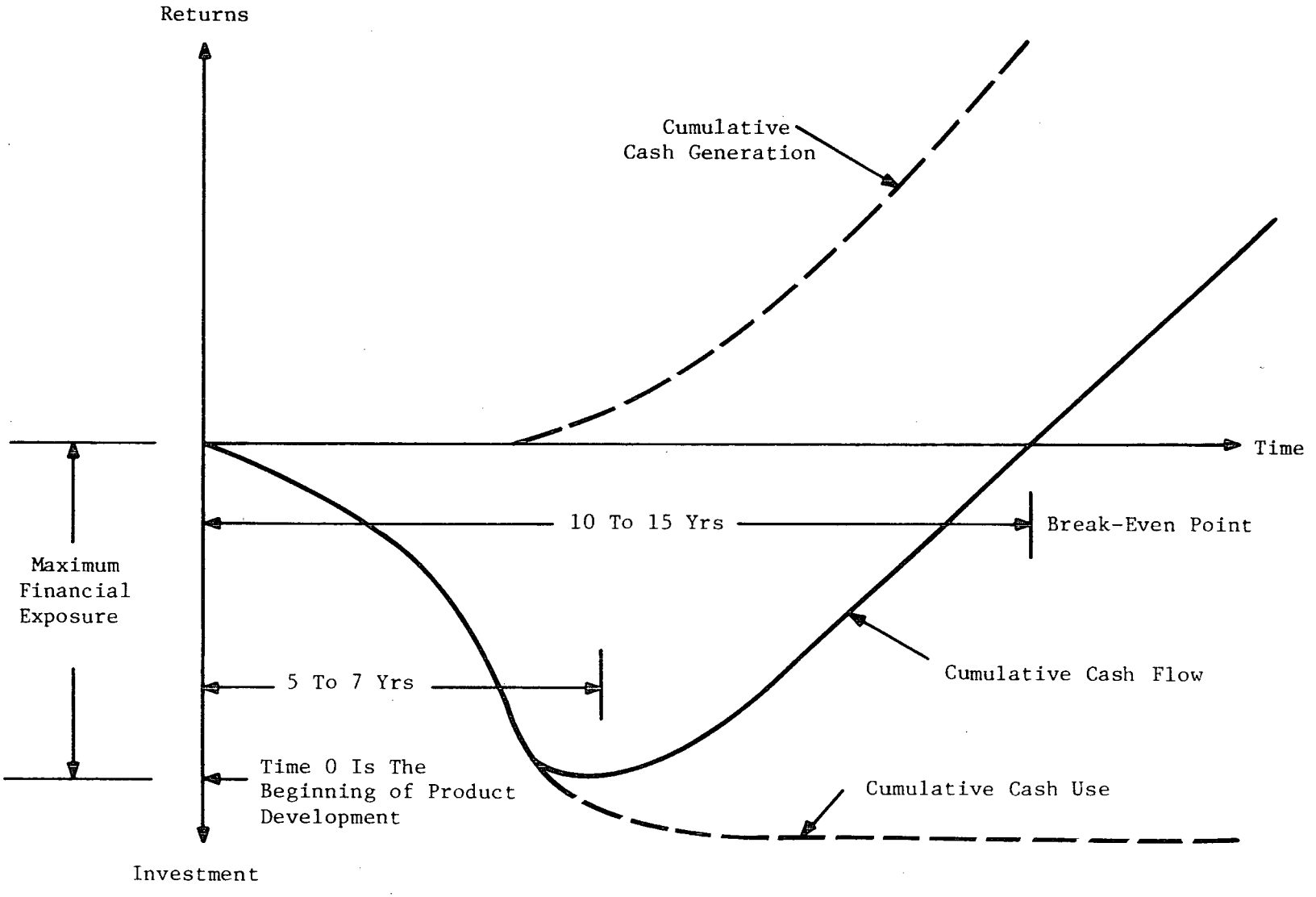

Fig. 5-7 Cumulative Cash Flow as a Means to Evaluate Financial Risk and Exposure

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TABLE 5-2

INVESTMENT CATEGORIES AND TYPICAL DCF THRESHOLD

Investment Category	DCF
Mandatory (e.g. EPA, OSHA, Stay-in-Business)	None
Production Expansion	10%-20%
New Products	15%-25%
Discretionary Cost Saving	20%-30%
Perceived Risky, Discretionary	>30%

The DCF is typical of modern quantitative investment analysis in that it takes into account the timing of the receipt and disbursement of funds. The time value of money concept is illustrated by the following example: If an investor were offered a dollar today or a dollar next year, the dollar today would be worth more. This is due to the fact that the dollar today could be invested in a zero risk bond, at, for example, 6 percent, and one year from now, the dollar received today would be worth $1.06. (This ignores inflation and taxes). The use of a discounted cash flow (also called "internal rate of return") provides an investor with a single rate of return or interest rate for a capital investment which will make the present value of the future flows of investment and return identical. Mathematically, this can be written as:

$$\sum_{t=1}^{N} \frac{R_t}{(1 + r)^t} - \sum_{t=1}^{N} \frac{I_t}{(1 + r)^t} = 0$$

where

N = the economic life of the investment which is specified

R_t = the return to the investor in period t which is specified

I_t = the investment in period t which is specified

r = the rate of return or interest rate which makes the equality valid.

The return and investment for each period are specified, and the relation is solved for the value of r which satisfies the equality. The solution for r is easily obtained by using computers or even the more powerful calculators.

It is important to note that the DCF has no meaning unless and until the cumulative cash flow attains a positive position value. This is shown in Figure 5-7. Prior to the attainment of a positive cash flow, there is by definition, no return. The investment is still in a loss position. While not a problem here, a negative cash flow after the attainment of a positive cash flow causes mathematical problems in the solution for the DCF.

Another criterion that was used in the interpretation of the results is the comparison of the ratios of "cash flow in to sales" to "cash flow out to sales". As long as the cash flow out per dollar of sales exceeds the cash flow in

per dollar of sales, the net cash flow will be negative and the cumulative cash flow will become more negative. The rapidity with which the cash flow out ratio declines below the cash flow in ratio is an indication of how fast the break-even point will occur and a DCF will become meaningful.

The decision criteria used in this study are summarized in Table 5-3.

The methodology described in this section was used as the basis for the initial business potential analysis. The conclusions from this first cut resulted in some variations to the basic methodology and some sensitivity analyses within the basic methodology being made. These variations and the impetus for their consideration are presented in the sections which follow.

TABLE 5-3

EVALUATION CRITERIA CONSIDERED IN BUSINESS POTENTIAL ANALYSIS

Cumulative Cash Flow (CCF):

$$\sum_{t=0}^{n} [(\text{Cash Flow In})_t - (\text{Investment})_t]$$

Discounted Cash Flow (DCF):

$$\sum_{t=0}^{n} \frac{(\text{Cash Flow In})_t}{(1 + \text{DCF})^t} - \sum_{t=0}^{n} \frac{(\text{Investment})_t}{(1 + \text{DCF})^t} = 0$$

$$\left[\frac{\text{Cash Flow Out}}{\text{Sales}}\right]_t \text{ vs } \left[\frac{\text{Cash Flow In}}{\text{Sales}}\right]_t$$

6.0 BUSINESS POTENTIAL ANALYSIS

The financial data from four firms in the HVAC industry were used in a simple model of the firm to investigate the business potential for these firms in order to introduce an innovative LSM HSPF heat pump as an add-on product. The financial data used are based on historic performance and costs. Non-reoccurring costs normally associated with new products such as R&D expenses, product introduction marketing expenses, and production costs variances, are not included, except as noted later. No royalty or licensing fees were considered. The analysis was conducted using constant 1979 dollars. No assumption was made as to the capital structure to support the financing of the new product.

The selection of the companies and approach to commercialization corresponds to paths 2, 3 and 4 in Table 3-1 on page 3-5. The specific approaches and the relation to the companies selected are shown in Table 6-1.

The sales projection is as developed in Section 4.0, with a 0% and a 50% price premium relative to existing standard equipment. The dollar value of sales for each of the four companies for the 0% premium is presented in Table 6-2.

The results of this baseline calculation showing the cumulative cash flow and the product line business DCF with a continuing business valuation in 1990 are presented for the four companies in Figures 6-1 through 6-4. The results show that the cumulative cash flow generation through the business is becoming more and more negative in all cases. The only reason for the existence of a DCF is the valuation of the product line as an ongoing business at a price of ten times after-tax operating income. Considering the business results, it is highly unlikely that such a valuation would actually be obtained.

The scenario assumed does not yield a business potential that would be attractive under any reasonable circumstances.

The data in Figures 6-1 through 6-4 show that although the cumulative cash flow is different between the 0% and 50% premium cases, the DCF is identical. This should be expected, since all financial variables are a function only of sales

TABLE 6-1

BUSINESS POTENTIAL ANALYSIS PATHS TO COMMERCIALIZATION CONSIDERED IN BASE ANALYSIS

Path No.	Description	Companies Considered
2	Existing Integrated HVAC Manufacturer	A Large Integrated Broad-Based HVAC Manufacturer B Large Integrated Commercial HVAC Manufacturer
3	Existing HVAC Component Manufacturer extending to be an integrated manufacturer	C Large Component Supplier to full-size range of air-conditioning equipment
4	Existing HVAC Assembler extending to be an integrated manufacturer	D Large Assembler of commercial sized HVAC equipment

Note: See also Table 3-1, Page 3-5

TABLE 6-2

INCREMENTAL SALES REVENUE PROJECTIONS FOR FOUR COMPANIES FOR 0% PREMIUM CASE, INCLUDING CANNIBALIZATION IMPACT

Year	Incremental Sales Revenues (thousands of 1979 dollars) Companies A&B	Company C	Company D
1979	0	0	0
1980	0	0	0
1981	3,066	4,380	4,161
1982	4,116	5,880	5,586
1983	5,565	7,950	7,553
1984	7,224	10,320	9,804
1985	9,681	13,830	13,139
1986	12,789	18,270	17,357
1987	17,283	24,690	23,456
1988	23,268	33,240	31,578
1989	31,206	44,580	42,351
1990	42,252	60,360	57,342
1991	57,603	82,290	78,176
1992	77,763	111,090	105,536
1993	106,533	152,190	144,581

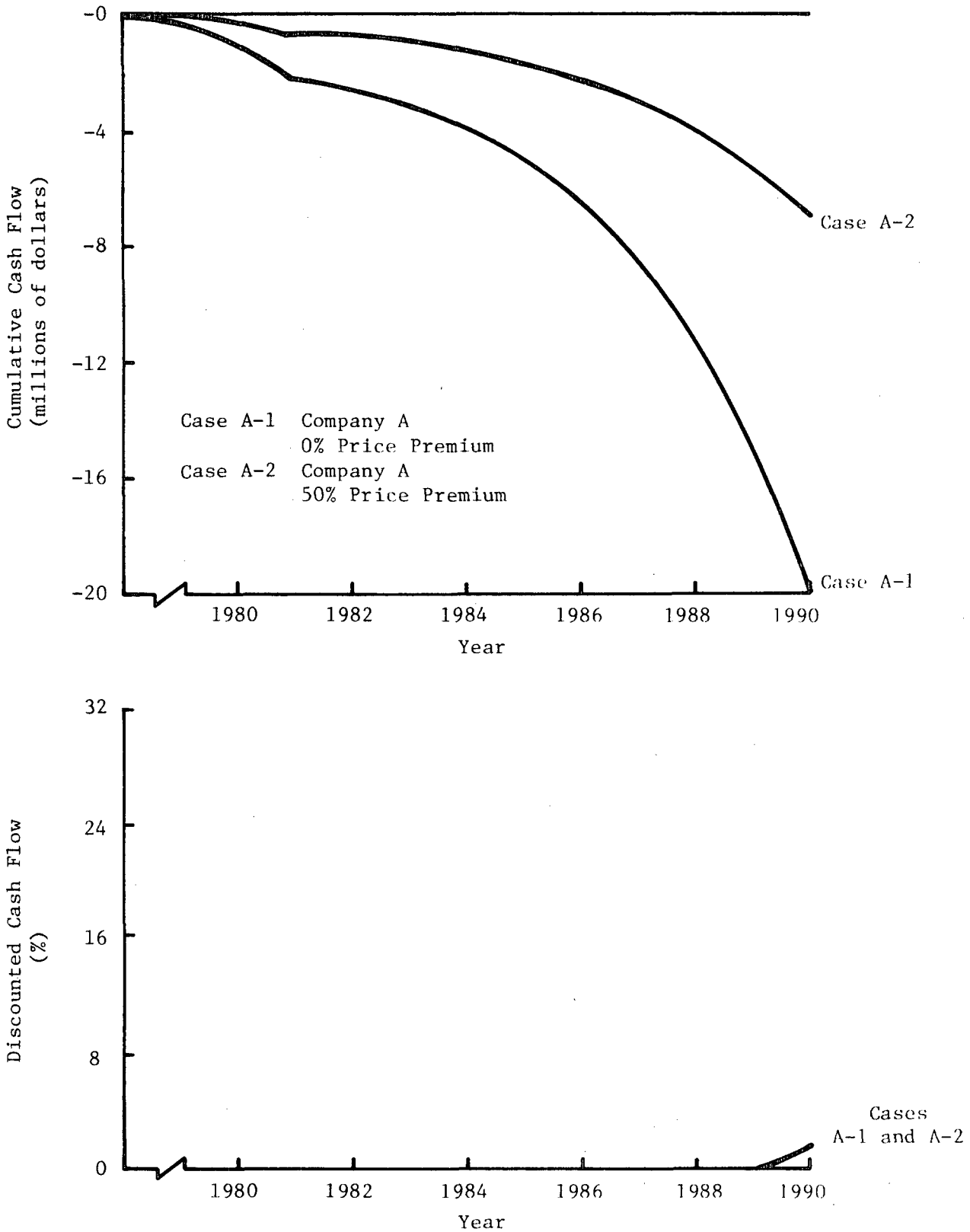


Fig. 6-1 Cumulative Cash Flow and DCF for Company A with Baseline Business Scenario

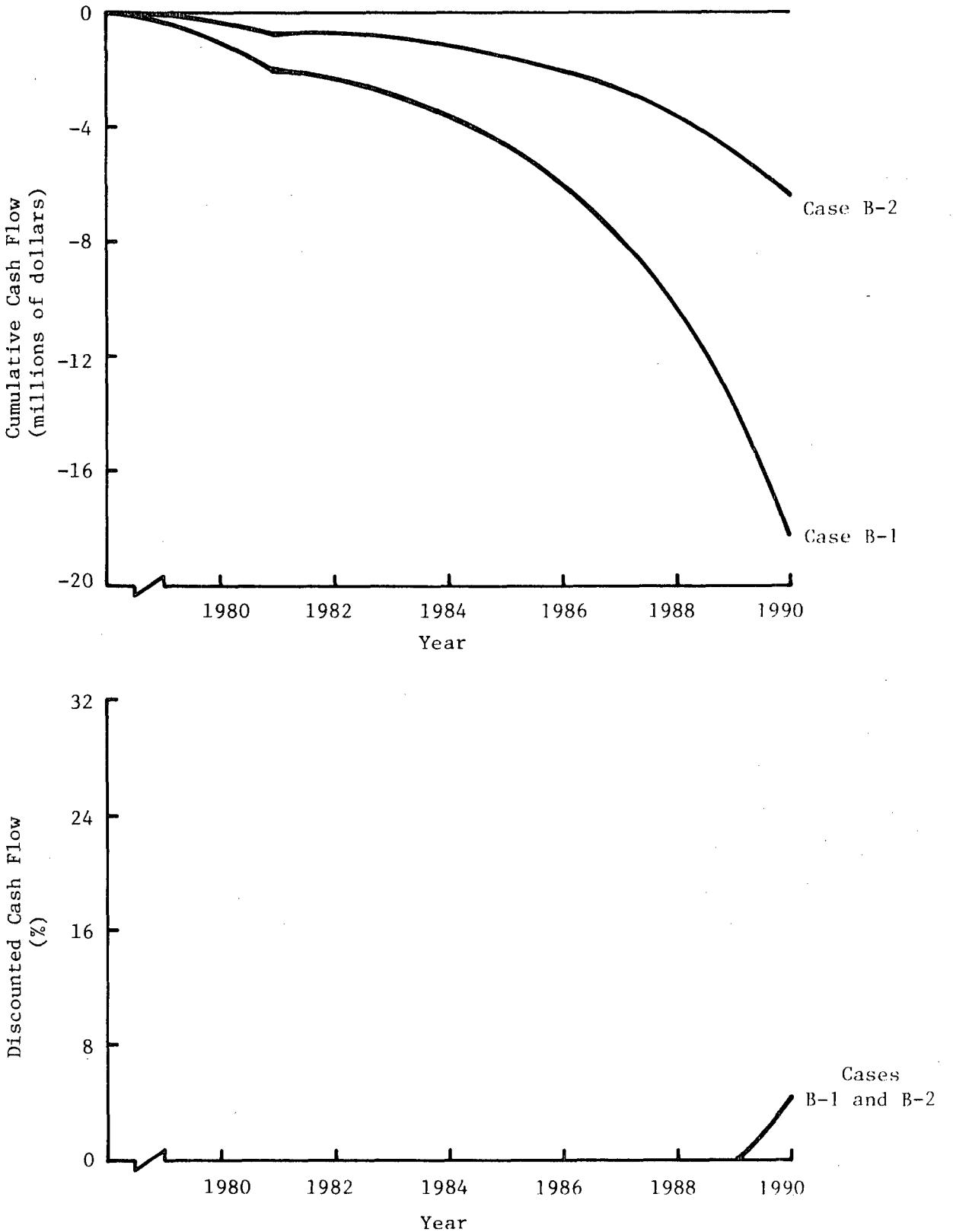


Fig. 6-2 Cumulative Cash Flow and DCF for Company B with Baseline Business Scenario

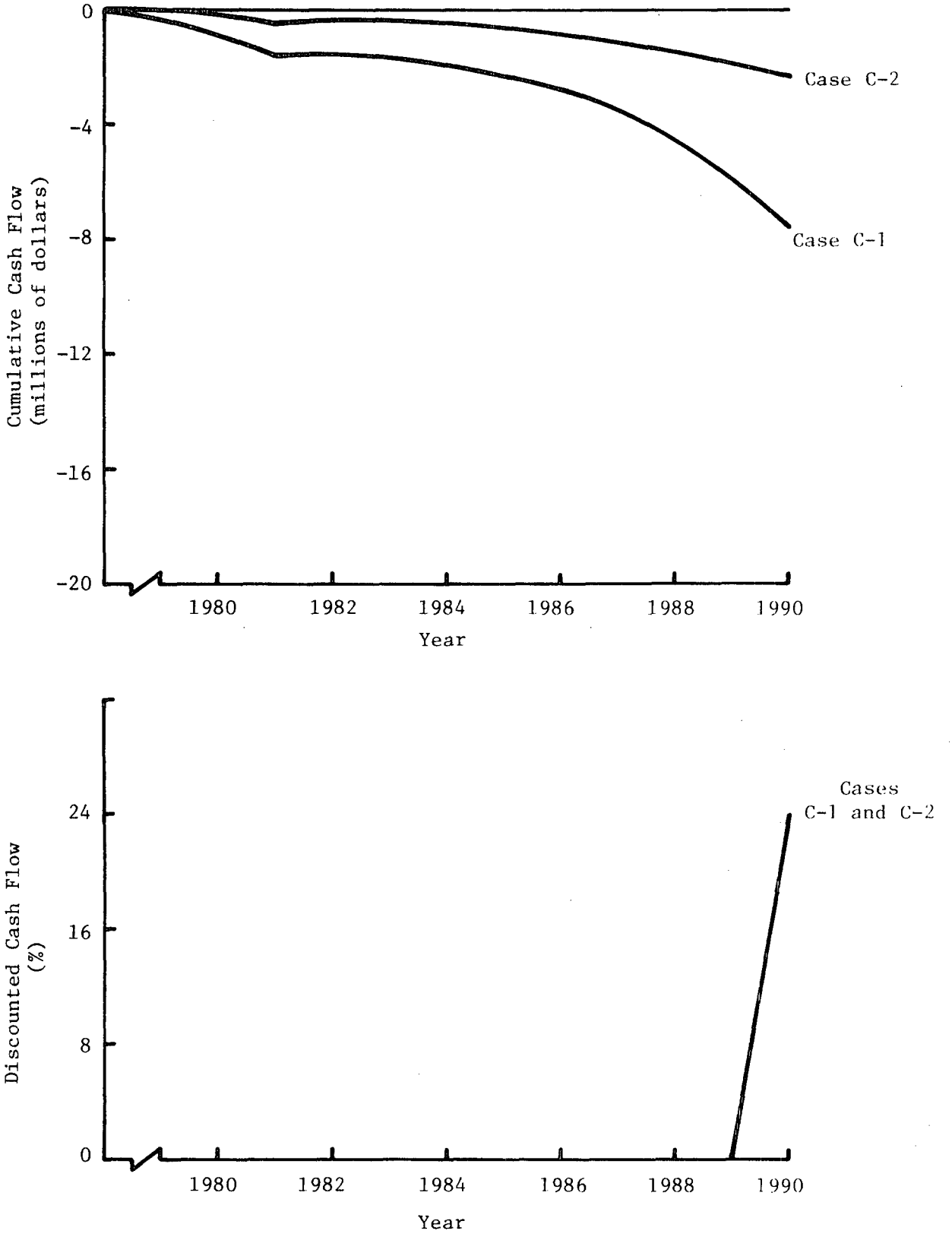
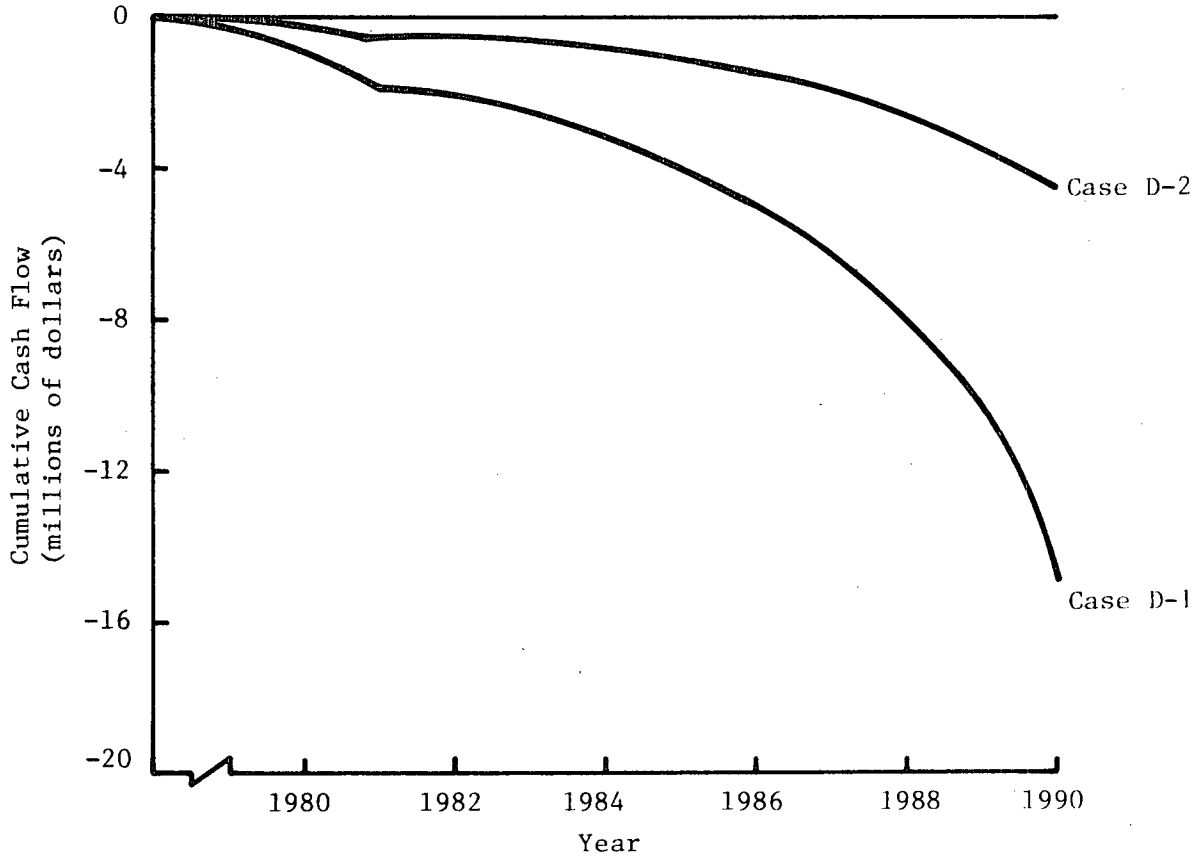


