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DEVELOPMENT OF A RISK ANALYSIS MODEL

Final Report

Appendix D — Gas-Fired Heat Pump Case Study

October 1979

Work Performed Under Contract No. EC-77-C-03-1470

Dynatrend Incorporated
Arlington, Virginia

MASTER

U. S. DEPARTMENT OF ENERGY

Division of Industrial Energy Conservation

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DEVELOPMENT OF A RISK ANALYSIS MODEL
FINAL REPORT
OCTOBER 1979

APPENDIX D
GAS-FIRED HEAT PUMP CASE STUDY

prepared for

THE OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS
OFFICE OF THE ASSISTANT SECRETARY FOR
CONSERVATION AND SOLAR ENERGY
DEPARTMENT OF ENERGY

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PREFACE

This document is Appendix D of DYNATREND INCORPORATED's report, "Development of a Risk Analysis Model, Final Report" October 1979, prepared for the Department of Energy's Office of Buildings and Community Systems under Contract DE-AC03-77CS20158. Three case studies were included in the process of the contract effort: Appendix D, "Gas Fired Heat Pump Case Study"; Appendix E, "1000 Ton Per Day Anaerobic Digestion Plant Case Study"; and Appendix F, "District Heating and Cooling System Case Study". Appendix C, "Risk Analysis Methodology", provides general information concerning the model used in the three case studies, its input data requirements, and its output reports.

This appendix presents the findings of studies related to the commercialization of a gas-fired heat pump.

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CHAPTER 1 INTRODUCTION

1.1 RATIONALE FOR THE STUDY

The commercialization of any new product or technology is a perilous undertaking. Experience has established that probably no more than one out of twenty new product ideas successfully traverse the process to full-scale commercialization. Energy-conserving technologies, needed now more than ever because of the significance of oil imports face even more hazardous evolutions. Confronted by major uncertainties in energy supply, demand, and cost (see Figure D-1), technology suppliers must attempt to make rational manufacturing decisions regarding new energy technologies, technology end-users must attempt to make rational purchasing decisions regarding them, and the Office of Buildings and Community Systems (BCS) of the Department of Energy (DOE) must attempt to make rational decisions regarding the type and amount of support it will provide for the development and commercialization of the technologies.

One new product development which contains the potential for significant energy savings on a nationwide basis is the gas-fired heat pump. It is one of a number of products or technologies which are being examined by BCS. This study has been undertaken to provide BCS with a clearer view of the factors affecting the gas-fired heat pump commercialization decision and to enable BCS to examine the likely results of any action it can take to foster that commercialization process.

This study concentrates on an analysis of the uncertainty associated with basic parameters required for evaluating a venture from the perspective of a manufacturer, such as price, market share, number of units sold, cost of sales, etc. The output from the analysis provides the decision maker with a

FIGURE D-1. UNCERTAIN ENVIRONMENT FACED BY NEW ENERGY CONSERVATION TECHNOLOGIES

quantified probabilistic description of the financial outcome (risk vs. return) of the venture in terms of profit, cash flow, net present value, return on investment, etc.

It is imperative that Federal policy analysts interested in furthering the commercialization of a product or technology have an explicit depiction of the proposed venture from the manufacturer's perspective. Only with this knowledge can the analyst hope to design a suitable strategy which will promote or accelerate the commercialization process. A major aspect of this study is the portrayal of various governmental strategies in the context of the risk analysis and the quantification of their resulting impacts on the venture's outcome.

1.2 THE COMMERCIALIZATION PROCESS

"Commercialization is a complex process involving a set of specific actions with decision points at key locations in development where, based on assessments of product viability, movement towards production may be continued or terminated." (Reference 1, p. 3*). This movement towards production can be characterized by a number of distinct stages or phases, with transition to the next phase occurring only when the probability of success in the marketplace is great enough to warrant investment in continued development by the firm (see Figures D-2 and D-3). In the private sector, this transition process is monitored by each of the participating departments (e.g., research, engineering/manufacturing, marketing, legal, and financial). Table D-1 illustrates a typical definition of stages and the roles played by various departments of a company involved in the development and commercialization of a new product. Continuous feedback of the results at each stage minimizes new product risk. Ultimately, commercialization of any product will occur only if it can be marketed successfully to an end-user at a cost which provides the manufacturer with an acceptable rate of return on his capital.