Fig. 6-3 Cumulative Cash Flow and DCF for Company C with Baseline Business Scenario



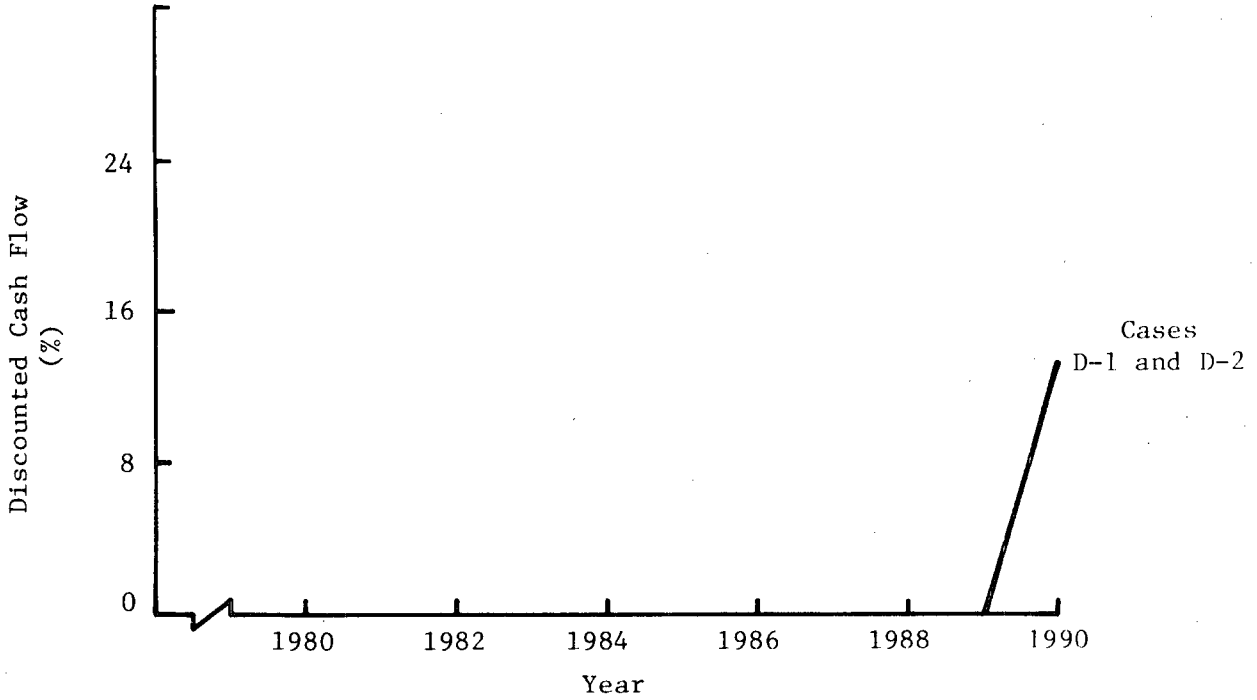


Fig. 6-4 Cumulative Cash Flow and DCF for Company D with Baseline Business Scenario

revenues. The cash flow in and cash flow out will increase or decrease but will always be directly proportional to the sales input. Thus, as long as there are no costs or income inputs that are independent of sales, the business analysis results will be the same in terms of the value of the DCF and the sign of the cumulative cash flow. Sales volume will not be explicitly considered as a parameter; sales growth rate, however, will be shown to be a very important parameter.

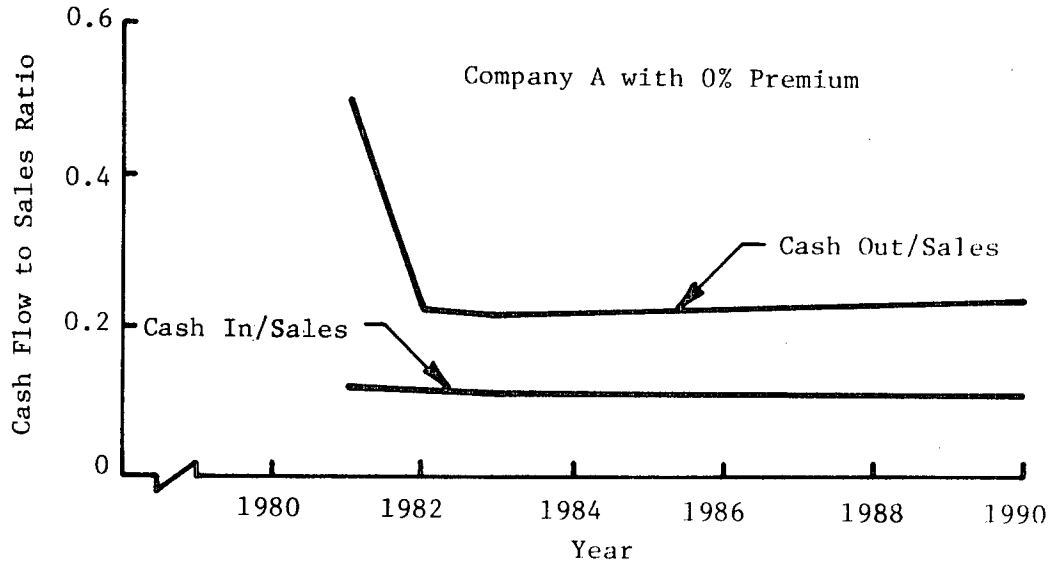
The comparison of the ratio of cash flow in to sales and the ratio of cash flow out to sales gives an indication of what is happening in this baseline scenario. Figures 6-5 to 6-8 present these ratios for the four firms considered with a 0% and a 50% premium. The comparison between the two price premium cases for each firm shows that the ratios are identical. The reason for this is as was explained above. The cause for the poor financial results is simply that the business scenario requires more cash than can be generated by the business. The ratio of cash flow in to sales always exceeds the ratio of cash flow out to sales. The difference must be met by additional investment. It is interesting to note that the two ratios tend to be parellel as time goes on. This means that there is no indication that a positive cash flow will ever occur as long as the assumptions for the scenario hold. Furthermore, since the difference between the two ratios becomes constant and sales volume is increasing, the cumulative cash flow will become increasingly more negative each year.

The overwhelming negative results of the quantitative analysis lead to the following reactions:

1) There is a computation or methodology mistake.

2) Assumptions relative to investment and profit margins are too pessimistic.

The answer to the first reaction was a total reevaluation of the logic, programming and data checks. The program model was also rerun. No change or error was detected. Also, a comparison was made between an unrelated product planning effort and the LSM as discussed in Attachment B of this volume. Although no methodology errors were detected from this comparison, the comparison gave a clear indication as to the principal problem in the baseline



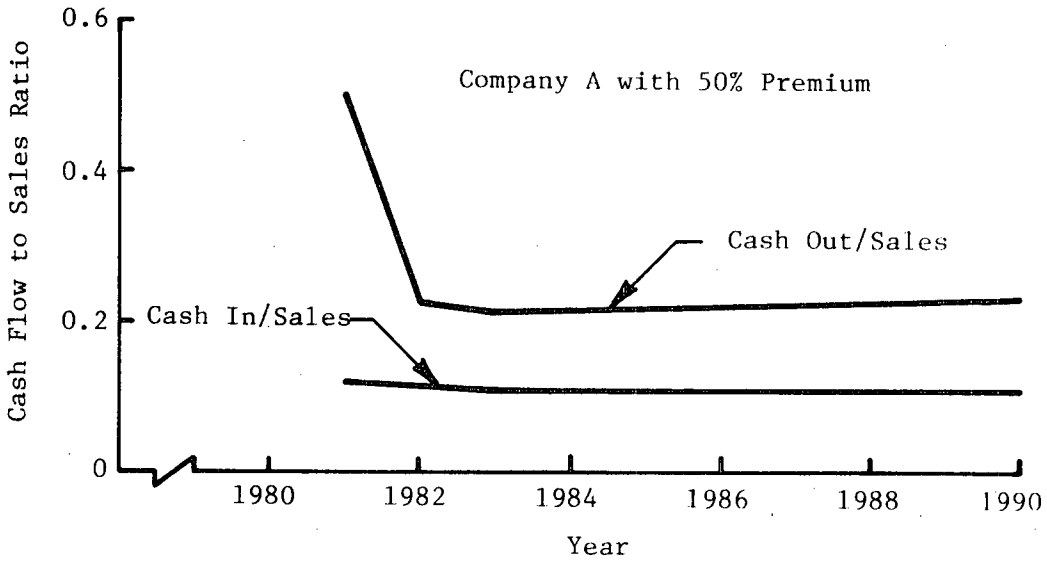
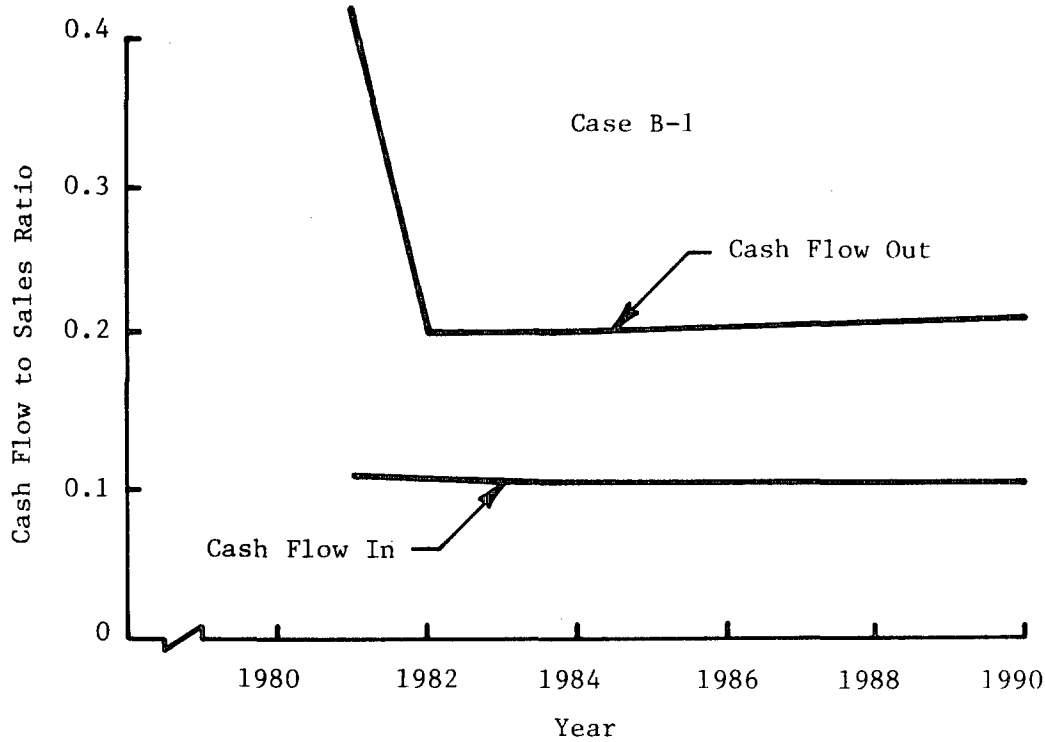


Fig. 6-5 Comparison of Cash Flow to Sales Ratios for Company A with Baseline Business Scenario



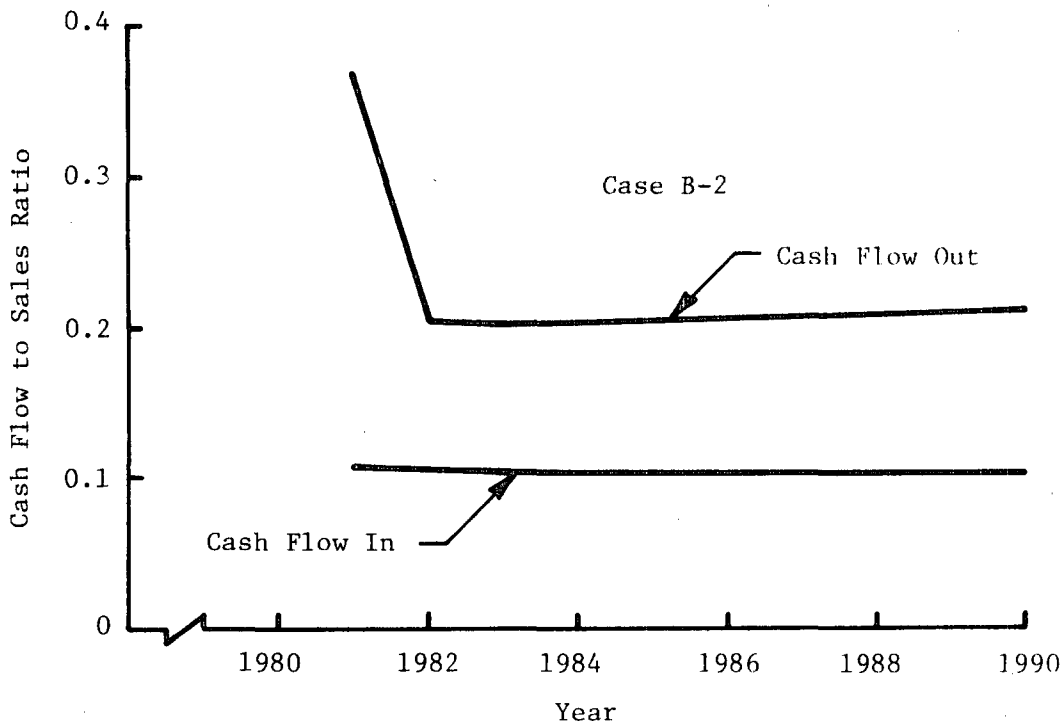
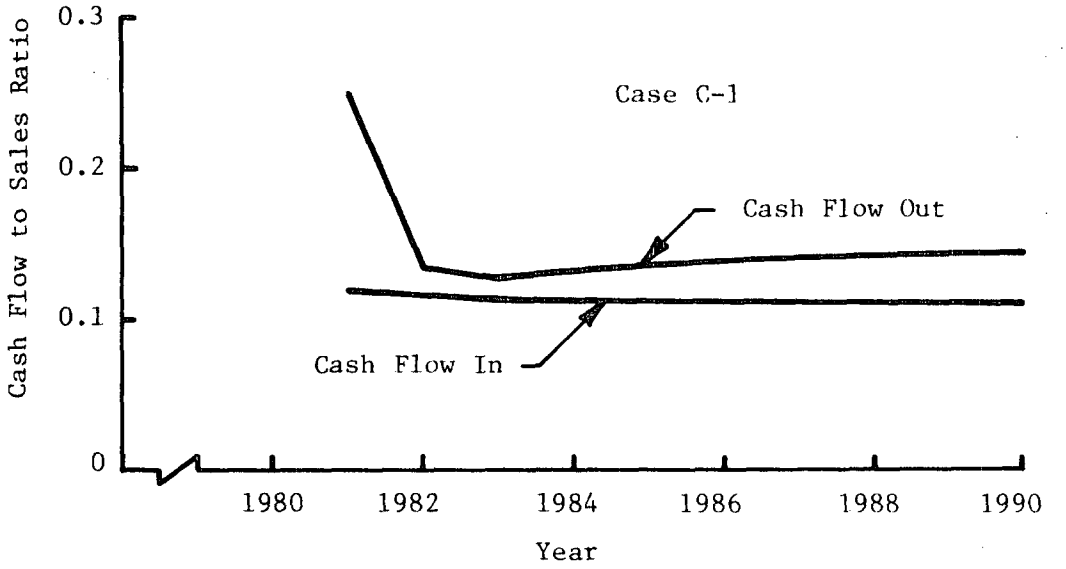


Fig. 6-6 Comparison of Cash Flow to Sales Ratios for Company B with Baseline Business Scenario



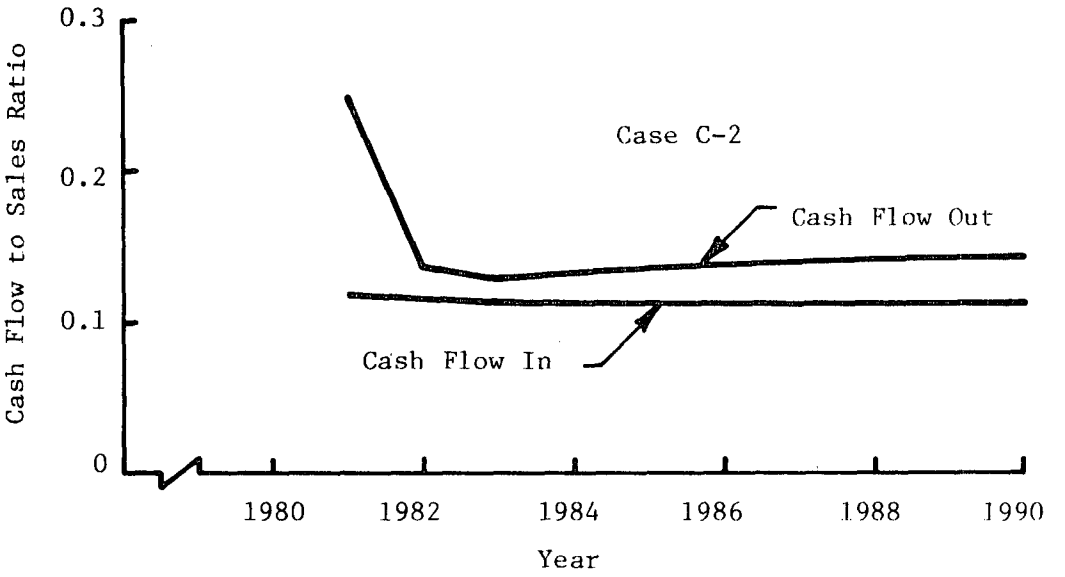
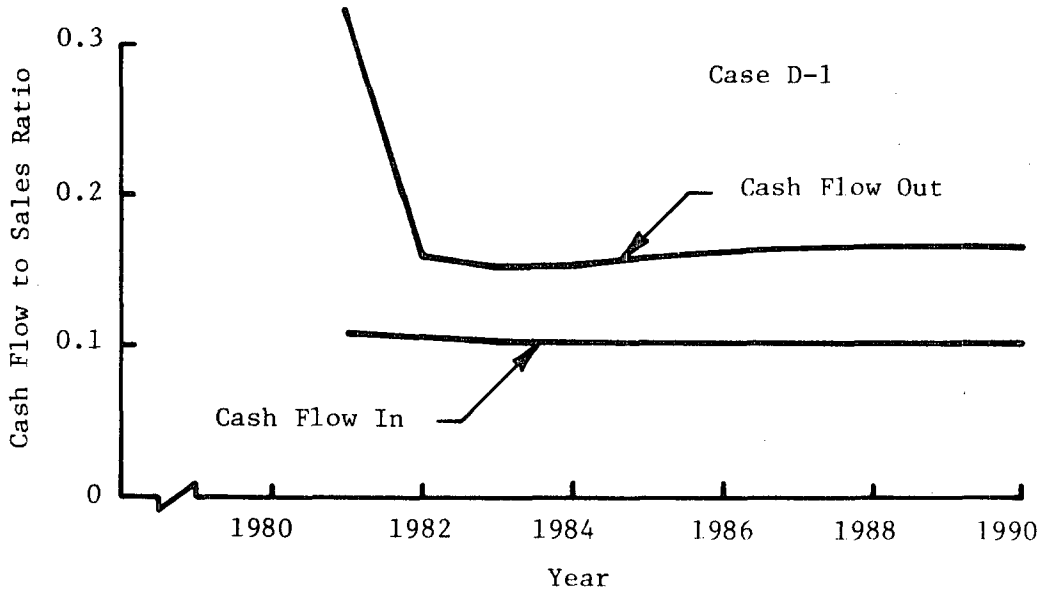


Fig. 6-7 Comparison of Cash Flow to Sales Ratios for Company C with Baseline Business Scenario



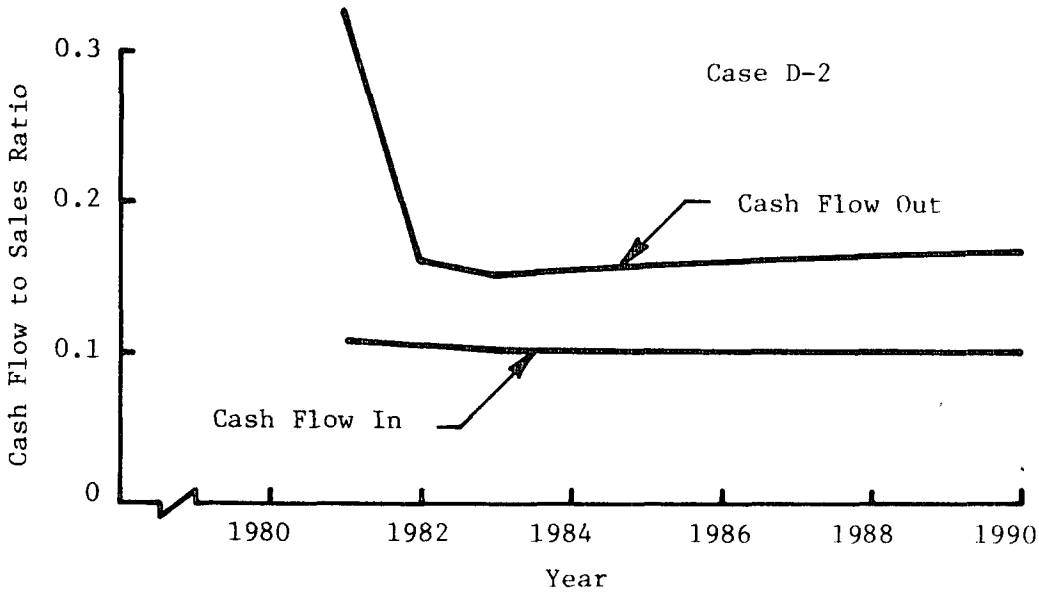


Fig. 6-8 Comparison of Cash Flow to Sales Ratios for Company D with Baseline Business Scenario

scenario - the inability of the HVAC industry to finance rapid sales growth. The answer to the second reaction was that a number of sensitivity runs were made in which the investment requirements and/or the profit margins were varied. Also, an expanded sensitivity analysis was conducted with a composite HVAC firm as discussed in Section 7.0 and an entrepreneurial firm scenario was evaluated as discussed in Section 8.0.

The sensitivity analyses to the baseline cases were justified partially upon the following logic. A reduction in the investment requirements in fixed assets was justified since excess plant capacity in the HVAC industry appears to exist. This evaluation is purely subjective and may not be true for any of the four firms selected. However, if the supposition is true, significant increases in production can be realized with very little increase in fixed assets. Therefore, the fixed asset requirements were reduced by 50% and 100% to evaluate the impact on profitability. For the profit margin, it was observed that the profit margins are low in the HVAC industry due to the competition and undifferentiated nature of the product. However, if a company exclusively had a differentiated product that offered a performance advantage, that company should be able to command a higher profit margin. Therefore, profit margins of 15%, 20% and 25% were evaluated. This evaluation was made under the assumption that the cost of manufacure of the new product allows increased profit margin within the constraints of the customer's sensitivity to premiums and operating advantages. From the results of the manufacturing cost study (Appendix Volume IV) and the cost-of-ownership study (Appendix Volume VII), the possibility for profit margin increases would seem to be nonexistent with the LSM. A final sensitivity was examined wherein the investment was reduced by 50% and the profit margin was increased to 15%. Table 6-3 summarizes the sensitivity analyses parameter variations. The resultant cumulative cash flows and DCF's are presented in figures 6-9 and 6-20.

Figures 6-9 to 6-12 present the comparison of the impact for reduction of fixed investment requirements. The results do not look any more encouraging for companies A, B and D than the baseline case even with no further fixed investment. The DCF increases with the reduction in fixed investment requirements. However, this DCF increase is due to end valuation of the business

TABLE 6-3

SUMMARY OF PARAMETER VARIATION FOR SENSITIVITY ANALYSIS FOR BASELINE BUSINESS SCENARIO

Variable	Run Number							
	1	2	3	4	5	6	7	8
Price Premium	0%	50%	0%	0%	0%	0%	0%	0%
Profit Margin	(1)	(1)	(1)	(1)	.15	.20	.30	.15
Land Ratio to Sales	(1)	(1)	0	0	(1)	(1)	(1)	0
Building Ratio to Sales	(1)	(1)	.5x(1)	0	(1)	(1)	(1)	.5x(1)
Equipment Ratio to Sales	(1)	(1)	.5x(1)	0	(1)	(1)	(1)	.5x(1)
Working Capital Ratio to Sales	Historic Company Data (see Table 5-1)							
Sales Volume	Baseline Projection (see Table 6-2)							

(1) Historic company data (see Table 5-1)

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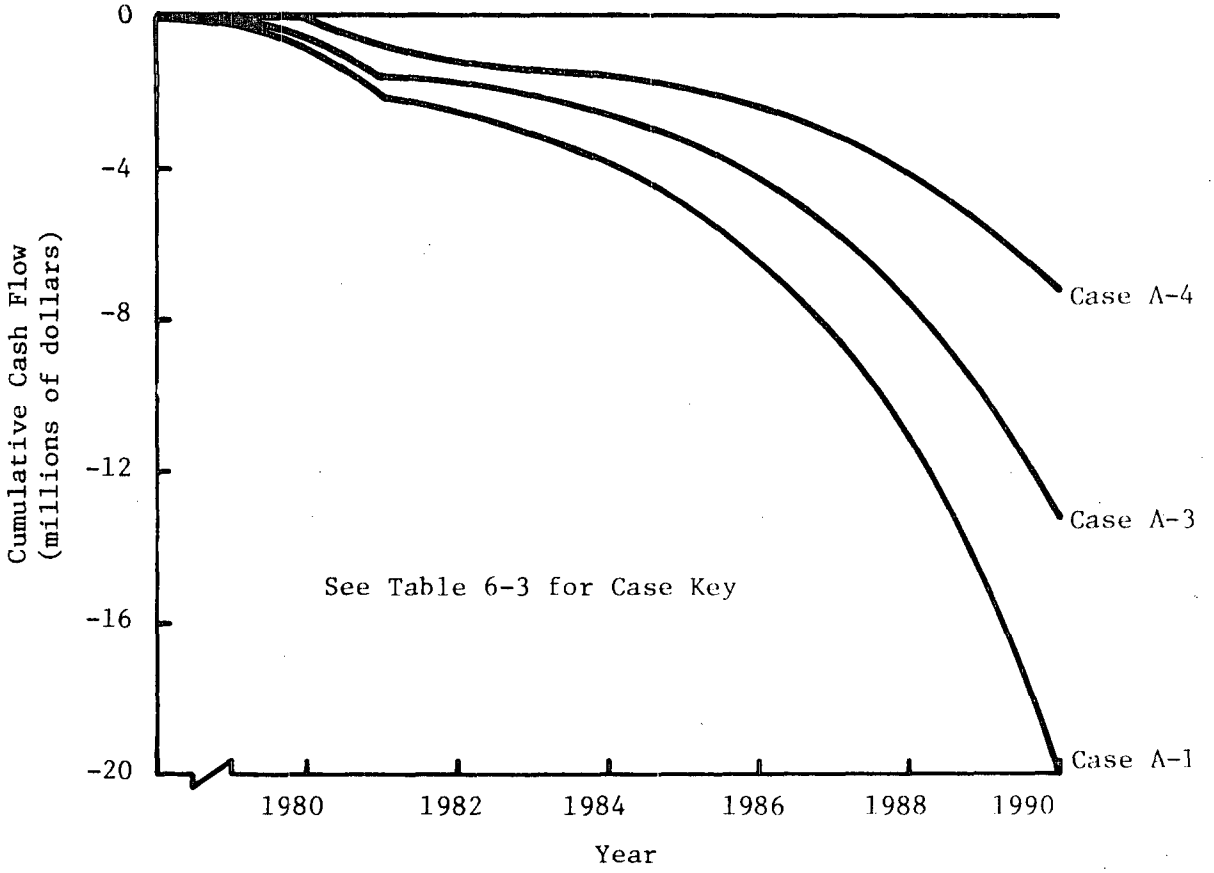

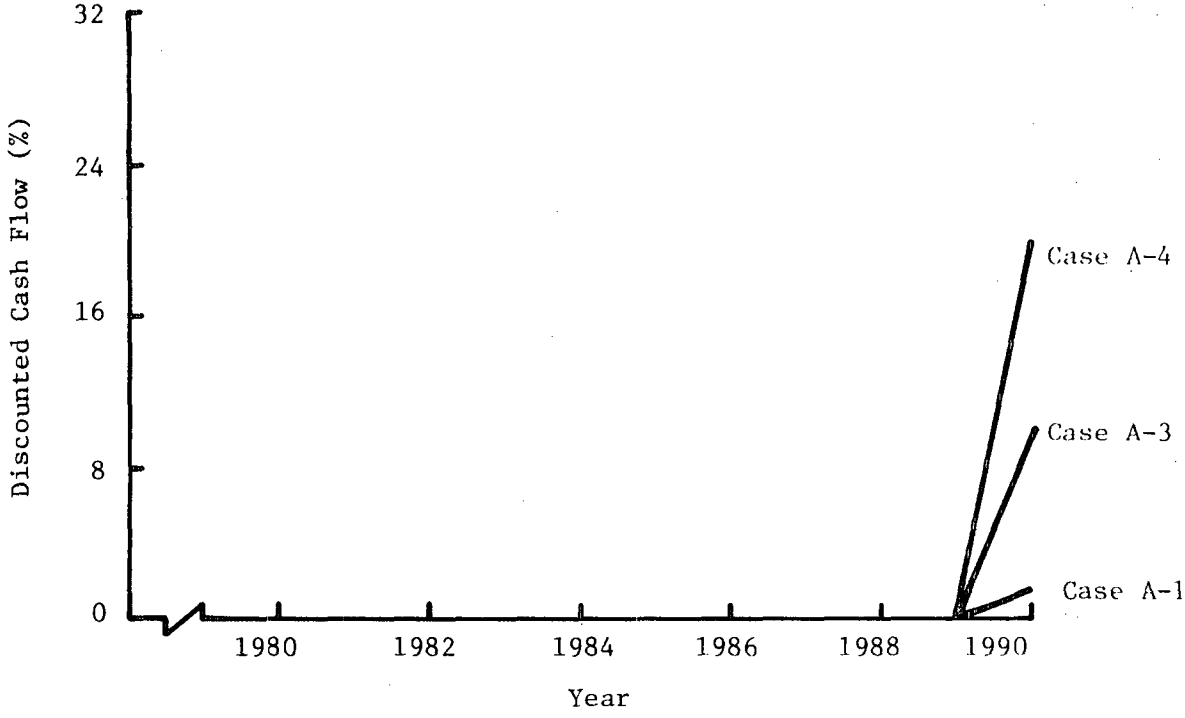

Fig. 6-9 Impact of Reduced Fixed Investment on Cumulative Cash Flow and DCF for Company A with Baseline Business Scenario

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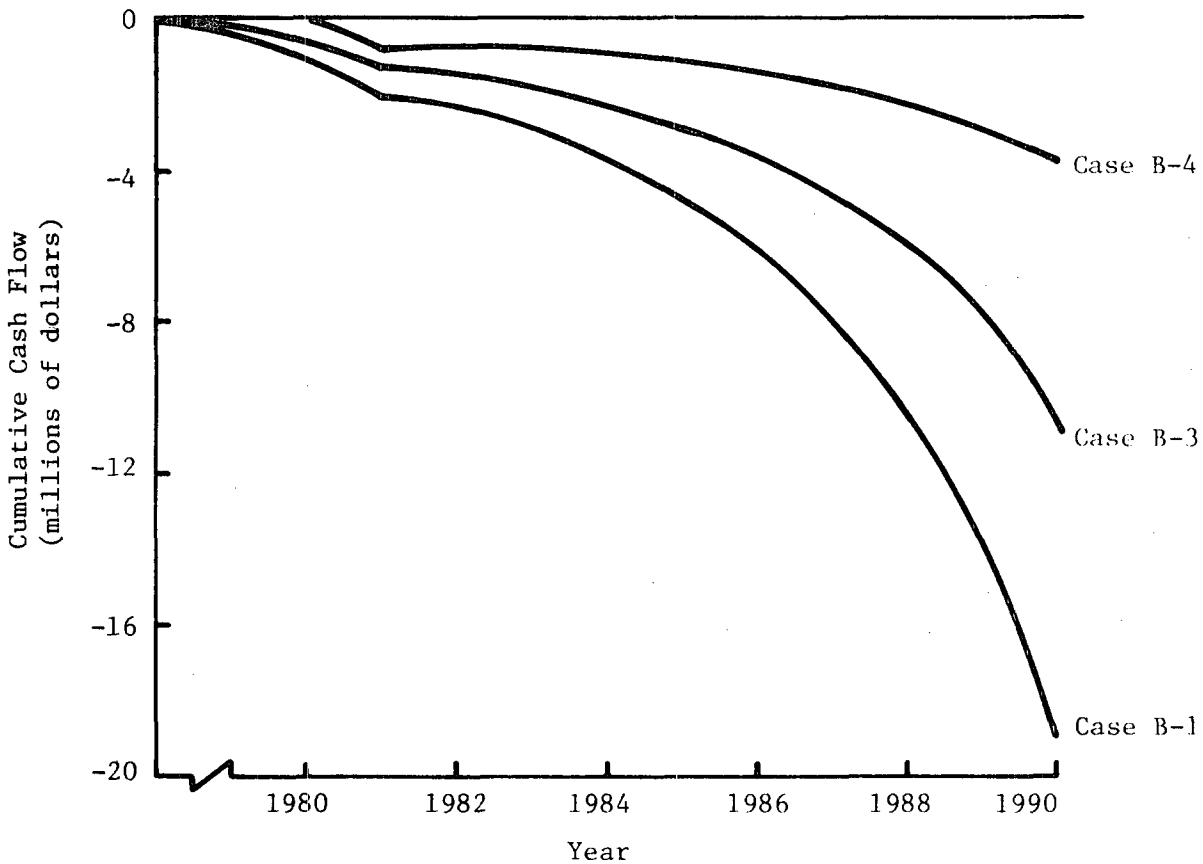

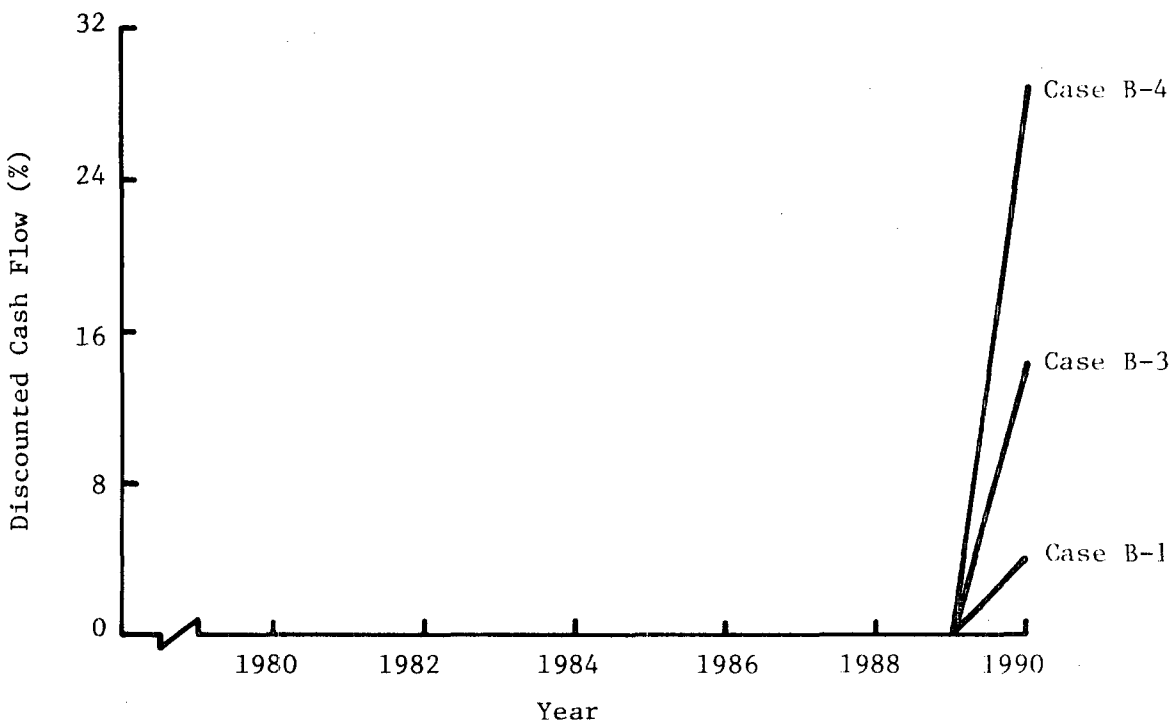

Fig. 6-10 Impact of Reduced Fixed Investment on Cumulative Cash Flow and DCF for Company B with Baseline Business Scenario

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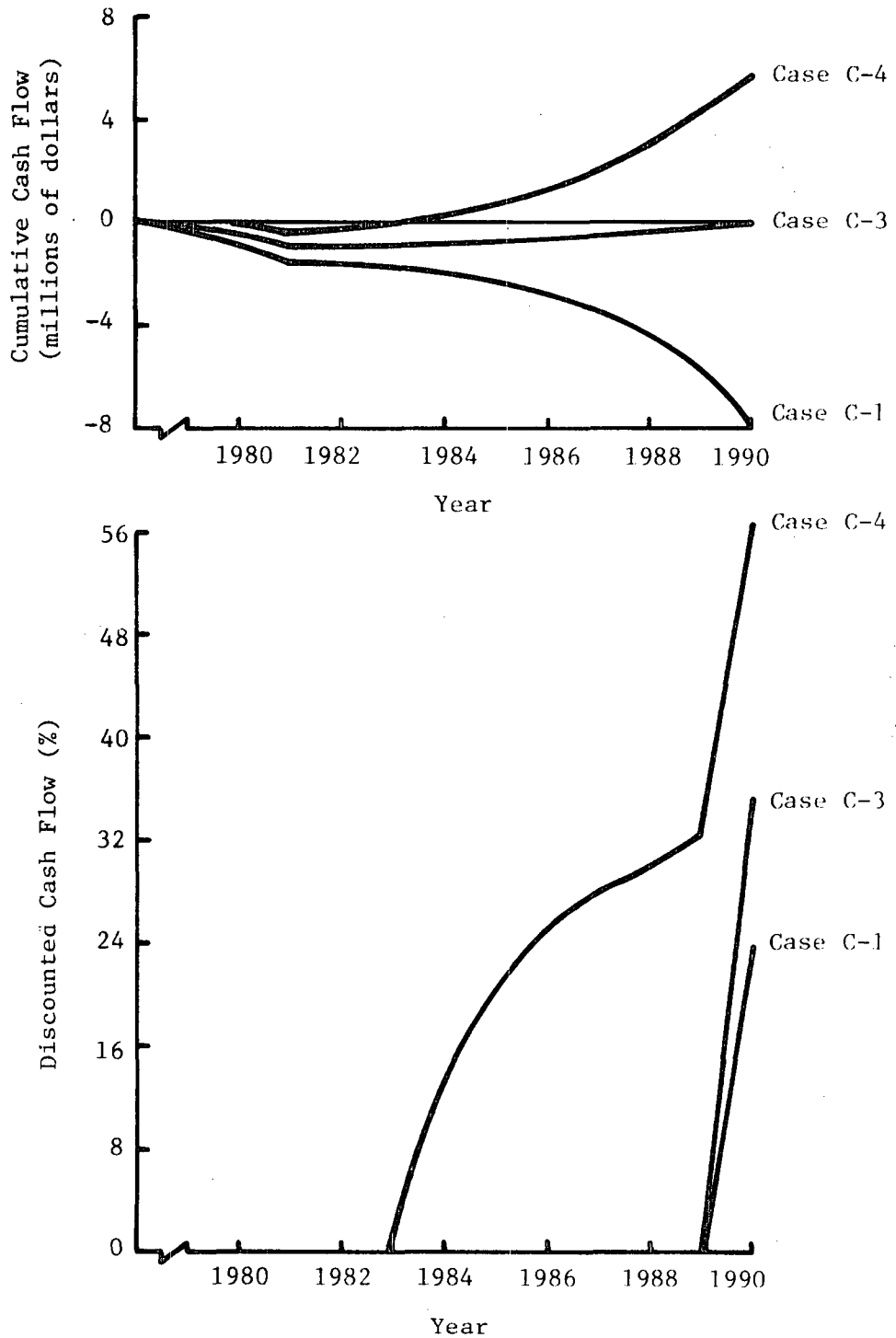

Fig. 6-11 Impact of Reduced Fixed Investment on Cumulative Cash Flow and DCF for Company C with Baseline Business Scenario

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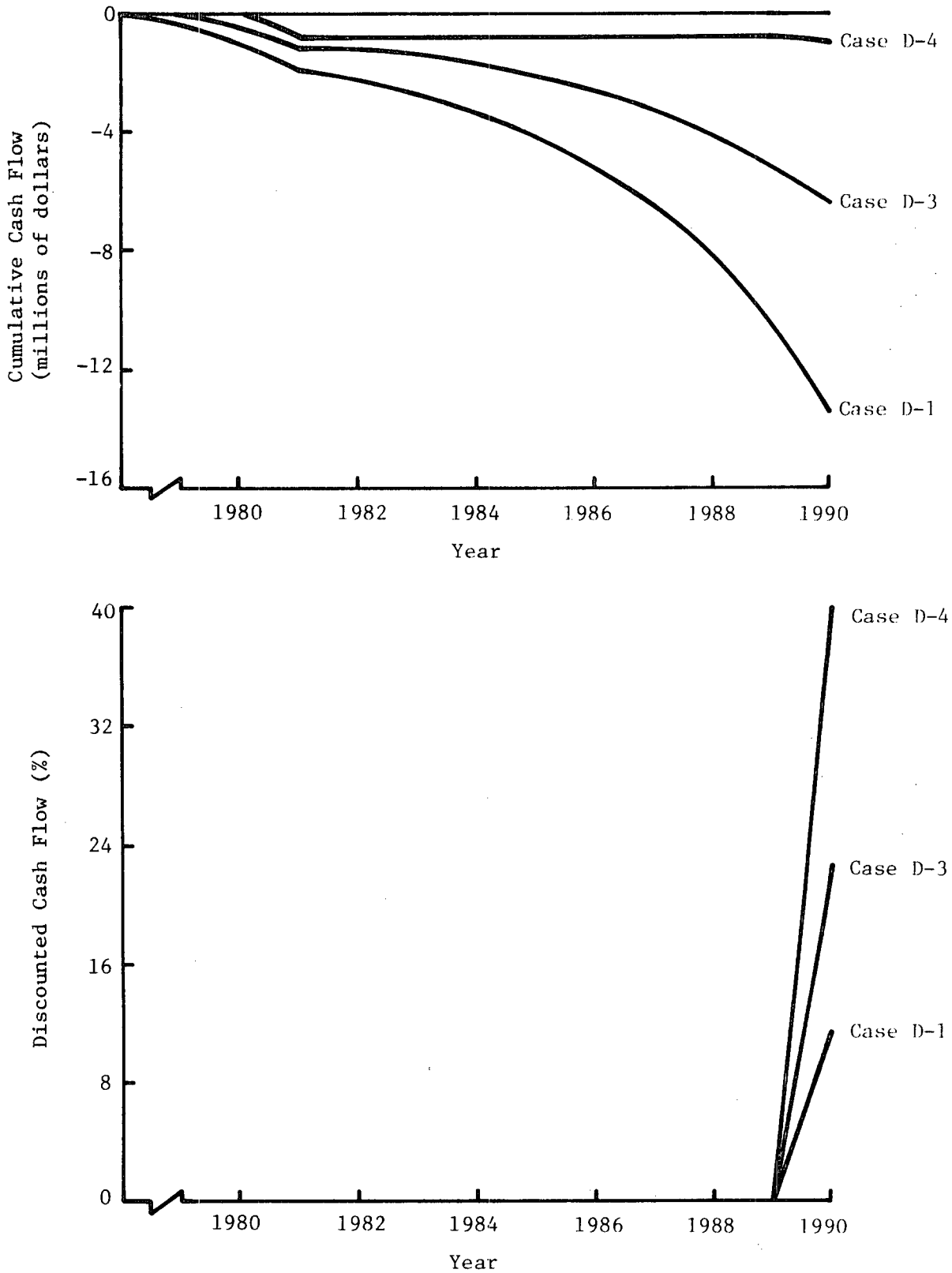

Fig. 6-12 Impact of Reduced Fixed Investment on Cumulative Cash Flow and DCF for Company D with Baseline Business Scenario

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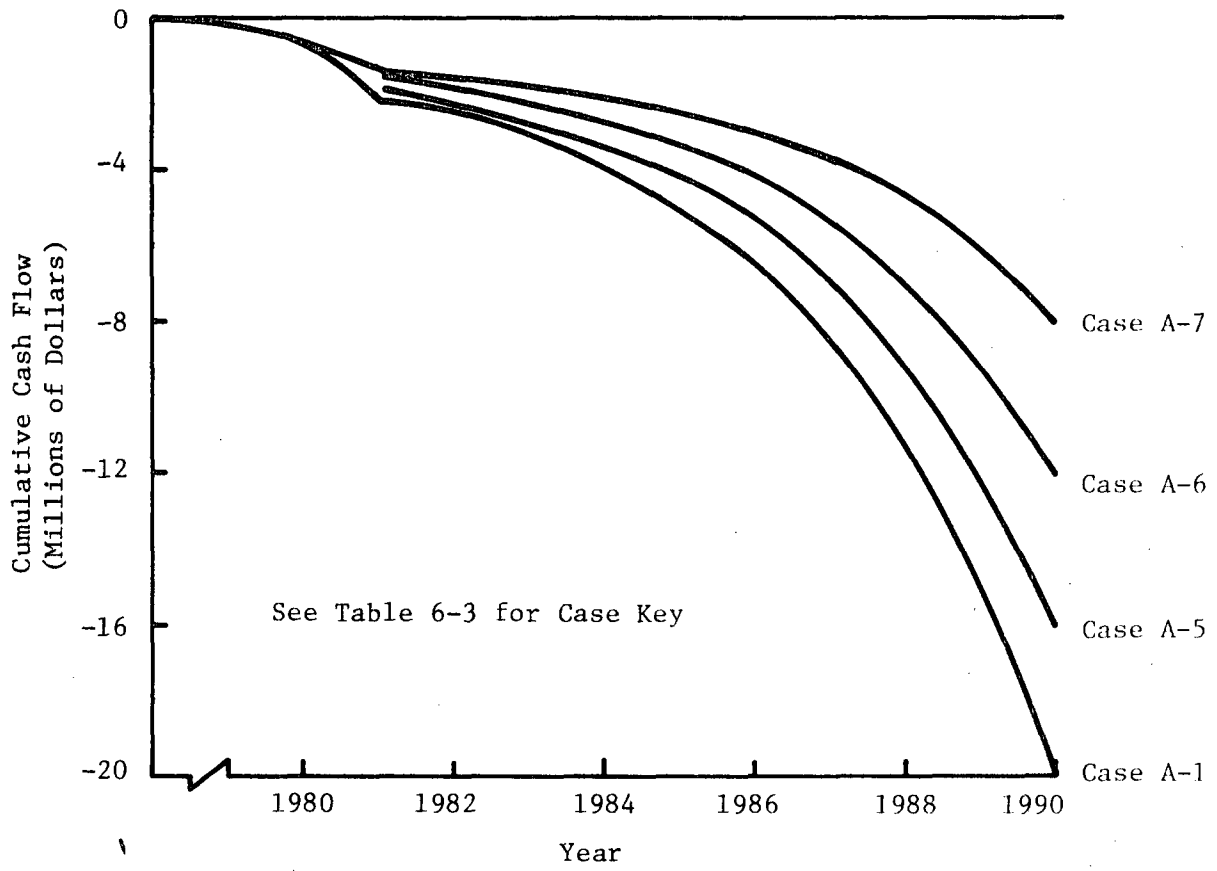