*References are listed in Chapter 11.

FRAMEWORK IN REPORT TEXT	Concept Exploration	Screening	Product Development	Applications Testing	Commercial Introduction
Resource Planning Associates	exploration---screening---business---development---market---commercialization analysis testing				
JPL SPSA Project Planning Terminology	_____ R & D _____ introduction _____ commercialization _____				
Massachusetts Institute of Technology	_____ Invention _____ development _____ introduction _____ diffusion _____				
General Electric	large scale _____ demonstration _____ test market _____ commercialization, _____ experiment experiment pilot product production and sales				

Source: Reference 1, p. 13

FIGURE D-2. ALTERNATIVE COMMERCIALIZATION FORMULATIONS

Source: Reference 1, p. 13

FIGURE D-3. TRANSITION BARRIERS BETWEEN COMMERCIALIZATION PHASES

TABLE D-1. TYPICAL ROLES PLAYED BY PARTICIPATING DEPARTMENTS IN THE COMMERCIALIZATION PROCESS

Function	Idea	Feasibility Demonstration	Product/Process Development
Research	Computerized patent and literature searches. Evaluation of previous in-house work and supportive technology.	Exploratory lab-scale experimentation to determine general validity of concept. Simulation of alternate technical routes and priorities for evaluation of each.	Systematic study and optimization of variables. First formulation, assembly, packaging, and application studies. Toxicity studies in process. End-use evaluation begun.
Engineering	First discounted cash flow simulations using option conditions, as a function of sales price.	DCF simulations as function of probability of success and sensitivity to cost/price factors. Identification of preferred manufacturing technology.	Detailed analysis of kinetics and thermodynamics complete. Materials of construction defined. Ecological requirements analyzed and design considerations complete. Flow-charts drawn.
Marketing	Preliminary analysis of market size growth and segments. Identification of major competitors and their strengths.	Detailed segment analysis by product, competitor, current technology, deficiencies, needs, and incentive for change.	Key needs of specific customers identified and priority ranking of R&D targets defined. Customer contacts established and first screening completed satisfactorily.
Legal	Analysis of patent literature in progress. Filing of invention disclosures complete. Identification of legal constraints to pursuit of technology in this area.	Patent applications filed and strategies for licensing technology purchase, etc., defined if necessary.	Patent action for continuing and licensing alternatives formalized. Acquisition possibilities analyzed and plan formalized if appropriate.
Financial	Simulation of minimum financial requirements. Based on preliminary DCF. Simulations and possible sales projections.	Budget projections for 3-5 years drafted, capital needs estimated.	Expense budgets and capital plans approved for 3-5 year period. Acquisition, leasing, or building of manufacturing facilities under review.

Source: Reference 2, p. 30-31.

TABLE D-1. TYPICAL ROLES PLAYED BY PARTICIPATING DEPARTMENTS IN THE COMMERCIALIZATION PROCESS

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Pilot Plant	Semicommercial	Full-scale Production
Continued process or product refinements and scale-up studies in process. Quality control methods defined. Ecology constraints satisfied. Thorough formulation and application studies complete. Toxicity data complete.	Interim manufacturing support, technical service and quality control continuing. Process refinements made as required FDA-toxicity negotiations complete.	Continued back-up support of engineering and marketing functions. Pursuit of spin-off technology.
Scale-up and operating design parameters in final stages. Materials of construction validated. DCF calculations completed. Final flow sheets drawn; construction plans approved.	Modifications to existing facilities complete, start-up demonstrated, continuing overview. Capital for plant approved. Construction started	Plant start-up successfully demonstrated. Technical audit complete. Continuing plant support as needed.
Customer sampling and preliminary market tests satisfactorily completed. Feedback to R&D for fine-tuning in process.	Final marketing strategy approved and in operation. Broad-scale sampling and evaluation activity in progress. Brochures, advertising, technical papers, etc., prepared and in use.	Aggressive market plan in operation utilizing public relations, advertising, and technical service functions as needed.
Patent pursuit continuing and legal strategies approved for licensing, joint venture, technology acquisition, etc.	Continuing patent pursuit, licensing, joint venture, etc., negotiations complete and operative.	Involvement as needed.
Financial plan approved; interdivision accounting procedures defined. Decision on manufacturing mode.	Control procedures worked out and in operation. Reporting mechanisms active.	Divisional reporting.