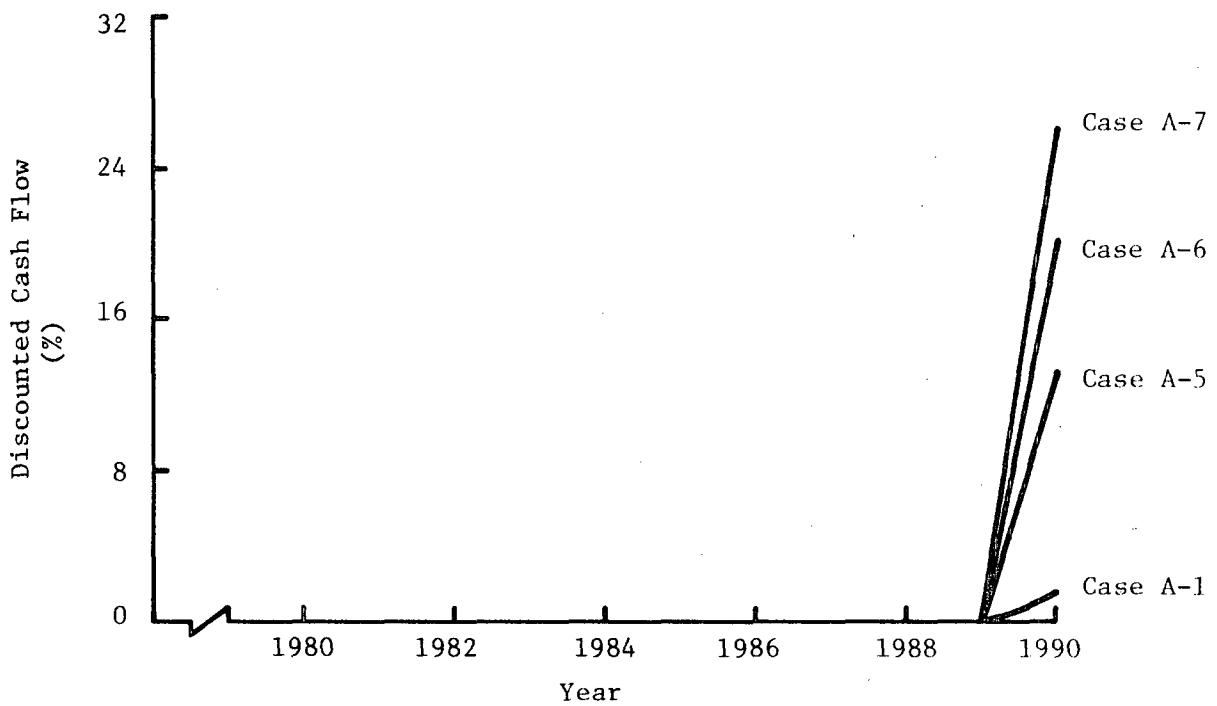

Fig. 6-13 Impact of Improved Profit Margins on Cumulative Cash Flow and DCF for Company A with Baseline Business Scenario

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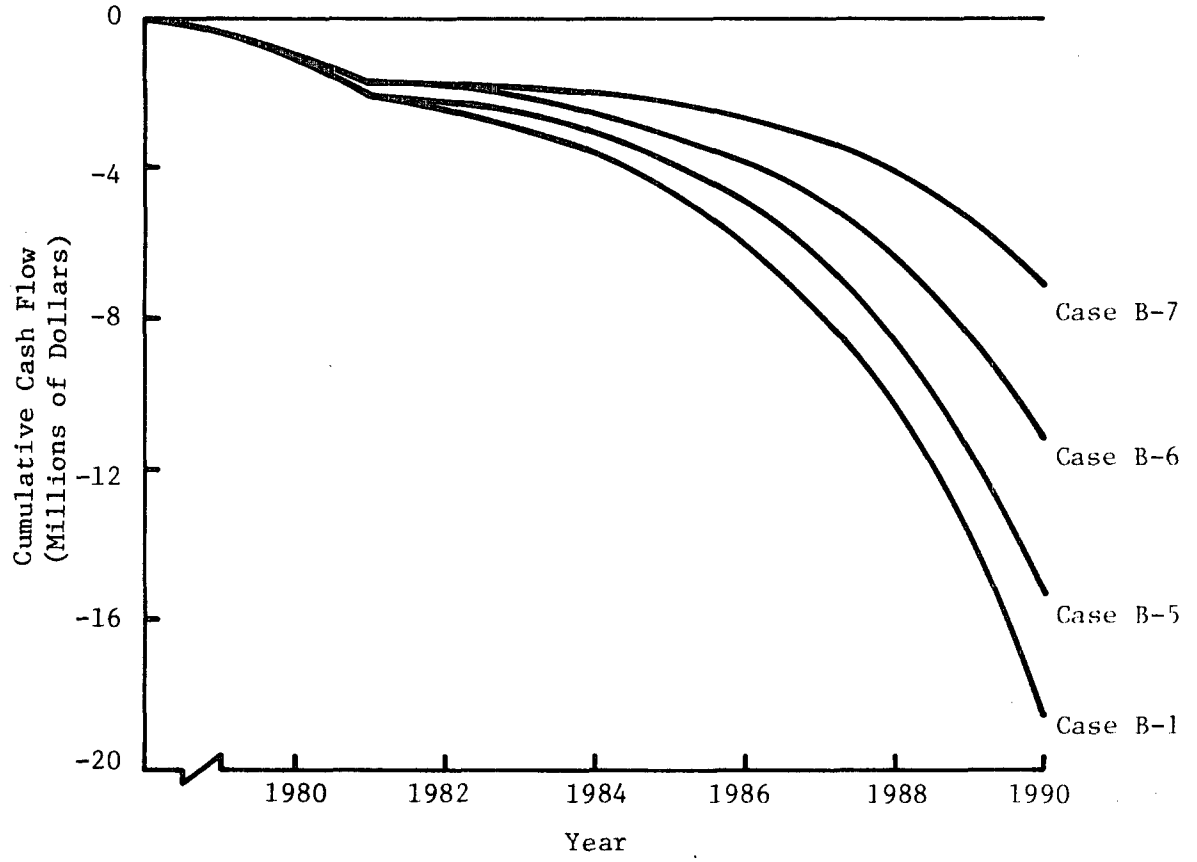

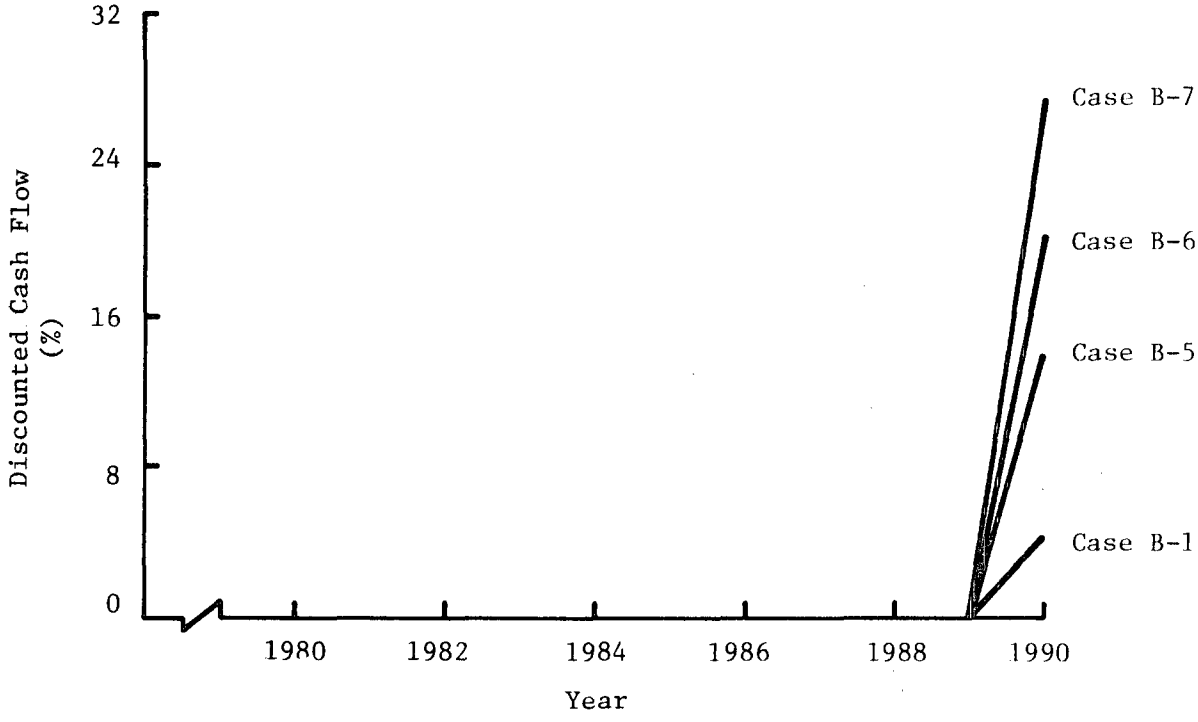

Fig. 6-14 Impact of Improved Profit Margins on Cumulative Cash Flow and DCF for Company B with Baseline Business Scenario

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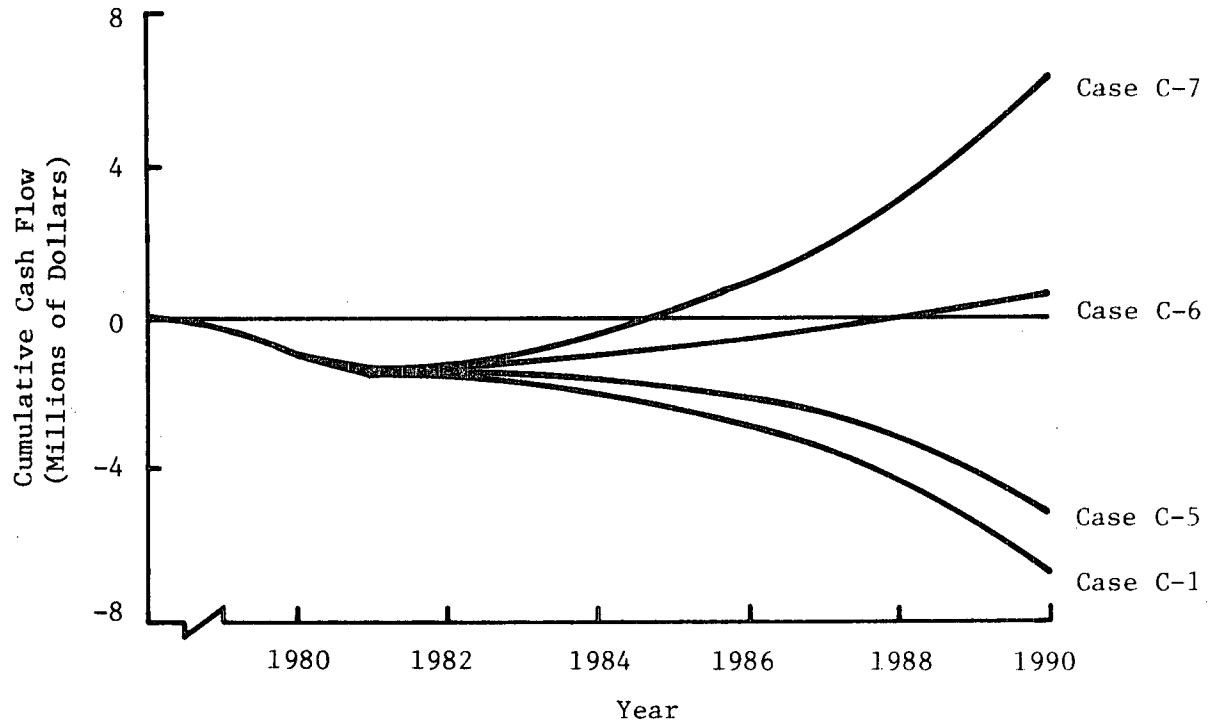

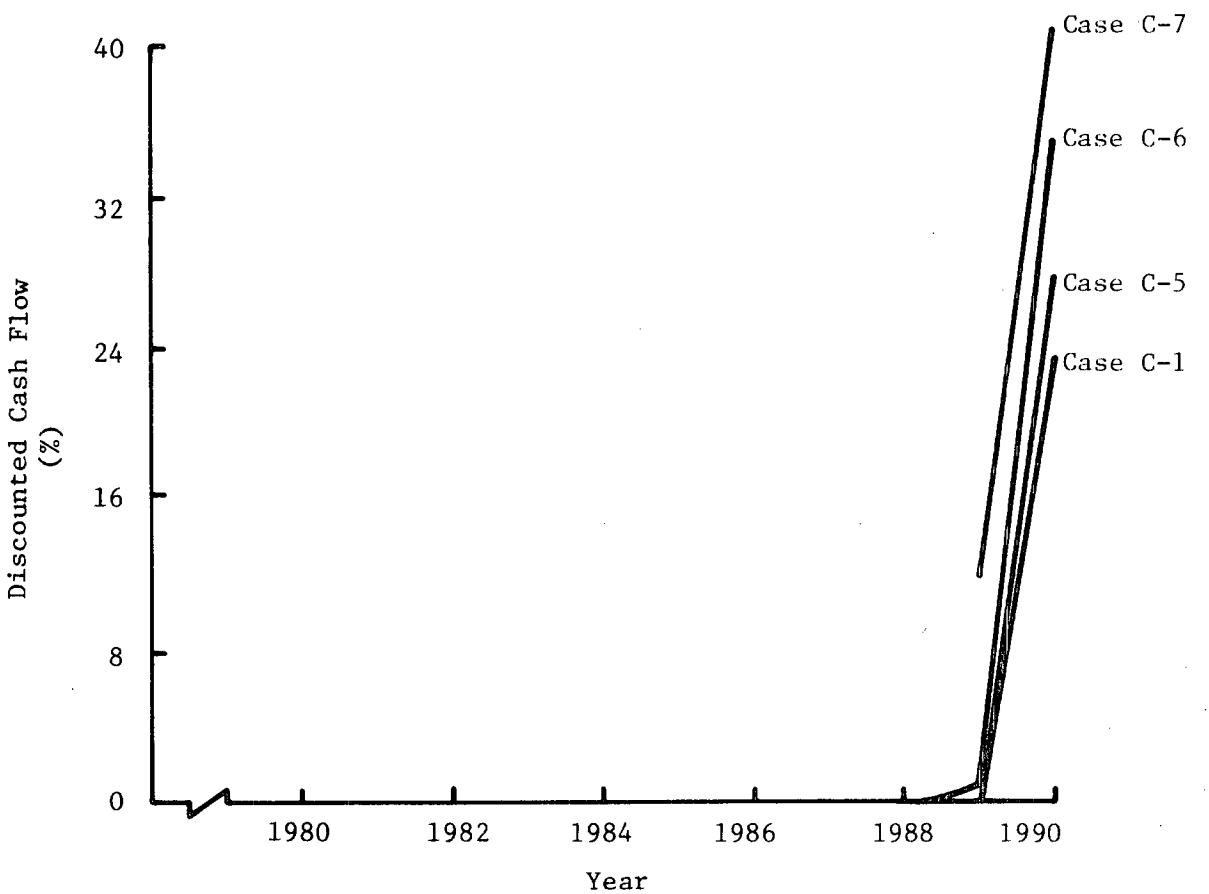

Fig. 6-15 Impact of Improved Profit Margins on Cumulative Cash Flow and DCF for Company C with Baseline Business Scenario

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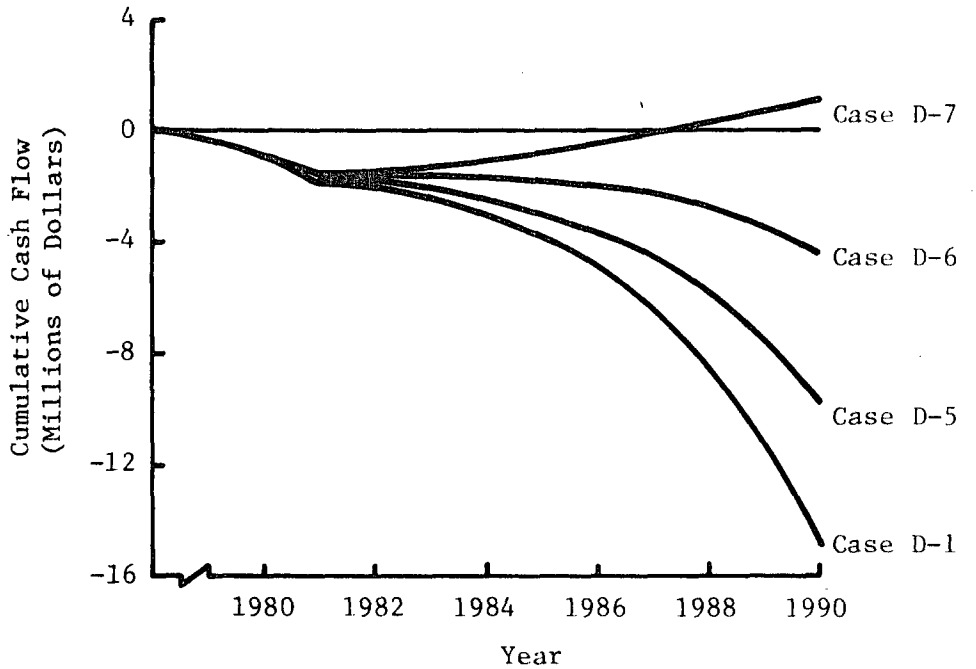

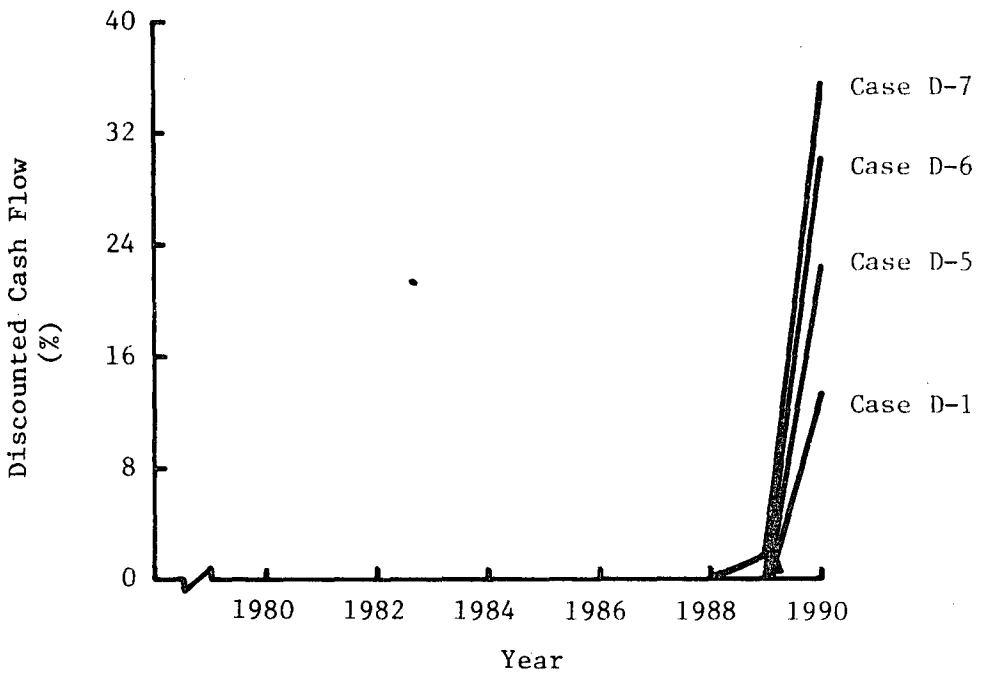

Fig. 6-16 Impact of Improved Profit Margins on Cumulative Cash Flow and DCF for Company D with Baseline Business Scenario

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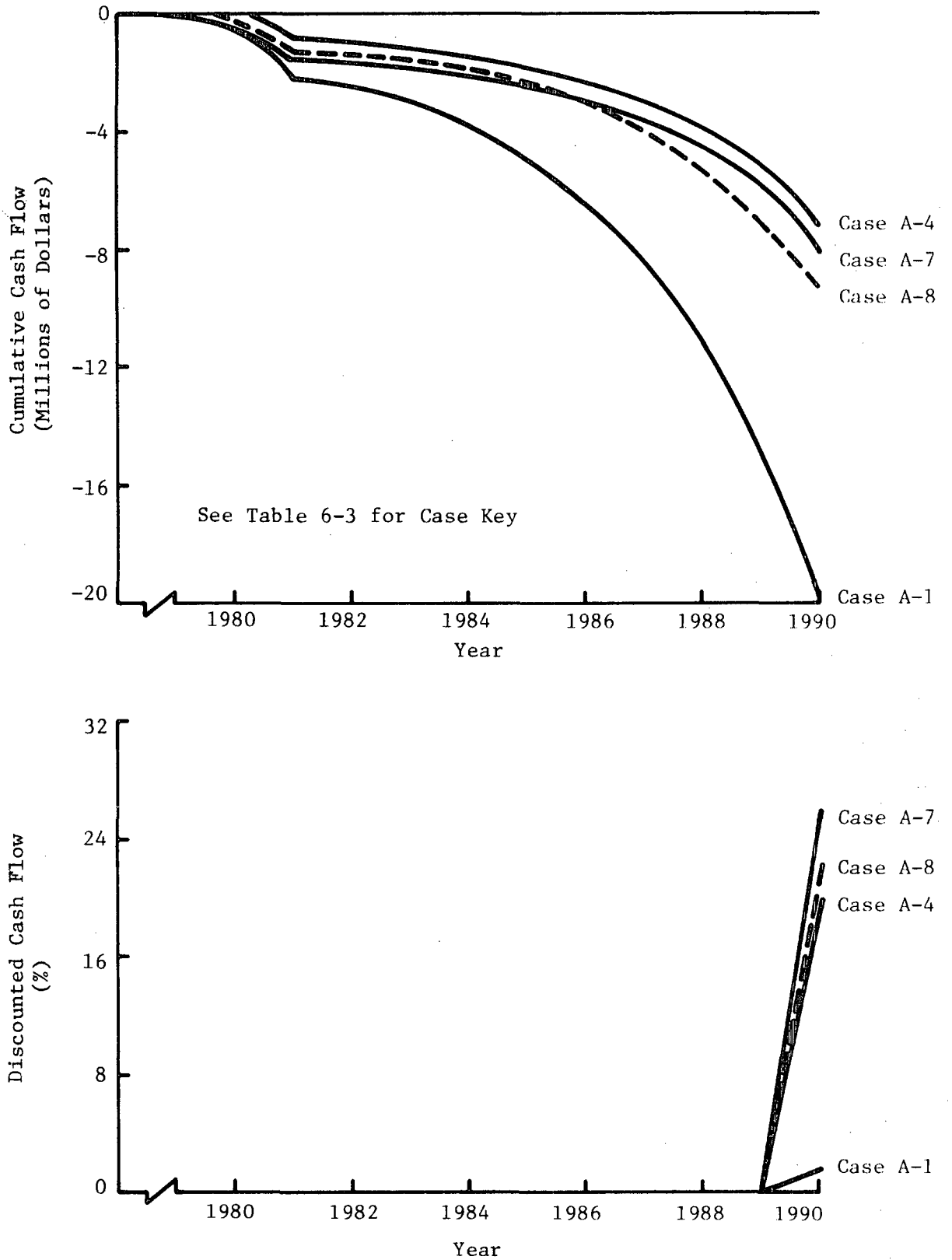
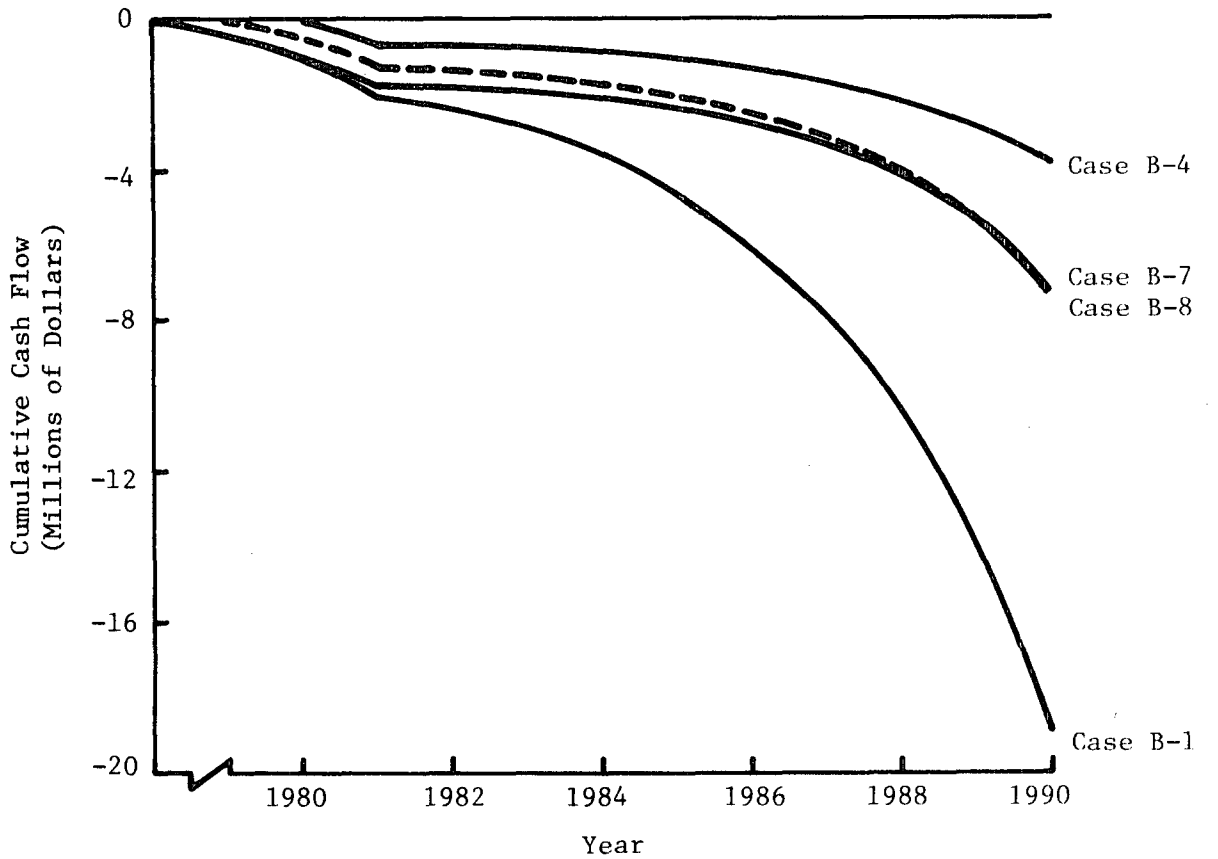


Fig. 6-17 Impact of Combined Changes on Cumulative Cash Flow and DCF for Company A with Baseline Business Scenario



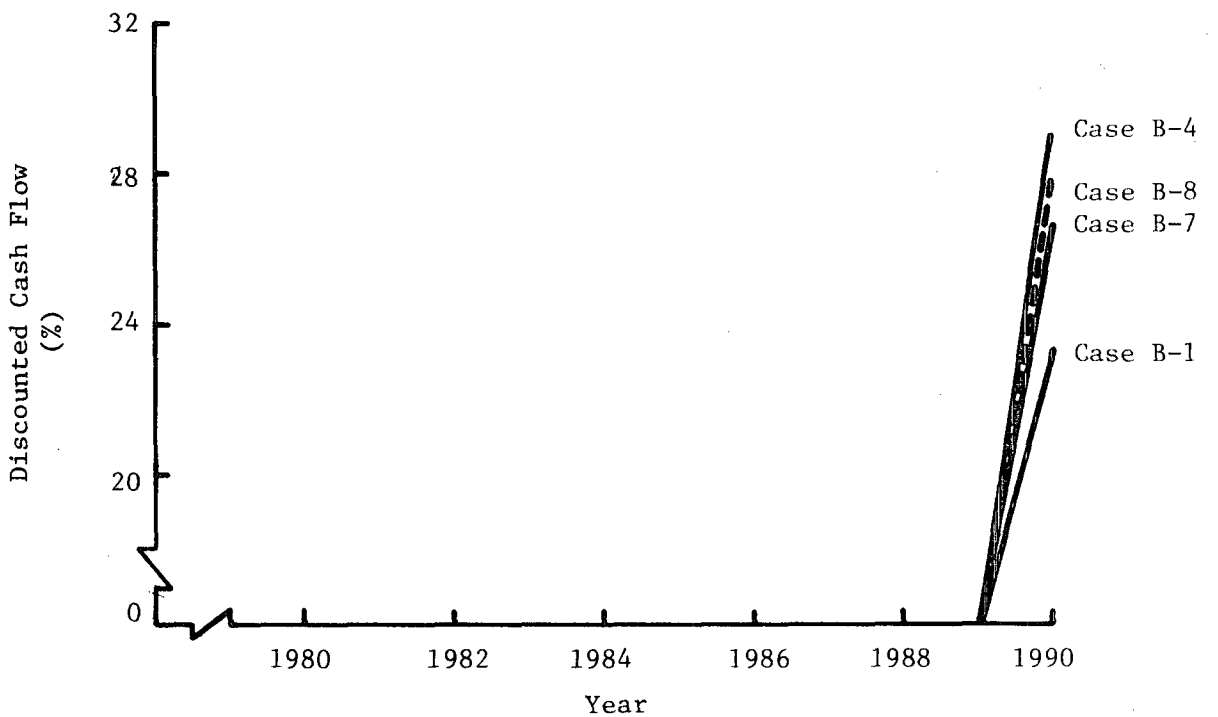


Fig. 6-18 Impact of Combined Changes on Cumulative Cash Flow and DCF for Company B with Baseline Business Scenario

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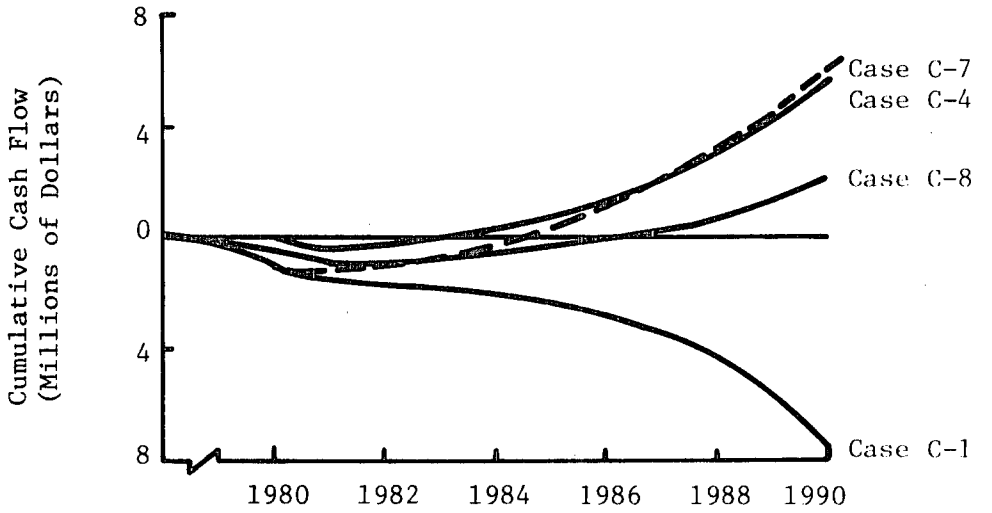

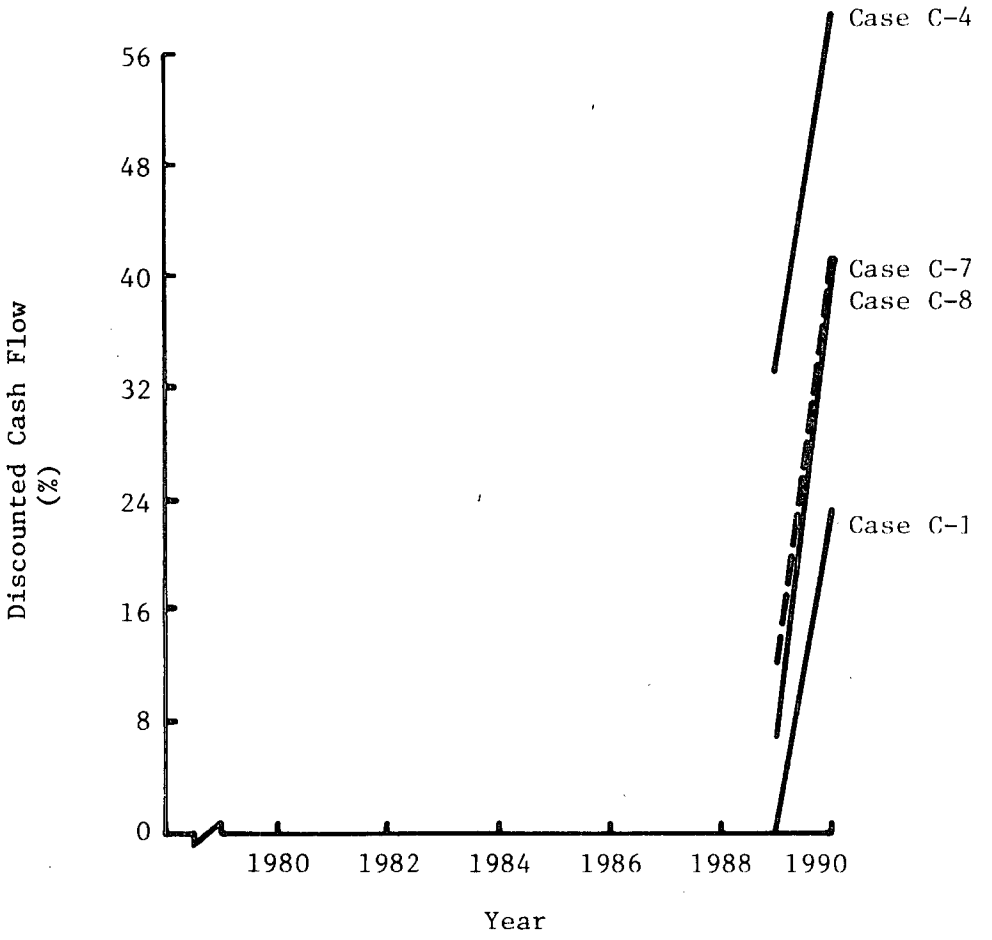

Fig. 6-19 Impact of Combined Changes on Cumulative Cash Flow and DCF for Company C with Baseline Business Scenario

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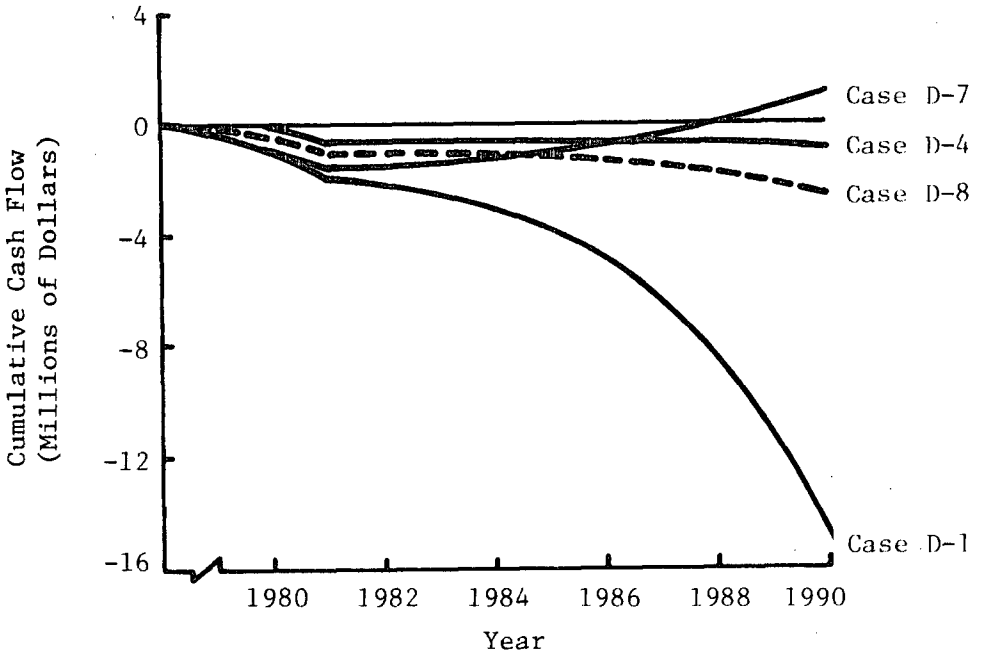

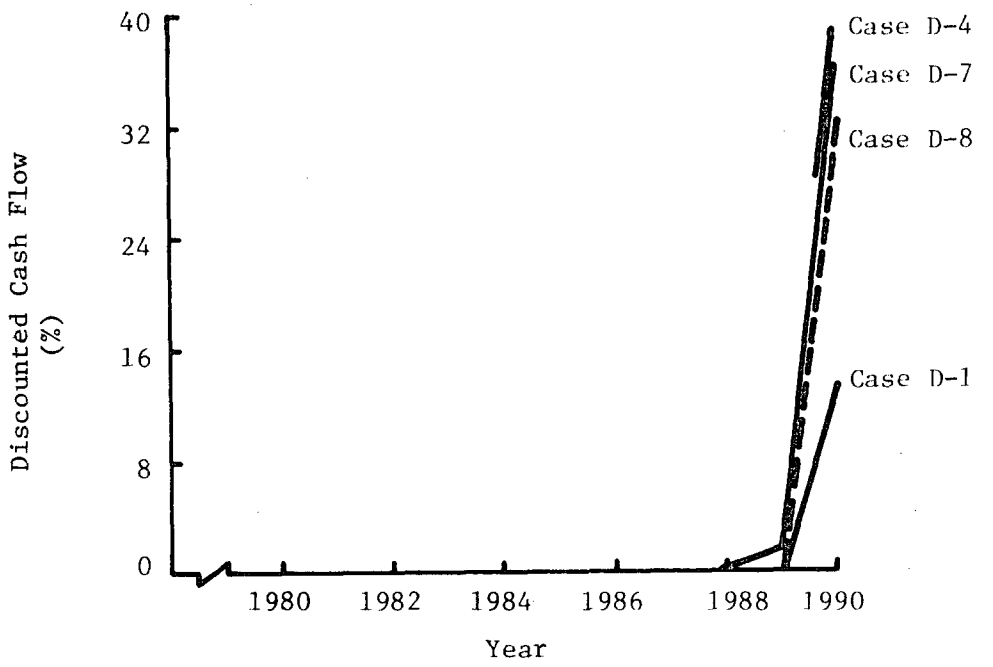

Fig. 6-20 Impact of Combined Changes on Cumulative Cash Flow and DCF for Company D with Baseline Business Scenario

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with reduced cumulative negative cash flows. The cumulative cash flows are still negative and headed to negative infinity. The results for company C do show some encouraging results. Without any new fixed investment the cumulative cash flow does become positive and a very respectable DCF is obtained even without the end valuation. With a 50% reduction in the new fixed investment, the cumulative cash flow is still negative but headed toward a positive value. It is highly unlikely that company C could achieve the increase in sales growth contemplated in the scenario without at least new fixed assets projected at the 50% reduction level. Thus a reduction in fixed asset investments would, in general, not yield a postive result at any resonable level of investment to sales.

It should be noted that in Figures 6-1 to 6-4 and in Figures 6-9 to 6-20 there is a break in the cumulative cash flow curves in 1981. This break is due to the fact that there are no sales in 1979 and 1980, but investments in land, plant, and equipment exist. Once the sales start, there is a cash flow in to offset the required cash flow out which changes the characteristic of the cumulative cash flow curve.

Figures 6-13 to 6-16 present the comparison of increased profit margins. Again, the results are negative for companies A, B and D. Company C could show positive results with a profit margin of 20%. This level of pretax profit margin is not unusual in many industrial product lines, or even in commercial consumer product lines. For example, such a mundane product as water faucets for homes achieves a 20% pretax profit margin. However, the faucet that achieves this profit performance does have a unique feature and a dominant market position. It is difficult to see how the LSM could achieve this level of profit margin. In fact, it is difficult to envision how this level of profit margin can be attained in the HVAC industry for heat pump systems.

Finally, Figures 6-17 to 6-20 present the impact of both increasing profit margin and decreasing fixed investment. The results are similar to the other sensitivity analyses. Only company C shows any potential for positive results.

The basic conclusion of this analysis is that companies in the HVAC industry cannot justify the increased sales as projected for the LSM product with

reasonable values of capital investment requirements and profit margins. This conclusion is based upon a quantitative financial analysis including the cash flows due to operations and the residual value of the business at the end of the evaluation period. The influence of changes in investment requirements and profit margins did not change the conclusion. The only variable which was not changed in these analyses was the sales projections. The verification analysis discussed in Attachment B suggested that the sales growth rate and sales objectives have a significant impact upon the outcome of the quantitative analyses. The sensitivity to sales growth is examined in Section 7.0.

It should be noted that these negative results were obtained with a series of assumptions that are extremely optimistic. The principal overly optimisic assumption is the lack of any start-up or nonreoccurring costs. A simple investment requirement of $1,000,000 at the beginning of the project would be equivalent to an end period valuation of $8,900,000 with a 20% discount factor. These types of start-up costs would make the results of all the scenarios not only uneconomic relative to reasonable investment criteria, but absolutely uneconomic in that there would never be a return with reasonable investment criteria.

7.0 SALES SENSITIVITY ANALYSIS

7.1 Impact of Sales Growth

It is well known that money in the form of investment is required to support sales growth. This is simply the old adage, "It takes money to make money." However, the results discussed in the previous section suggests that there is an economic limitation to how fast a company or business can grow. The objective of this section is to evaluate the impact of sales growth upon the economic viability of a product or business. The first part of this section will explore the general impact of sales growth on cash flows. The second part conducts a sensitivity analysis of sales growth patterns upon the profitability of a hypothetical HVAC company.

The first step in the general evaluation of the impact of sales growth on a company or product line was to subject a very simplified model of the firm to a steady sales growth. The assumptions that were made are that no nonreoccurring costs associated with the sales growth exist and that all fixed assets are obtained in the year in which the sales growth requires them.

Table 7-1 presents an example of this simplified model with two years of sales. The sales growth is 20% and the after-tax profit margin is set at 5% of sales. An assumption was made that the noncash expenses related to depreciation charges are equal to 1% of sales. Thus, the business will generate a cash flow into the business equal to 6% of sales, which is typical of the HVAC companies. A 20% increase in sales results in a 20% increase in total cash flow. This increase is shown in Table 7-1.

The impact on cash flow into the company to support the expanded sales is also shown in Table 7-1. The working capital requirements are taken as 29% of sales, and the fixed investment as 18% of sales. Again, these values are typical of the HVAC companies. To support the 20% sales growth, the working capital must increase by $58 and the fixed investment by $36. The combined required cash flow in is $94, but the cash flow generated by the business is only $72. Thus, in order to support the 20% sales growth, the company must go outside the company, either to the stockholders or banks, for $22. As

TABLE 7-1

SIMPLIFIED EXAMPLE OF THE EFFECT OF SALES GROWTH RATE ON VENTURE ECONOMICS

	Year	
	1	2
Sales Volume	1000	1200
Profits (5% of Sales)	50	60
Depreciation (1% of Sales)	10	12
Total Funds from Business	60	72
Change in Working Capital (29% of Sales)	-	58
Change in Plant Investment (18% of Sales)	-	36
Total Funds for Business		94
Surplus (Deficit) of Funds		(22)

long as the sales grow at 20%, this company will have to obtain more and more money from the outside. In other words, the cumulative cash flow is negative and will continue to be negative.

Figure 7-1 shows the impact of various sales growth rates on the cumulative cash flow. This plot suggests that there is a sales growth rate beyond which the business will not show a return. The value of this growth rate can be calculated as follows. The basic criterion is that the sales cash flow in equals cash flow out. This calculation is written as follows:

$$\text{(Cash flow in)} = \text{(Cash flow out)}$$

$$(\text{Sales})_t \times [(\text{After tax profit}) + (\text{Depreciation})] = [(\text{Sales})_t - (\text{Sales})_{t-1}] \times [(\text{Working Capital}) + (\text{Fixed Assets})]$$

The realtionship between the sales in the two years can be defined as:

$$(\text{Sales})_t = (\text{Sales}) + (\Delta\ \text{Sales})$$

$$(\text{Sales})_t - (\text{Sales})_{t-1} = (\Delta\ \text{Sales})$$

Substituting this back and simplifying, the following is obtained:

$$[(\text{Sales}) + (\Delta\ \text{Sales})] \times [(\text{After-tax profit}) + (\text{Depreciation})] = (\Delta\ \text{Sales}) \times [(\text{Working Capital}) + (\text{Fixed Assets})]$$

OR

$$\text{Sales Growth} = (\Delta\ \text{Sales})/(\text{Sales}) = \frac{(\text{After-tax profit}) + (\text{Depreciation})}{[(\text{Working Capital}) + (\text{Fixed Assets}) - (\text{After-tax profit}) - (\text{Depreciation})]}$$

This relation is repeated in Table 7-2. Applying this relation to the specific values in Table 7-1 and Figure 7-2 shows that the maximum sales growth rate to attain a positive cumulative cash flow is 14.6%.

The average sales growth rate for the baseline business scenario in Section 6.0 is 35%. The results of the analysis above show that beyond a growth rate of about 15%, the HVAC companies will sustain a negative cumulative cash flow. This is exactly what happened.

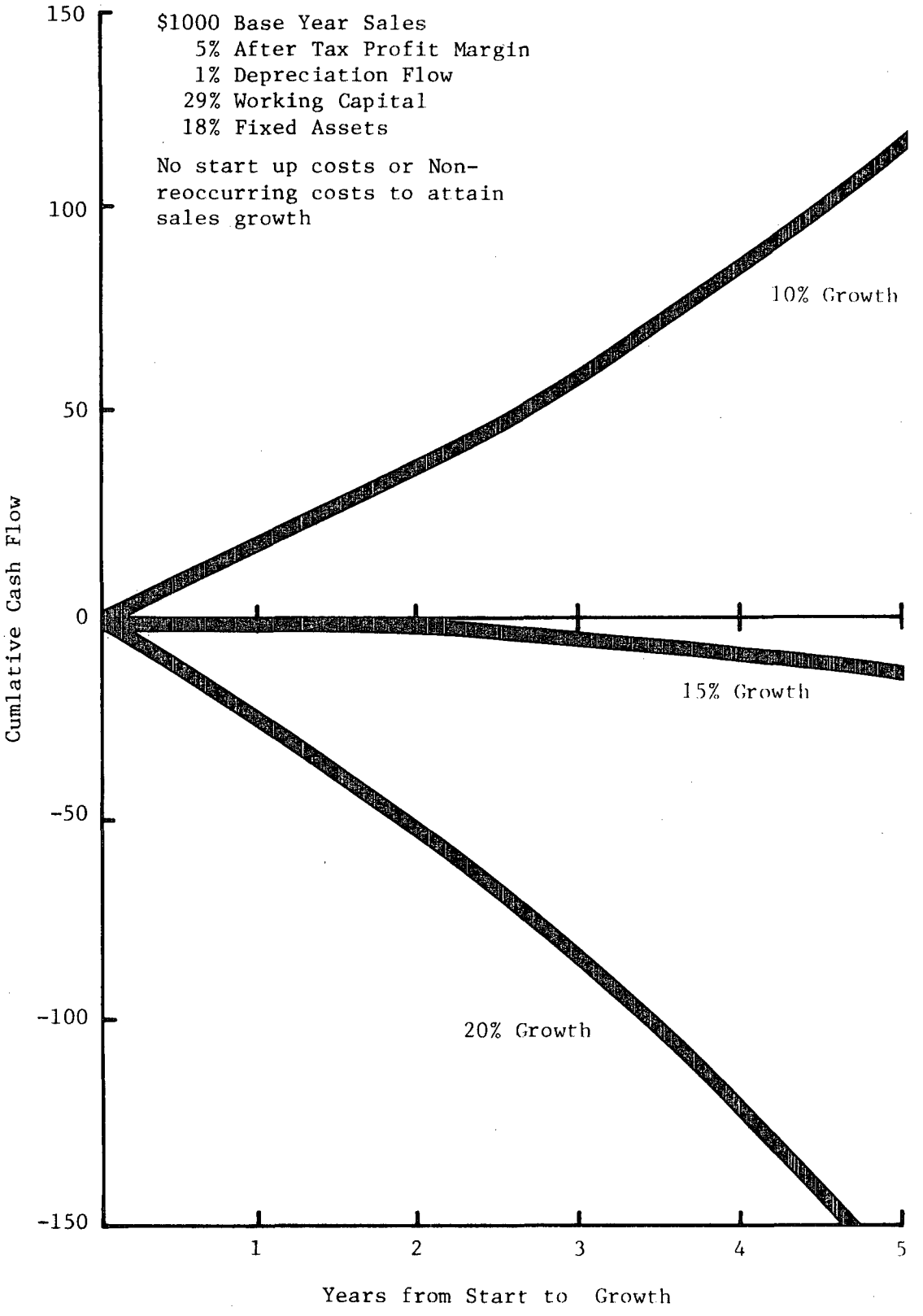

Fig. 7-1 Comparison of Cumulative Cash Flow as a Function of Sales Growth

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TABLE 7-2

LIMITATION OF BUSINESS GROWTH
WITH NO START-UP COSTS

$$\left\{\begin{array}{l}\text{Maximum Allowable}\\ \text{Sales Growth}\\ \text{Rate for Positive}\\ \text{Cash Flows}\end{array}\right\} = \frac{\text{(After Tax Profit + Depreciation)}}{\left(\begin{array}{l}\text{Working Capital + Fixed Assets}\\ \text{- After-Tax Profit - Depreciation}\end{array}\right)}$$

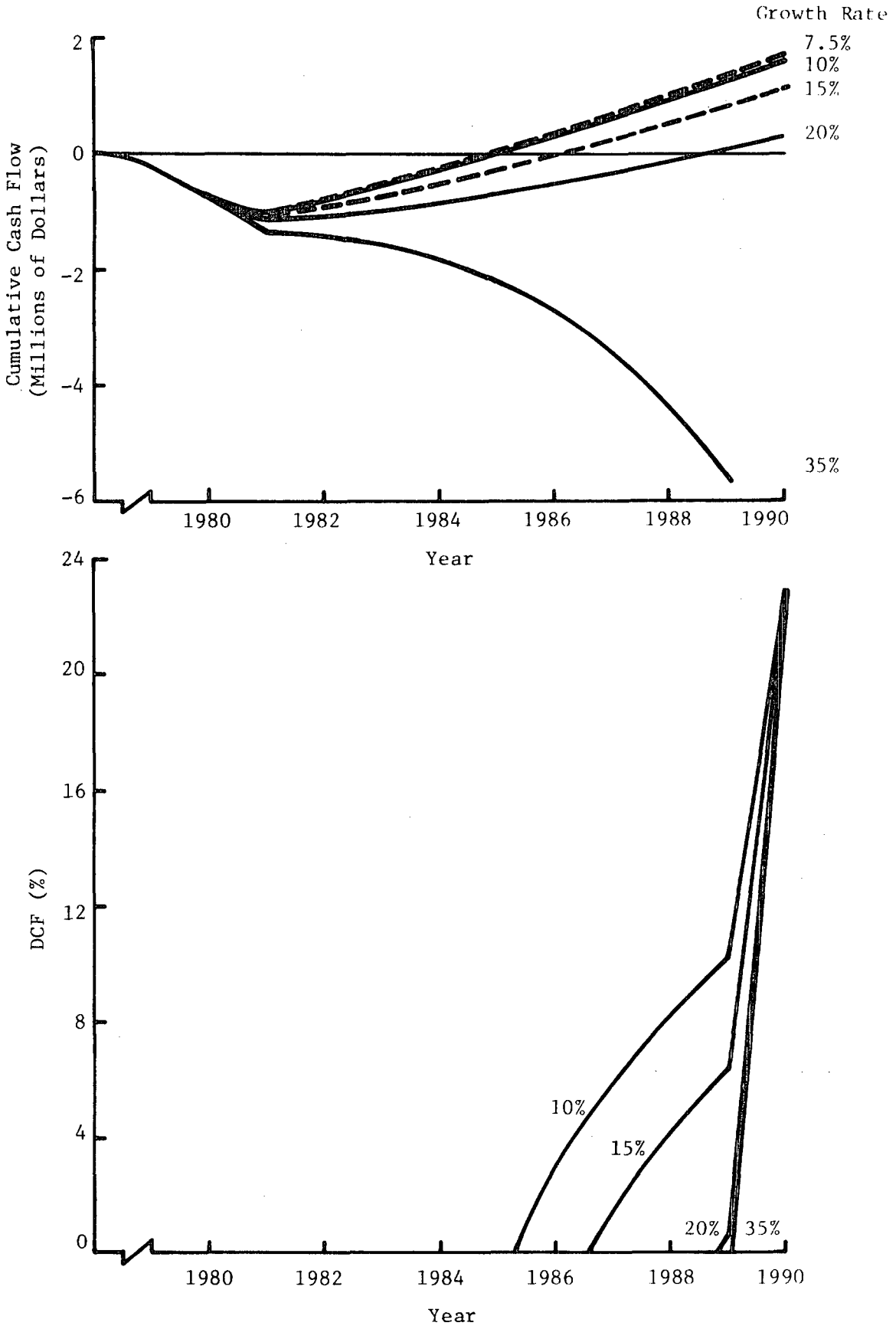

Fig. 7-2 Cumulative Cash Flow and DCF Variation with Time for Different Growth Rates

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The relation in Table 7-2 can be used to determine what the value of profit margin and fixed assets are needed to sustain a growth rate of 35%. These relations are:

$$\text{After-tax Profit} = \frac{\left\{\begin{array}{l}[(\text{Growth})\text{x}(\text{Working Captial}) + (\text{Fixed Assets})] \\ \quad - [1 + (\text{Growth})]\text{x}(\text{Depreciation})\end{array}\right\}}{[1 + (\text{Growth})]}$$

$$\text{Fixed Asset} = \frac{\left\{\begin{array}{l}[1 + (\text{Growth})]\text{x}[(\text{After-tax Profit}) + (\text{Depreciation})] \\ \quad - (\text{Growth})\text{x}(\text{Working Capital})\end{array}\right\}}{\text{Growth}}$$

Using the values as shown in Table 7-1 and a 35% growth rate, the after-tax profit margin required is 11.1% and the fixed asset ratio is -5.8%. The after-tax profit margin corresponds to a 23.1% pretax margin as used in Section 6.0. Again, these results correspond with the analysis in Section 6.0. Profit margins of 25% were needed in Section 6.0 to result in a positive cash flow. A fixed asset ratio of zero was not adequate to produce a positive cash flow in Section 6.0. The analysis here suggests that somehow fixed assets must be created as part of the production process in order to get a positive cash flow with the values assumed for the other parameters. This creation of fixed assets is impossible.

With this clear indication of the impact of sales growth upon the business potential outcome as shown in Table 7-3, the business potential analysis was reevaluated with different growth rates and sales growth patterns.

7.2 Alternate Sales Scenarios

The impact of various sales growth scenarios was tested with a hypothetical HVAC company. The values of profitability, working capital, and fixed asset accounts were selected to approximate the best that might be expected for such a company as presented in Table 7-4. All values except profitability are comparable to the four firms examined in Section 6.0. An improved profitability was assumed for the hypothetical company. Since no start-up costs were assumed, the actual level of sales or cash flows is not important. However, the growth patterns and trends are important. Therefore, a base year sales of 10 was taken, starting in 1981. The base sales was grown at a number of

TABLE 7-3

SALES GROWTH IMPLICATIONS

- Without start-up costs, there is a sales growth rate above which the business cannot generate a positive cash flow

- With start-up costs, the absolute level of sales, as well as sales growth, define the economic limits of sales growth

TABLE 7-4

COMPARISON OF FINANCIAL RATIOS
USED FOR HYPOTHETICAL FIRM

Financial Ratio	Company				
	A	B	C	D	Hypothical E
Pretax Profit Margin	10.01%	10.53%	12.89%	10.54%	15.0%
Working Capital Ratio	36.52	29.36	15.15	21.89	20.0
Fixed Asset Ratios					
Land	0.91	0.71	0.69	0.57	0.7
Buildings	9.76	15.63	6.20	8.02	8.0
Equipment	23.62	18.53	19.20	18.97	20.0
Maximum Theoretical Allowable Growth Rate*	7.93	9.32	19.41	12.46	19.07

* Depreciation cash flow is ignored in these values.

different constant rates of growth over the entire evaluation period until 1993. Three ramp type growth rates were also evaluated. In the ramp sales scenario, the sales were grown over five years at the rate necessary to equal values achieved by a constant growth rate in 1993. After the five-year accelerated growth, sales were then kept constant. The cases considered are presented in Table 7-5. Also noted in Table 7-4 is the value of growth that would show a break-even point in the cumulative cash flow by the equation in Table 7-2.

The results of the effect of constant growth rate are shown in Figure 7-2. The cumulative cash flow and DCF with an end valuation are presented as in Section 6.0. Figure 7-2 shows that the cumulative cash flow becomes more positive as the sales growth rate decreases. The change in DCF cannot be readily seen in Figure 7-2. Figure 7-3 presents the values of DCF with and without valuation and the cumulative cash flow in 1990 as a function of sales growth rate. This figure clearly shows the impact of sales growth rate. Both the cumulative cash flow and the DCF without valuation decrease with increasing sales growth. The DCF with the end point valuation, however, increases slightly with growth rate. This apparent anomaly is the result of the fact that the end valuation depends on the profit in 1990. At higher growth rates, the profits are higher and the valuation is higher in dollar terms. This increase offsets the increased negative cumulative cash flow in such a way that the DCF remains about constant. An interesting point is that the break-even growth rate is about 21.8% while the equation in Table 7-2 predicts a break-even growth rate of 19.1%. The difference can be accounted for by the impact of investment tax credits and the inclusion of depreciation.

The comparison of the cumulative cash flow in Figures 7-1 and 7-2 shows that the cash flow in Figure 7-1 lacks the characteristic "bathtub" shape. This is due to the fact that investment is made simultaneously with its need in the calculation for Figure 7-1. As noted, the investment in fixed assets leads the sales growth for the computation in Figure 7-2. Also, there are two years without any sales in the data in Figure 7-2.

TABLE 7-5

SALES GROWTH RATE SCENARIOS CONSIDERED

Type	Values	Comment
Constant	7.5%, 10%, 12.5%, 15% 20%, 35%	Simple Growth Rate for Break Even Cumulative Cash Flow by Equation in Table 7-2 is 19%
Ramp	55% for Five Years, Then Zero	Equivalent Sales in 1993 to 20% Constant Growth
	40% for Five Years, Then Zero	Equivalent Sales in 1993 to 15% Constant Growth
	25% for Five Years, Then Zero	Equivalent Sales in 1993 to 10% Constant Growth

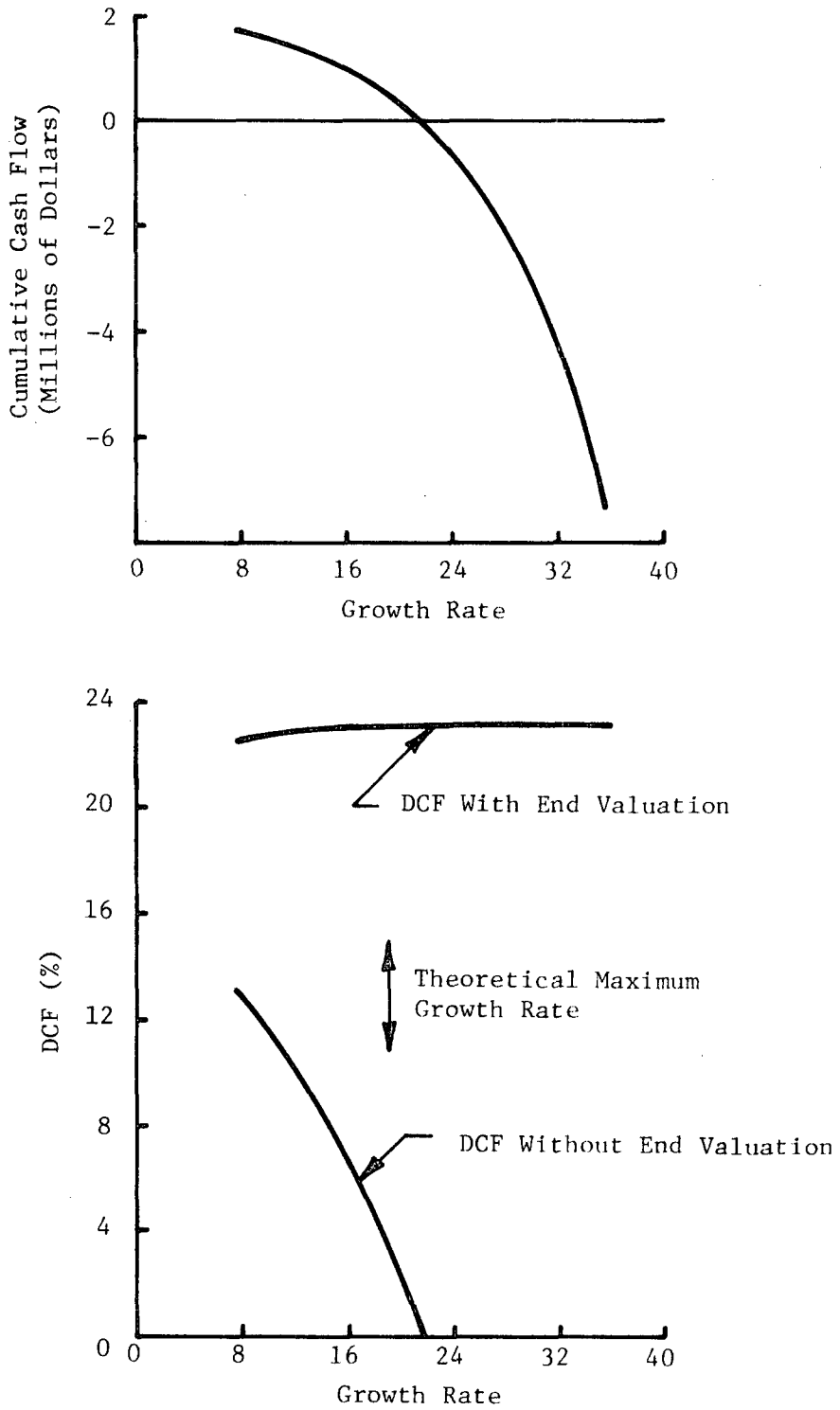

Fig. 7-3 Variation of 1990 Cumulative Cash Flow and DCF with Sales Growth Rate

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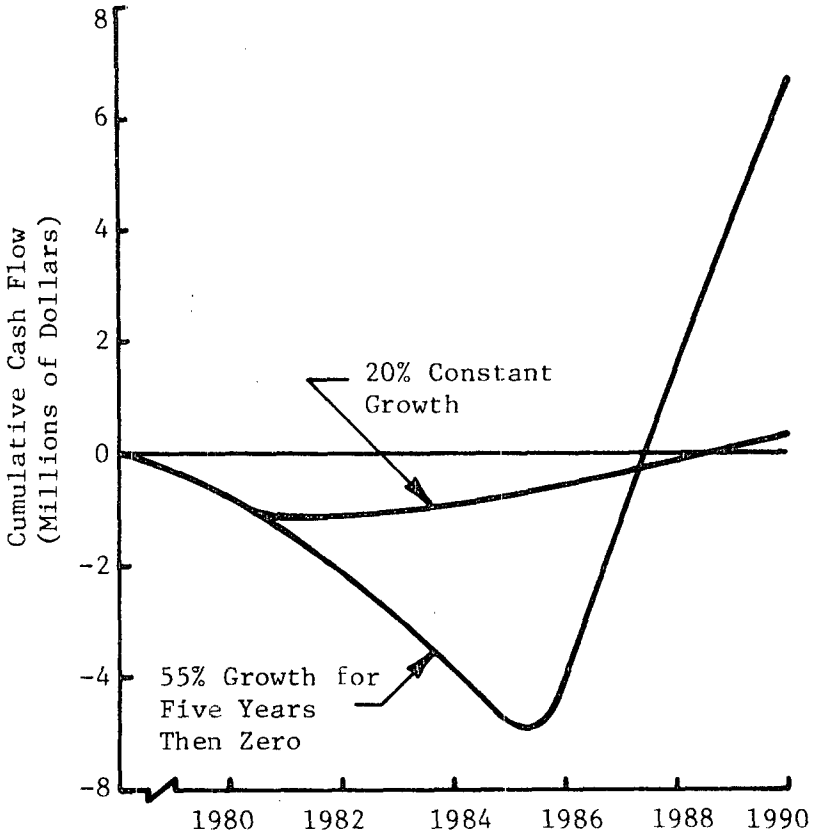
The impact of a ramp type growth pattern is shown in Figure 7-4. These data are only for the 55% growth ramp and its equivalent 20% growth case. The interesting features are that the maximum negative cumulative cash flow is greater for the ramp case, but it shows an earlier break-even point and a higher positive cumulative cash flow in 1990. There is very little difference in the DCF with end valuation in 1990. There is, however, a very large difference in the DCF without valuation.

Figure 7-5 presents the cumulative cash flow and DCF without valuation for the constant growth and the ramp growth cases. The ramp growth is considered equivalent to the average annual growth rate in sales from 1981 to 1993. The data in Figure 7-5 are extremely interesting. While, as seen in Figure 7-3, the constant growth rate scenario shows that a growth rate beyond about 21.8% results in no return, the ramp growth scenario does not show any maximum growth rate restrictions. The conclusion reached is that from a DCF basis, a ramp growth is the preferred strategy. However, the risks associated with this strategy are great since the maximum negative cumulative cash flow is so much greater. Also, it is unlikely that the HVAC market will permit such a penetration strategy. An interesting study would be to examine other product areas to see if such marketing strategies are possible. This strategy would be expected in soft consumer goods such as shampoo and clothing (women's fashions particularly), but may not be the case in either consumer durable goods or industrial goods. Such a study was beyond MTI's obligations to the program.

The sales growth strategy may be the most dominant variable in the determination of the business potential of a new product. In the case of the LSM, there is no indication that the market will permit a ramp growth or that any company would accept the financial risk, Therefore, expansive sales growth variations were not considered further. The analysis in Attachment C presents a controlled nonexpansive sales growth option.



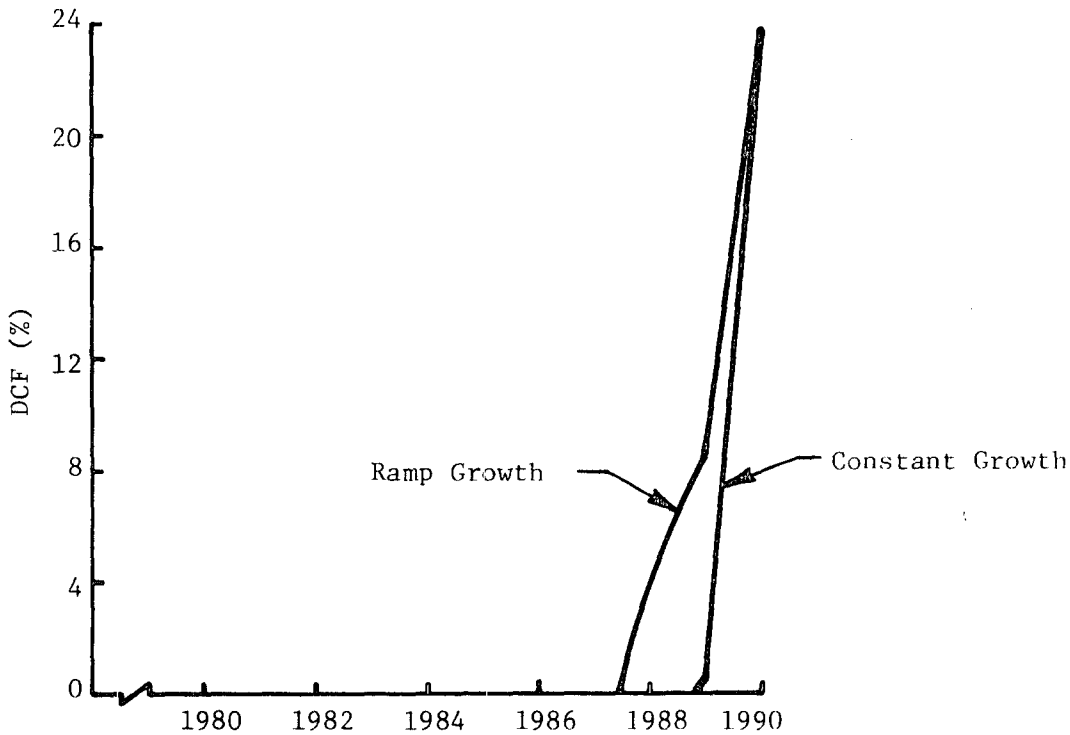


Fig. 7-4 Comparison of Growth Scenario on Cumulative Cash Flow and DCF

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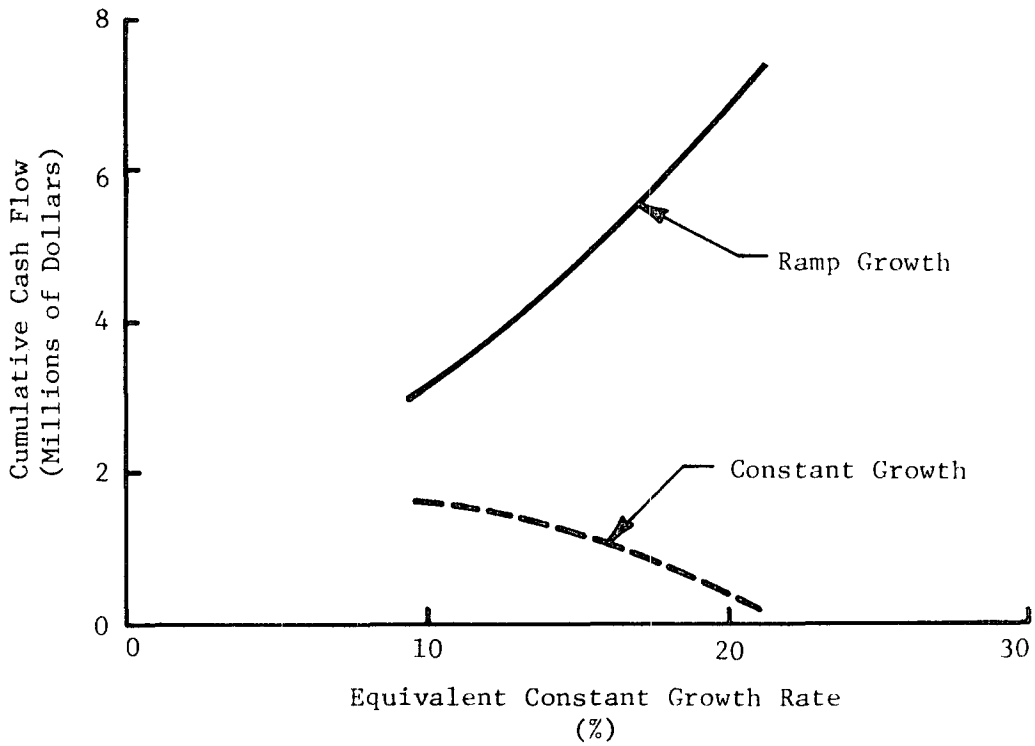

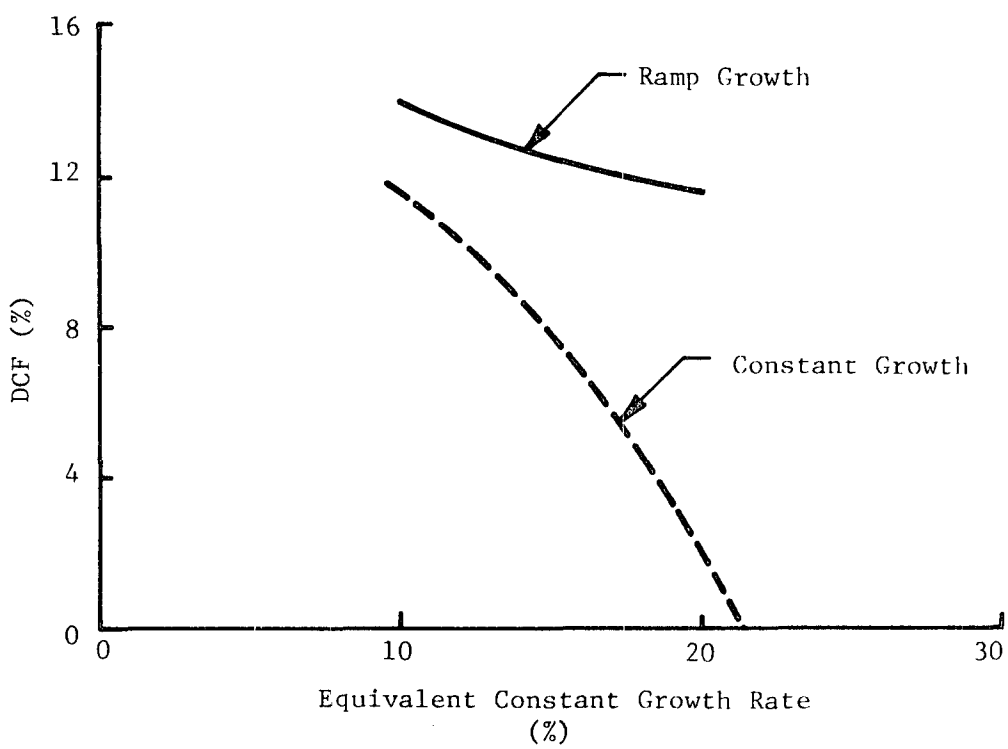

Fig. 7-5 Impact of Variations of Growth Scenarios on Cumulative Cash Flow and DCF without Valuation in 1990

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8.0 ENTREPRENEURIAL ANALYSIS

A number of firms in the HVAC industry offer products that are not applicable to the mass HVAC market. These products provide special features or functions at prices that clearly fall outside the range specified as being desirable in the market studies conducted as part of this heat pump development program. It was further observed that the firms offering these products are typically entrepreneurial in nature. That is, they are either true entrepreneurial new businesses or specialty divisions of larger companies not in the HVAC business. The existence of these firms suggests that an innovation may possibly be introduced by a firm with limited market objectives. While such a limitation in market objectives will not satisfy the objectives of DOE for energy conservation, the successful introduction of a true energy conservation innovation into the HVAC market might result in changes in the bulk of the market to affect energy conservation. That is, the success of an entrepreneurial firm might help change the market environment such that functional equivalents to the innovation will be introduced by the dominant firms in the market. The market share or sales volume of each firm will not change significantly since no one will have an exclusive position. The impact of sales growth will be removed and the basic evaluation criteria changed. Then, rather than justifying an expansive new product, the companies would be faced with a defensive market decision. As shown in Section 5.0, defensive investments are often made without a DCF criteria limit.

In developing the entrepreneurial firm, an assumption was made that this firm would be a division of a larger firm so that some of the early production could be "boot-strapped". Also, the advantage of the early losses can be offset against current income. The former assumption limits capital expenditures early in the development of the business. The latter assumption makes the government a de facto partner by absorbing 48% of the start-up losses. The sales objectives and growth were limited by a number of factors. A new firm in the business simply could not serve the full national market. The product pricing, based on a limited production and an above average (for the HVAC industry) profit margin objective, will result in a very high product premium. The high premium will limit the potential market to those building types in those geographic regions that will show the highest return. This market will be

further limited to those buyers who are early innovators and/or exclusively life-cycle cost sensitive. Some start-up costs were explicitly included in the evaluation of the entrepreneurial firm. The start-up costs and fixed plant investment requirements were derived from a turbomachinery product plan that was under evaluation by MTI. The total cost for the development of a new gas heat pump were not charged to the entrepreneurial firm. A benevolent "Sugar Daddy" would be needed to pick up the $5-$10 million development and demonstration costs. Since this is an entrepreneurial venture, the impact of debt leverage was evaluated.

The evaluation of the results was made on the same basis as the results in Sections 6.0 and 7.0. The product DCF in 1990 and the cumulative cash flow were the principal evaluation factors.

Two complete pro forma financial statements were developed for the entrepreneurial firm including one with 100% equity funding and one with a high degree of debt leverage. The pro forma statements are presented in Tables 8-1 and 8-2. The results of these two cases are presented in Table 8-3. The heavily leveraged case looks attractive. This case has a positive cummulative cash flow in 1990, an overall DCF of 18.2% and shows a very acceptable profitability and return on equity in 1990. The heavily leveraged case does not have any significant growth potential but is simply an operation that has gross revenues of $10,000,000 a year and provides over $1,000,000 in cash.

The positive results are highly dependent on the achievement of the market penetration and profit objectives. Competitive response by the dominant companies in the market could affect both assumptions. The risk associated with the response of the dominant companies may make this approach unacceptable.

This analysis shows that with modest expectations for market share and total financial return, an entrepreneurial firm could be financially successful in introducing an innovation into the HVAC market. However, similar results can be obtained for a similar limited sales objective scenario for a current HVAC firm. If this analysis is combined with the fact that entrepreneurs tend to be overly optimistic about profits and investment, the existence of the entrepreneurial small firms in the HVAC industry can be explained.

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TABLE 8-1

PRO FORMA FINANCIAL STATEMENT FOR ENTREPRENEURIAL FIRM WITHOUT LEVERAGE

DCF = 13.7% With End Valuation

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sales (Tons)	-	-	240	1200	2400	3600	5400	7800	10200	12000	12000	12000
Revenues	-	-	200	1000	2000	3000	4500	6500	8500	10000	10000	10000
Cost of Goods	-	-	180	800	1600	2100	2925	3900	5700	6000	6000	6000
General	150	200	250	250	250	300	450	650	850	1000	1000	1000
Sales	-	100	150	200	250	300	450	650	850	1000	1000	1000
R&D	150	150	150	150	150	150	150	150	150	150	150	150
Product Development	50	200	150	50								
Total Expenses	350	650	880	1450	2250	2850	3975	5350	6950	8150	8150	8150
Profit Before Taxes	(350)	(650)	(680)	(450)	(250)	150	525	1150	1550	1850	1850	1850
Interest	-											
Income Tax	(168)	(312)	(326)	(216)	(120)	72	252	522	744	888	888	888
Invest Tax Credit	-		10	50	200		75	75				
After-Tax Profit	(182)	(338)	(344)	(184)	70	88	348	553	806	962	962	962
Current Assets	40	100	200	600	1000	1500	2250	3250	4250	5000	5000	5000
Fixed Assets												
Land			50	100	100	100	100	100	100	100	100	100
Buildings			500	1250	1250	1250	2250	2250	2250	2250	2250	2250
Equipment			100	600	2600	2600	3350	4100	4100	4100	4100	4100
Accum Dep			-	-	552	1055	1508	2245	2904	3485	3986	4409
Net			650	1950	3398	2895	4192	4205	3546	2965	2464	2041
Total Assets	40	100	850	2550	4398	4395	6442	7455	7796	7965	7464	7041
Current Liabilities	20	50	100	300	500	750	1125	1625	2125	2500	2500	2500
Debt												
Equity	20	50	750	2250	3898	3645	5317	5830	5671	5465	4964	4541
Sources of Funds												
Profit	(182)	(338)	(344)	(184)	70	88	348	553	806	888	888	888
Depreciation					552	503	453	737	659	581	501	423
Debt												
Capital	282	368	1044	1684	1578		1324					
Use of Funds												
Working Capital	20	30	50	200	200	250	375	500	500	375	0	0
Fixed Assets			650	1300	2000		1750	750				
Dividends						341		40	964	1168	1463	1385
Cash Flow	(202)	(368)	(1044)	(1684)	(1578)	341	(1324)	40	964	1168	1463	1385
Cumulative Cash Flow	(202)	(570)	(1614)	(3298)	(4876)	(4535)	(5859)	(5819)	(4855)	(3687)	(2224)	(839)

Note: Values are in thousands of 1979 dollars.

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TABLE 8-2

PRO FORMA FINANCIAL STATEMENT FOR ENTERPRENEURIAL FIRM WITH LEVERAGE

DCF = 18.2% With End Valuation

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sales (Tons)	-	-	240	1200	2400	3600	5400	7800	10200	12000	12000	12000
Revenues	-	-	200	1000	2000	3000	4500	6500	8500	10000	10000	10000
Cost of Goods	-	-	180	800	1600	2100	2925	3900	5700	6000	6000	6000
General	150	200	250	250	250	300	450	650	850	1000	1000	1000
Sales	-	100	150	200	250	300	450	650	850	1000	1000	1000
R&D	150	150	150	150	150	150	150	150	150	150	150	150
Product Development	50	200	150	50								
Total Expenses	350	650	880	1450	2250	2850	3975	5350	6950	8150	8150	8150
Profit Before Taxes	(350)	(650)	(680)	(450)	(250)	150	525	1150	1550	1850	1850	1850
Interest	-		30	90	220	230	300	330	330	300	270	240
Income Tax	(168)	(312)										
Invest Tax Credit	-		10	50	200		75	75				
After-Tax Profit	(182)	(338)	(359)	(230)	(44)	(32)	192	381	634	806	821	837
Current Assets	40	100	200	600	1000	1500	2250	3250	4250	5000	5000	5000
Fixed Assets												
Land			50	100	100	100	100	100	100	100	100	100
Buildings			500	1250	1250	1250	2250	2250	2250	2250	2250	2250
Equipment			100	600	2600	2600	3350	4100	4100	4100	4100	4100
Accum Dep			-	-	552	1055	1508	2245	2904	3485	3986	4409
Net			650	1950	3398	2895	4192	4205	3546	2965	2464	2041
Total Assets	40	100	850	2550	4398	4395	6442	7455	7796	7965	7464	7041
Current Liabilities	20	50	100	300	500	750	1125	1625	2125	2500	2500	2500
Debt			300	900	2200	2300	3000	3300	3300	3000	2700	2400
Equity	20	50	450	1350	1698	1345	2317	2530	2371	2465	2264	2141
Sources of Funds												
Profit	(182)	(338)	(359)	(230)	(44)	(32)	192	381	634	806	821	837
Depreciation					552	503	453	737	659	581	501	423
Debt			300	600	1300	100	700	300	0	(300)	(300)	(300)
Capital	282	368	759	1130	392		780					
Use of Funds												
Working Capital	20	30	50	200	200	250	375	500	500	375	0	0
Fixed Assets			650	1300	2000		1750	750				
Dividends						321		168	793	712	1022	960
Cash Flow	(202)	(368)	(759)	(1130)	(392)	321	(780)	168	793	712	1022	960
Cumulative Cash Flow	(202)	(570)	(1329)	(2459)	(2851)	(2530)	(3310)	(3142)	(2349)	(1637)	(615)	345

Note: Values are in thousands of 1979 dollars.

TABLE 8-3

SUMMARY RESULTS OF THE ENTREPRENEURIAL FIRM ANALYSIS FOR 1990

	Model	
	No Leverage	High Leverage
Cumulative Cash Flow	($839,000)	$345,000
DCF with End Period Valuation	13.7%	18.2%
Return on Equity	21.2%	40.5%

9.0 CONCLUSIONS

A quantitative business potential analysis shows that under historic financial conditions, the HVAC industry cannot make large investments in revolutionary product innovation and/or significant market share changes resulting in a high and sustained growth rate for one company. (See Table 9-1). There are a number of very important qualifiers in this statement. First, only the HVAC industry is being addressed. Second, the historic financial ratios of four specific firms in the HVAC industry are being used. These firms were selected because they met the qualifications specified for the exclusive license for the LSM technology. While there may be some HVAC component manufacturers that may have financial characteristics more typical of a different industry (such as instrumentation or control manufacturers), the four companies selected appear to be typical of the HVAC industry as a whole. If there is any bias, it would appear as the four companies having better financial characteristics than the average HVAC company. The third qualification is that the evaluation criteria are based on a quantitative financial analysis. Specifically, the project DCF is the principal determination of financial viability. Fourth, while the analyses basically ignored the nonreoccurring developments and start-up costs, the present value of cummulative cash flows that will be available to offset start-up costs are small with reasonable discount rates. From MTI's experience, the development of a revolutionary gas or electric heat pump requires a minimum of $10 million and three to five years. None of the scenarios could accomodate the development costs of a revolutionary new product. The final qualification is that relating to significant growth rates. Many smaller growth-oriented companies have corporate sales growth objectives of 20% to 30% per year. Many new companies or product lines have even higher growth rates. In fact, a recent study by the Harvard Business School[1] suggests that if a new business venture does not aim for a rapid movement into the market, its chances for ultimate success are very much reduced. Companies in the HVAC industry simply cannot support even modest overall growth rates. These qualifications arise from the specifications felt necessary for the ultimate success of the LSM

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(1) Biggadike, R., "The Risky Business of Diversification" Harvard Business Review, May-June 1979, pp 103-111

TABLE 9-1

BUSINESS POTENTIAL CONCLUSIONS

Quantitative Financial Business Analysis(1) shows that under Historic Conditions(1), a company in the HVAC Industry(1) cannot afford:

- Investment in Revolutionary Product Innovation
- Significant increase in market share from a high and sustained growth.

(1) Important qualifiers to the conclusion - see text

introduction. However, all the qualifications that appeared necessary for the success of the LSM business combined to produce a business scenario that is an investment disaster.

The business potential analysis shows that by relaxing some of the constraints upon the baseline business scenario and/or by assuming some different financial characteristics, it is possible to develop scenarios that are marginally attractive. If, for example, the vast bulk of product development were paid by someone else, an entrepreneurial firm could bring out a new product. Also, the HVAC companies considered could achieve reasonable financial results if their sales objectives were managed. However, in this event, even they would need a benevolent investor to support the development costs. Table 9-2 lists those factors which would need to change if a quantitative business analysis is to show a positive investment criteria. Attachment C presents a business scenario in which all these factors were appropriately included.

Another alternative is that the decision be made on a basis other than a quantitative financial analysis, as for example, the threat of product obsolescence, which was implied in the discussion of the entrepreneurial firm. Also, government regulation of product performance, fuel use policy, and energy price policy can significantly impact the decision process.

This analysis clearly points out the reasons for the lack of product innovation in the HVAC industry. It is not practical for manufacturers to innovate, even assuming their customers will buy the innovation. The analysis also indicates that there may be a shakeout in the industry. A number of the smaller integrated firms and assemblers could be badly hurt by any business slowdown or a forced shift in their product design. Recent sales of HVAC divisions by companies whose principal business is not in the HVAC business suggest a confirmation of these observations. Whether a product innovation comes through government action or noneconomic business decision, it would seem highly probable that a product innovation will occur. When it does, the impact on the HVAC industry will not necessarily be positive.

TABLE 9-2

FACTORS NEEDING CHANGE

Changes needed to make an HVAC innovation financially attractive under a quantitative financial analysis:

- Higher profit margins
- Lower fixed plant investments
- Lower working capital requirements
- Minimization of development costs
- Managed sales growth

The ultimate commercialization of any new innovation in the HVAC industry will be difficult. The baseline business scenario which is characteristic of the conventional approach will not be successful. As much innovation is needed in the commercialization approach as in the product itself. Therefore, due to the nature of this development, the government seems to be the only entity capable of initiating this innovative commercialization approach.

ATTACHMENT A

THE IMPLICATION OF THE COST-OF-OWNERSHIP STUDY RESULTS

The cost-of-ownership study results showed that the LSM unit had the liklihood of being an attractive product in northern climates and for buildings that have higher heating-to-cooling ratios than offices. This means that the market is more in the classifications of building types such as: hospitals and health related buildings, apartments and nonhousekeeping residential structures. The impact of restricting the market to these building types is shown in Table A-1. This segmentation reduces the market potential by almost 70% by class of building.

The next segmentation would be by region. This regional segmentation concerns not only the percentage of buildings of the specific class in those regions characterized by more than 6000 degree days of heating, but also the trend of future additions. The available data suggest that between 25% and 33% of the existing building stock will fall into the classification given. A smaller percentage than this would be in new construction. Tables A-2 and A-3 show that construction of all classifications of buildings has been declining in the Northeast and Midwest and that the building classifications of interest have shown a steady decline. Thus, of the 250,000 tons per year potential shown in Table A-1 only between 62,000 and 83,000 tons will constitute the actual market of the right building type and climate. Furthermore, this market will not grow with time.

The next segmentation is the life-cycle, costing-sensitive market. The product costing data show that at least a 50% price premium will exist. The cost-of-ownership study shows that a two-year payback would be optimistic. Therefore, market potential will be reduced by another 80%. This reduction brings the market potential down to between 12,000 and 17,000 tons per year. This equates to a 98% reduction in total market as shown in Figure A-1.

The implication of this almost unbelievable market potential reduction is that the maximum total business volume is simply not attractive for a new business venture. Using the 50% premium, the market revenues would amount to only $5,400,000 to $7,600,000. This amount does not warrant a significant development effort.

TABLE A-1

MARKET POTENTIAL RESTRICTION IMPACTS

Project 1981 Sale (Thousands of Tons) 50 to 400 Ton Built-up

Market Segment	Total	LSM
Commercial		
Banks and Offices		
High Rise	84.0	-0-
Low Rise	113.3	-0-
Stores and Other	102.0	-0-
Industrial	90.6	-0-
Institutional		
Education and Science	65.9	-0-
Hospital and Health	110.1	110.1
Public Buildings	35.8	-0-
Religious	9.0	-0-
Amusement and Other	42.6	-0-
Apartment	108.4	108.4
Nonhousekeeping Residential	32.1	32.1
Total	793.8	250.6

TABLE A-2

PROJECTED AVERAGE ANNUAL CONSTRUCTION GROWTH RATE BY REGION

Region	1967 to 1981
Northeast	(2.9%)
Midwest	(0.6%)
South	0.5
West	1.7
Total	(0.2%)

TABLE A-3

PROJECTED AVERAGE ANNUAL CONSTRUCTION GROWTH RATE BY BUILDING TYPE

Building Type	1967 to 1981
Commercial	
Office	0.5%
Stores and Other	1.4%
Industrial	0.1%
Institutional	(0.8%)
Apartments	(0.8%)
Nonhousekeeping Residential	(2.5%)
Total	(0.2%)

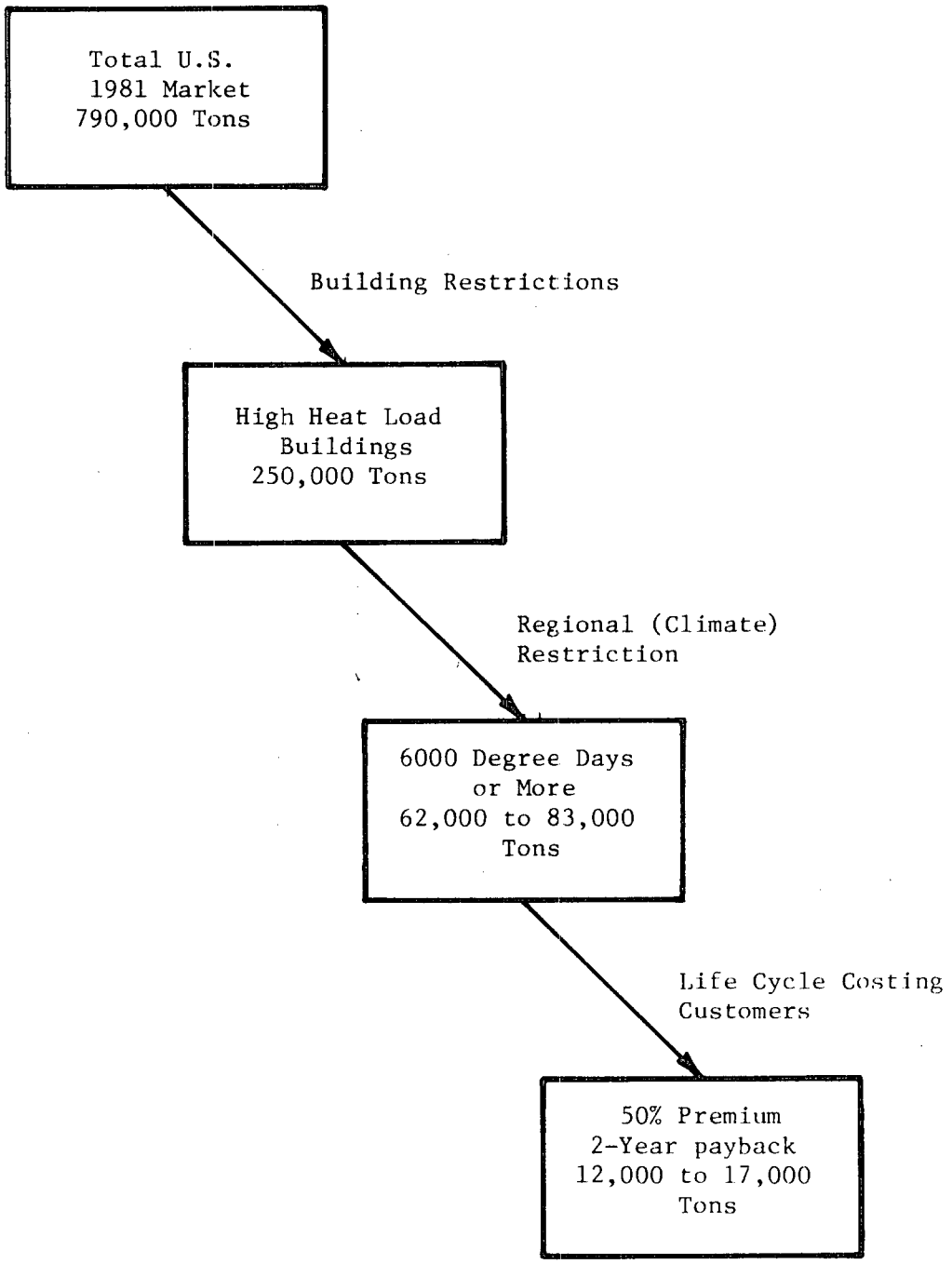

Fig. A-1 Results of Market Segmentation upon the Market Potential for the LSM

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The results of the business potential analysis are only slightly affected by the results of the cost-of-ownership study. The basic results were that under the best of circumstances it would be difficult to introduce the LSM. The reduced market potential makes the LSM totally unattractive under any business scenario.

ATTACHMENT B

COMPARISONS TO OTHER PRODUCTS

The methodology described in Section 5.0 is typical of investment analyses and similar to analyses used at MTI on other potential product evaluations.

To see if the basic methodology in Section 5.0 was deficient, a comparison of the results of the baseline business scenarios described in Section 6.0 with a business potential for a turbomachinery product under evaluation by MTI was made. The pro forma income statement, balance sheet, funds flow and evaluation criteria are presented for this turbomachinery business potential analysis in Table B-1. Since this product line had been produced in prototype form and since the business structure was well defined, significantly more detail was available and used in the business analysis.

Table B-2 summarizes the key variables used in the turbomachinery product analysis and the LSM baseline business analysis for Companies A and C. The first comparison of interest is the growth rate of sales. The turbomachinery product achieves a very rapid growth rate (a 1000% growth in 1981) over a six-year period and then sales growth is flat. The average growth rate is 73% over a ten-year period. The LSM has a sales growth rate of an almost constant 35% over the entire product evaluation period. Both growth rates are in excess of the theoretical growth rate that either product line could sustain according to the relation developed in Section 7.0. However, the turbomachinery line is successful. The turbomachinery line has a higher profit margin due to the fact that it can be value priced and that a strong proprietary position exists. However, the sales growth rate used in the turbomachinery business scenario exceeds the maximum sales growth rate which, according to Section 7.0, would yield a positive cumulative cash flow. The form of the sales growth has an impact on profitability. The effect of various sales growth rates along with ramp type sales growth was investigated in Section 7.0 for the LSM business scenarios.

Both the working capital ratio and the fixed investment ratio for the turbomachinery line are slightly lower than those for Company A, but actually higher than those for Company C as shown in Table B-2. The only computational or methodological difference between the turbomachinery model and the LSM models was that the investment in plant occurred in an incremental fashion for the

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TABLE B-1

PRO FORMA FINANCIAL DATA FOR A TURBOMACHINERY PRODUCT BUSINESS

a) Income Statement

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
UNIT SALES	2.	20.	40.	130.	300.	400.	500.	500.	500.	500.	500.
UNIT PRICE	75.	75.	75.	75.	75.	75.	75.	75.	75.	75.*	75.
TOTAL REVENUES	150.	1500.	3000.	9750.	22500.	30000.	37500.	37500.	37500.	37500.	37500.
PURCHASED MATER.	22.	22.	21.	21.	21.	21.	21.	21.	21.	21.	21.
MANUFACT. LABOR	15.	15.	14.	14.	14.	14.	14.	14.	14.	14.	14.
UNIT ENGINEERING	2.	2.	1.	1.	1.	1.	1.	1.	1.	1.	1.
TOTAL UNIT COST	39.	39.	36.	36.	36.	36.	36.	36.	36.	36.	36.
GROSS MARGIN(%)	48.	48.	52.	52.	52.	52.	52.	52.	52.	52.	52.
GROSS MARGIN($)	72.	720.	1560.	5070.	11700.	15600.	19500.	19500.	19500.	19500.	19500.
GEN & ADMIN EXP	50.	180.	355.	1135.	2580.	3389.	4172.	4110.	4048.	3988.	3928.
MKTG & SALES EXP	150.	150.	225.	709.	1588.	2054.	2490.	2415.	2343.	2272.	2204.
R&D & ENG EXPENSE	150.	150.	150.	146.	327.	423.	513.	498.	483.	469.	454.
WARRANTY EXPENSE	5.	45.	75.	195.	338.	450.	562.	562.	562.	562.	562.
EARNINGS(EBIT)	-283.	195.	755.	2884.	6867.	9284.	11762.	11914.	12063.	12209.	12351.
INTEREST EXPENSE	7.	193.	521.	765.	958.	1008.	987.	929.	864.	791.	709.
INVESTMENT TAX CR.	10.	100.	400.	300.	200.	100.	0.	0.	0.	0.	0.
AFTER TAX PROFIT	-279.	101.	526.	1444.	3391.	4569.	5818.	5932.	6048.	6166.	6287.
ATP AS % REV	-186.2	6.7	17.5	14.8	15.1	15.2	15.5	15.8	16.1	16.4	16.8

TABLE B-1 CONT'D

b) Balance Sheet

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CASH ON HAND	10.	101.	201.	653.	1508.	2010.	2513.	2513.	2513.	2513.	2513.
RECEIVABLES	19.	189.	378.	1229.	2835.	3780.	4725.	4725.	4725.	4725.	4725.
INVENTORIES											
FINISHED GOODS	7.	75.	150.	488.	1125.	1500.	1875.	1875.	1875.	1875.	1875.
WORK IN PROGRESS	15.	150.	300.	975.	2250.	3000.	3750.	3750.	3750.	3750.	3750.
RAW MATERIALS	4.	36.	72.	234.	540.	720.	900.	900.	900.	900.	900.
TOTAL INVENT	26.	261.	522.	1697.	3915.	5220.	6525.	6525.	6525.	6525.	6525.
OTHER CURRENT ASSETS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL CURRENT ASSETS	55.	551.	1101.	3578.	8258.	11010.	13763.	13763.	13763.	13763.	13763.
LAND INVESTMENT	0.	500.	1100.	1100.	1100.	1100.	1100.	1100.	1100.	1100.	1100.
PLANT INVESTMENT	0.	1900.	2755.	3567.	4339.	4122.	3916.	3720.	3534.	3357.	3189.
EQUIPMENT INVESTMENT	80.	864.	3891.	5513.	6010.	5608.	4485.	3573.	2775.	2032.	1311.
TOTAL BALANCE	80.	3264.	7746.	10180.	11449.	10830.	9501.	8393.	7410.	6489.	5600.
OTHER ASSETS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL ASSETS	135.	3815.	8847.	13758.	19707.	21840.	23264.	22155.	21172.	20251.	19363.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
NOTES PAYABLE	5.	51.	102.	332.	765.	1020.	1275.	1275.	1275.	1275.	1275.
ACCOUNTS PAYABLE	7.	71.	141.	458.	1058.	1410.	1763.	1763.	1763.	1763.	1763.
ACCRUED EXPENSES	4.	37.	75.	244.	562.	750.	937.	937.	937.	937.	937.
TAXES PAYABLE	0.	-25.	-73.	169.	630.	927.	1239.	1263.	1288.	1313.	1339.
ACCRUED WARRANTY	2.	21.	23.	66.	95.	85.	79.	23.	0.	0.	0.
TOTAL CURRENT LIAB	18.	155.	268.	1268.	3110.	4191.	5293.	5261.	5263.	5288.	5314.
LONG TERM DEBT	47.	1763.	4411.	6156.	7312.	7398.	6932.	6409.	5820.	5158.	4423.
TOTAL EQUITY	70.	1896.	4168.	6334.	9285.	10251.	11038.	10485.	10089.	9805.	9626.
TOTAL LIAB + EQUITY	135.	3815.	8847.	13758.	19707.	21840.	23264.	22155.	21172.	20251.	19363.

TABLE B-1 CONT'D

c) Funds Flow and Financial Ratios

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CURRENT RATIO	3.03	3.54	4.11	2.82	2.66	2.63	2.60	2.62	2.62	2.60	2.59
WORK CAP AS % SALES	0.25	0.26	0.28	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
RETURN ON ASSETS	0.00	0.03	0.06	0.10	0.17	0.21	0.25	0.27	0.29	0.30	0.32
RETURN ON EQUITY	0.00	0.05	0.13	0.23	0.37	0.45	0.53	0.57	0.60	0.63	0.65
RETURN ON INVEST	0.00	0.03	0.06	0.11	0.20	0.24	0.30	0.33	0.35	0.38	0.41
SOURCES OF FUNDS:											
AFTER TAX PROFIT	-279.	101.	526.	1444.	3391.	4569.	5818.	5932.	6048.	6166.	6287.
DEPRECIATION	20.	316.	1118.	1566.	1731.	1619.	1329.	1109.	983.	921.	889.
NEW L.T. DEBT	47.	1716.	2648.	1745.	1156.	86.	-466.	-524.	-589.	-662.	-735.
NEW PD. IN CAP	367.	1725.	1745.	722.	0.	0.	0.	0.	0.	0.	0.
TOTAL SOURCES	155.	3858.	6038.	5477.	6278.	6274.	6682.	6517.	6442.	6424.	6440.
USES OF FUNDS:											
DIVIDENDS PAID	0.	0.	0.	0.	441.	3603.	5030.	6485.	6444.	6449.	6466.
NEW LD,PL, & EQ.	100.	3500.	5600.	4000.	3000.	1000.	0.	0.	0.	0.	0.
NEW WORK. CAP.	55.	358.	438.	1477.	2838.	1671.	1651.	32.	-2.	-25.	-26.
TOTAL USES	155.	3858.	6038.	5477.	6278.	6274.	6682.	6517.	6442.	6424.	6440.
CASH FLOW	-367.	-1725.	-1745.	-722.	441.	3603.	5030.	6485.	6444.	6449.	6466.
CUM. CASH FLOW	-367.	-2093.	-3838.	-4560.	-4119.	-516.	4514.	10999.	17443.	23892.	30359.

TABLE B-2

SUMMARY OF MODEL INPUTS AND RESULTS

		Company A(1)	C(1)
Sales Growth	Average 150% over 6 years, then 0%; 73% average over 10 years	Constant at about 35%	
Profit Margin Before Taxes (1990)	32.9%	10.1%	12.9%
Working Capital Ratio (1990)	22.5%	36.5%	15.2%
Gross Fixed Investment Ratio (1990)	27.9%	34.3%	26.1%
Theoretical Maximum Sales Growth Rate	51.0%	8.0%	19.0%
Start-Up Costs	Partially Included	- Not Included -	
Cumulative Cash Flow (1990)	30,359	-20,251	-7,638
DCF Without End Valuation (1990)	33.6%	0	0
DCF With End Valuation (1990)	41.7%	1.7%	23.7

(1) Baseline case with 0% premium

turbomachinery business while the investment in plant occurred continuously as a function sales for the LSM business. This should hurt the turbomachinery business since plant capacity is added before it would be fully utilized. This fact is also included in the cost-of-goods consideration for the turbomachinery product. Production cost variances as well as the other start-up costs were considered in the turbomachinery line. The product development costs were not included since they had already been incurred and were, therefore, considered as a sunk cost for the business analysis. Again, the inclusion of start-up costs should further hurt the performance of the turbomachinery line.

The evaluation criteria for the three cases shown in Table B-2 show that the turbomachinery line is a feasible business venture while the LSM is not. The methodology of the analyses are similar. The input data for the turbomachinery were more stringent than for the LSM, except for the profit margins. The form of the sales growth may have some impact on the results. Obviously, the profit margin will impact the results.

As a final check on methodology, the baseline business scenario data for Company C were inputted to the more rigorous model of the firm. There is some limitation due to the difference in data specification but the results are shown in Table B-3. The only discrepancy between the results in Table B-3 and those in Section 6.0 is due to the inclusion of a short-term debt in Table B-3. This check shows that the results are inherent in the product/business line and not the methodology.

TABLE B-3

PRO FORMA FINANCIAL DATA FOR COMPANY C BASELINE BUSINESS SCENARIO WITH EXPANDED MODEL OF THE FIRM

a) Income Statement

CNG MODEL

	1979	1980	1981	1982	1983	1984	1985	1986
UNIT SALES	0.	0.	44.	59.	79.	103.	138.	183.
UNIT PRICE	100.	100.	100.	100.	100.	100.	100.	100.
TOTAL REVENUES	0.	0.	4400.	5900.	7900.	10300.	13800.	18300.
PURCHASED MATER.	37.	37.	37.	37.	37.	37.	37.	37.
MANUFACT. LABOR	32.	32.	32.	32.	32.	32.	32.	32.
UNIT ENGINEERING	2.	2.	2.	2.	2.	2.	2.	2.
TOTAL UNIT COST	71.	71.	71.	71.	71.	71.	71.	71.
GROSS MARGIN(%)	29.	29.	29.	29.	29.	29.	29.	29.
GROSS MARGIN($)	0.	0.	1276.	1711.	2291.	2987.	4002.	5307.
GEN & ADMIN EXP	0.	0.	440.	590.	790.	1030.	1380.	1830.
MKTG & SALES EXP	0.	0.	247.	331.	443.	578.	774.	1027.
R&D & ENG EXPENSE	0.	0.	0.	0.	0.	0.	0.	0.
WARRANTY EXPENSE	0.	0.	22.	30.	40.	52.	69.	92.
EARNINGS(EBIT)	-0.	-0.	567.	761.	1018.	1328.	1779.	2359.
INTEREST EXPENSE	0.	0.	18.	24.	32.	42.	56.	75.
INVESTMENT TAX CR.	0.	84.	29.	38.	46.	67.	86.	121.
AFTER TAX PROFIT	-0.	84.	325.	436.	579.	761.	1017.	1354.
ATP AS % REV	0.0	0.0	7.4	7.4	7.3	7.4	7.4	7.4

TABLE B-3 CONT'D

b) Balance Sheet

CNG MODEL

	1979	1980	1981	1982	1983	1984	1985	1986
CASH ON HAND	0.	0.	295.	395.	529.	690.	925.	1226.
RECEIVABLES	0.	0.	228.	306.	410.	534.	716.	949.
INVENTORIES								
FINISHED GOODS	0.	0.	220.	295.	395.	515.	690.	915.
WORK IN PROGRESS	0.	0.	358.	480.	643.	838.	1122.	1488.
RAW MATERIALS	0.	0.	94.	126.	169.	220.	295.	392.
TOTAL INVENT	0.	0.	672.	901.	1207.	1573.	2108.	2795.
OTHER CURRENT ASSETS	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL CURRENT ASSETS	0.	0.	1195.	1602.	2146.	2797.	3748.	4970.
LAND INVESTMENT	10.	24.	41.	65.	96.	139.	199.	199.
PLANT INVESTMENT	259.	335.	436.	555.	734.	962.	1285.	1727.
EQUIPMENT INVESTMENT	0.	676.	771.	924.	1108.	1424.	1830.	2421.
TOTAL BALANCE	270.	1035.	1247.	1544.	1937.	2525.	3314.	4347.
OTHER ASSETS	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL ASSETS	270.	1035.	2442.	3146.	4083.	5323.	7062.	9317.

	1979	1980	1981	1982	1983	1984	1985	1986
NOTES PAYABLE	0.	0.	150.	201.	269.	350.	469.	622.
ACCOUNTS PAYABLE	0.	0.	207.	277.	371.	484.	649.	860.
ACCRUED EXPENSES	0.	0.	110.	148.	198.	258.	345.	458.
TAXES PAYABLE	-0.	-21.	56.	75.	102.	131.	176.	232.
ACCRUED WARRANTY	0.	0.	11.	8.	6.	8.	11.	15.
TOTAL CURRENT LIAB	-0.	-21.	533.	709.	946.	1231.	1650.	2187.
LONG TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL EQUITY	270.	1056.	1909.	2438.	3137.	4092.	5411.	7130.
TOTAL LIAB + EQUITY	270.	1035.	2442.	3146.	4083.	5323.	7062.	9317.

TABLE B-3 CONT'D

c) Funds Flow and Evaluation Measures

CNG MODEL

	1979	1980	1981	1982	1983	1984	1985	1986
CURRENT RATIO	0.00	0.00	2.24	2.26	2.27	2.27	2.27	2.27
WORK CAP AS % SALES	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15
RETURN ON ASSETS	0.00	0.08	0.13	0.14	0.14	0.14	0.14	0.15
RETURN ON EQUITY	0.00	0.08	0.17	0.18	0.18	0.19	0.19	0.19
RETURN ON INVEST	0.00	0.08	0.16	0.17	0.17	0.17	0.17	0.17
SOURCES OF FUNDS:								
AFTER TAX PROFIT	-0.	84.	325.	436.	579.	761.	1017.	1354.
DEPRECIATION	14.	187.	216.	260.	316.	407.	525.	710.
NEW L.T. DEBT	0.	0.	0.	0.	0.	0.	0.	0.
NEW PD. IN CAP	270.	702.	528.	93.	121.	193.	303.	364.
TOTAL SOURCES	283.	973.	1069.	789.	1015.	1361.	1845.	2428.
USES OF FUNDS:								
DIVIDENDS PAID	0.	0.	0.	0.	0.	0.	0.	0.
NEW LD,PL, & EQ.	283.	952.	429.	557.	709.	994.	1314.	1743.
NEW WORK. CAP.	0.	21.	640.	232.	306.	367.	531.	686.
TOTAL USES	283.	973.	1069.	789.	1015.	1361.	1845.	2428.
CASH FLOW	-270.	-702.	-528.	-93.	-121.	-193.	-303.	-364.
CUM. CASH FLOW	-270.	-971.	-1499.	-1592.	-1713.	-1906.	-2209.	-2573.

ATTACHMENT C

SAMPLE OF A FINANCIALLY ATTRACTIVE HVAC INNOVATION

In the body of this report, it was indicated that if a number of changes to the basic business scenario for an HVAC innovation existed, then the quantitative financial analysis could be attractive. This attachment presents a pro forma financial analysis of a company which is currently in the HVAC business and has the choice of staying with its current product line (Product A) or introducing a new product line (Product B). The difference between the two options results in a cash flow over the product life which will determine if the new product option is worthwhile.

The analysis begins with a successful company in the HVAC industry. This company is offered a new product under an exclusive license. The bulk of the development is completed, but the company has to invest in the "productizing" of the development. The characteristics of the business scenario relating to this company and product are presented in Table C-1.

The first assumption made is that the company does not expect to change its market share but that its potential market will grow at an average annual rate of 5% in real terms. The introduction of the new product will be managed so that total unit production is the same, whether it is just Product A or a combination of Products A and B. A further assumption made is that the new product will not be completely applicable to the market. Ultimate penetration of Product B will occur by 1990 and take 80% of the market previously held by Product A.

The basic cost structure of Product A yields a 9% pre-tax operating margin. The cost of goods is 85% of sales; sales, general and administrative costs are 5% of sales, and R&D is 1% of sales. Product B is assumed to have features that will permit it to be sold at a 5% premium but cost 5% less to make, creating an immediate 10% increase in operating margin. This increase is reflected by assuming that the cost of goods for Product B is 75% of sales. The base SG&A and R&D expenses are assumed to remain the same with or without the new product. In effect, SG&A expenses are reduced to 4.76% of Product B revenues and R&D to 0.95%. This reduction results in a minimal addition to the profit margin. The start-up costs are separately considered as a variance.

TABLE C-1

ASSUMPTIONS FOR A SUCCESSFUL HVAC INNOVATION

- BASE MARKET HAS 5% REAL GROWTH
- SALES VOLUME IS CONSTRAINED TO SAME UNIT PRODUCTION
- NEW PRODUCT CANNIBALIZES ENTIRE APPLICABLE OLD PRODUCT SALES (80% OF UNIT PRODUCTION) BY 1990
- BASIC COST OF GOODS FOR CURRENT PRODUCT IS 85% OF SALES
- NEW PRODUCT CAN BE SOLD WITH 5% PREMIUM
- NEW PRODUCT HAS 5% LOWER COST OF GOODS
- SG&A AND R&D IS SAME FOR BUSINESS WITH OR WITHOUT NEW PRODUCT
- ROYALTY OF 3% OF SALES IS PAYABLE ON NEW PRODUCT
- $24 MILLION OF NONREOCCURRING COST IS INVESTED IN NEW PRODUCT FOR DEVELOPMENT, MARKET INTRODUCTION AND PRODUCTION COST VARIANCES
- BUSINESS JUST MADE INVESTMENT IN NEW PLANT THAT CAN SUPPORT 50% INCREASE IN SALES
- DEPRECIATION CASH FLOW IS REINVESTED IN PLANT
- PLANT CAN BE MODIFIED TO MANUFACTURE NEW PRODUCT WITH DEPRECIATION CASH PLUS INCREMENT IN 1986

The "productizing" of the development, introductory sales expenses, and production cost variances are accumulated as the new product costs. The actual development of Product B was paid for by another party. This party will recoup its investment through a royalty on sales. The royalty rate, assumed to be 3% of Product B sales, reduces the effective operating profit margin. To make the analysis simple, any licensing fees and minimum royalty payments are included in the new product development cost.

The company just made a new plant investment. Based on its historical ratios, this new plant can support a 50% increase in sales volume, which means there is no new net investment in plant for eight (8) years. The depreciation cash flow is fully reinvested in plant. The depreciation cash flow plus a single investment in plant in 1986 are assumed to be adequate to modify the production processes to accommodate Product B.

These assumptions were combined to produce pro forma financial statements for both alternatives as shown in Table C-2. The differential in the cash flow between the two alternatives was computed and is shown in Table C-2. The resulting DCF for the alternative of producing Product B is 54.1%. This percentage includes the effect of 71.8% increase in profits. While the end point valuation is very attractive, a couple of features exist which could impact the decision negatively, due to short-term stock valuation effects. Profit growth through 1984 is less for the new product than the base case. Also, a decline in earning in 1983 exists. Both of these facts could impact on stock prices should the Product B alternative be accepted.

The assumptions made are not unreasonable for some HVAC product innovations. This analysis shows that if the business changes indicated in the body of the report are implemented, a quantitative financial analysis can result in a favorable outcome.

MECHANICAL TECHNOLOGY INCORPORATED

TABLE C-2

SAMPLE OF SUCCESSFUL NEW HVAC PRODUCT

Higher Margins - Low Investment - Controlled Sales Growth

DCF = 17.9% without end valuation and 54.1% with valuation

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sales (Product A)	1000.0	1050.0	1102.6	1157.8	1215.4	1276.3	1340.0	1407.1	1477.4	1551.4	1628.6	1708.6
Cost of Goods (85%)	850.0	892.5	937.2	984.1	1033.1	1084.9	1139.0	1196.0	1255.8	1318.7	1384.3	1452.3
SG & A (5%)	50.0	52.5	55.1	57.9	60.8	63.8	67.0	70.4	73.9	77.6	81.4	85.4
R&D (1%)	10.0	10.5	11.0	11.6	12.1	12.8	13.4	14.1	14.8	15.5	16.3	17.1
Oper. Prof. Before Tax	90.0	94.5	99.3	104.2	109.4	114.8	120.6	126.6	132.9	139.6	146.6	153.8
Oper. Prof. After Tax (50% Marginal Rate)	45.0	47.2	49.6	52.1	54.7	57.4	60.3	63.3	66.4	69.8	73.3	76.9
Net Fixed Assets	148.0	148.0	148.0	148.0	148.0	148.0	148.0	148.0	157.1	214.3	214.3	214.3
Working Capital (15%)	150.0	157.5	165.4	173.7	182.3	191.4	201.0	211.1	221.6	232.7	244.3	256.3
Oper. Uses of Funds	296.0	305.5	313.4	321.7	330.3	339.4	349	359.1	378.7	447.0	458.6	470.6
Annual Cash Flow	-	37.7	41.7	43.8	46.1	48.3	50.7	53.2	46.8	1.5	61.7	64.9
Business With New Prod. Sales												
(Product A)	1000.0	1050.0	1102.6	1157.8	1215.4	1276.3	1206.0	1125.7	960.3	775.7	570.0	342.0
(Product B)	-	-	-	-	-	-	140.6	295.4	542.9	814.3	1111.4	1436.6
Total	1000.0	1050.0	1102.6	1157.8	1215.4	1276.3	1346.6	1421.1	1503.2	1590.0	1681.4	1778.6
Cost of Goods Sold A (85%)	850.0	892.5	937.2	984.1	1033.1	1084.9	1025.1	956.8	816.3	659.3	484.5	290.7
Cost of Goods Sold B (75%)	-	-	-	-	-	-	105.5	221.6	407.2	610.7	833.5	1077.5
SG&A (5%)	50.0	52.5	55.1	57.9	60.8	63.8	67.0	70.4	73.9	77.6	81.4	85.4
R&D STD (1%)	10.0	10.5	11.0	11.6	12.8	12.8	13.4	14.1	14.8	15.5	16.3	17.1
New Prod. Dev.	-	2.9	2.9	5.8	11.6	11.6	17.4	17.4	-	-	-	-
Royalty B (3%)	-	-	-	-	-	-	4.2	8.9	16.3	24.4	33.3	43.1
Oper. Prof. Before Tax	90.0	91.6	96.4	98.4	97.8	103.2	114.0	131.9	174.7	202.5	232.4	264.8
Oper. Prof. After Tax (50% Marginal Rate)	45.0	45.8	48.2	49.2	48.9	51.6	57.0	65.9	87.4	101.2	116.2	132.4
Net Fixed Assets	148.0	148.0	148.0	148.0	148.0	148.0	148.0	202.9	214.3	271.4	271.4	271.4
Working Capital	150.0	157.5	165.4	173.7	182.3	191.4	202.0	213.1	225.4	238.6	252.3	266.9
Oper. Uses of Funds	296.0	305.5	313.4	321.7	330.3	339.4	350.0	416.0	439.7	510.0	523.7	538.3
Annual Cash Flow	-	36.3	40.3	40.9	40.3	42.5	46.4	(0.1)	63.7	30.9	102.5	117.8
Dif. Annual Cash Flow	-	(1.4)	(1.4)	(2.9)	(5.8)	(5.8)	(4.3)	(53.3)	16.9	29.4	40.8	52.9
Cum Dif. Cash Flow	-	(1.4)	(2.8)	(5.7)	(11.5)	(17.3)	(21.6)	(74.9)	(58.0)	(28.6)	12.2	65.1

Note: Normalization of values to prevent company identification may result in columns not adding.