New product risk has been traced to a number of causes. A 1971 study conducted by Hopkins and Bailey focused on identification of the principal causes of new product failure, as experienced by 125 members of the Conference Board's Senior Marketing Executives' Panel. The study results are shown in Table D-2.

TABLE D-2. CAUSES OF PRODUCT FAILURE

<u>Cause of Failure</u>	<u>Percent of Companies Citing</u>
Inadequate market analysis	45
Product problems or defects	29
Lack of effective marketing effort	25
Higher costs than anticipated	19
Competitive strength or reaction	17
Poor timing of introduction	14
Technical production problems	12
Other causes	24

Source: Reference 3, p. 60

The most frequently cited cause of product failure, by far, was inadequate appraisal of the market in advance. It is the ability to portray the effect that uncertain variables, such as number of units sold, market share, etc., have on the ultimate outcome of a venture that lends credibility to the risk analysis methodology. Risk analysis also provides an analytical framework within which decreasing uncertainty can be accounted for as the transition through the commercialization process takes place.

The commercialization process of the gas-fired heat pump is expected to proceed from product evaluation through prototype development, pilot production and full-scale production in accordance with the schedule shown in Figure D-4.

Source: Reference 4

FIGURE D-4. GAS FIRED HEAT PUMP COMMERCIALIZATION SCHEDULE.

1.3 DOE's ROLE IN THE COMMERCIALIZATION PROCESS

Consideration of the Federal role in the commercialization process revolves around the concepts of risk versus return on investment. Figure D-5 is a conceptual portrayal of the analysis involved in deciding on the need for DOE/BCS assistance. Basically, any projects which initially fall on or above the private sector investment curve (curve A) are not considered viable candidates for BCS Research, Development and Demonstration (RD&D) investment since it is expected that the projects would be initiated by the private sector without government assistance.

BCS focuses its attention on energy-conserving projects lying below the private sector investment curve. Government RD&D investment in these projects would be aimed at affecting these projects in one of three ways (see Figure D-5):

- o The rate of return can be increased to offset the risk associated with the project (e.g., moving X to X_2).
- o Risk can be reduced (e.g., moving X to X_3); or
- o A combination of these options which would move X to X_4 .

The implementation of any of these options may result in the successful commercialization of the project by the private sector.

Because of its interest in every savings, BCS is additionally concerned with accelerating the rate of market penetration of the technology or product. Once again, this is basically accomplished by reducing the risk faced by the private sector. Developmental funding assistance and cost sharing are two methods which will speed the commercialization process.

FIGURE D-5. RISK/RETURN TRADE-OFF CRITERIA

1.4 ROLE OF RISK ANALYSIS IN COMMERCIALIZATION CASE STUDY

The risk analysis methodology utilized in this case study provides the means for examining in detail the problem faced by the company and the feasibility of meeting the risk versus return criteria needed for commercialization as illustrated in Figure D-5. By explicitly accounting for the uncertainty in key input variables through the use of probability distributions, the risk associated with various evaluation criteria can be quantified. This enables the government analysts to study the merits of the venture and better assess its need for Federal assistance. Government actions can then be tested to determine their impact on the venture.

The case study of the gas-fired heat pump will first analyze the financial ramifications of the venture from a purely private sector perspective. This analysis will locate where the project presently lies in the private sector's risk vs. return plane.

The study will then proceed to analyze the impact of various governmental strategies designed to promote or accelerate commercialization; i.e., to provide the level of return required for the specific amount of perceived risk.

The use of risk analysis in commercialization case studies of select technologies not only provides a useful end product for policy analysis but also forces the analyst to consider the numerous uncertainties involved in developing, manufacturing, and marketing a new product. Quantification of these uncertainties, whether by a single skilled analyst, or more likely, by a team of experts, provides very important insights to the venture and its needs.

CHAPTER 2

THE DEVELOPMENT OF THE GAS FIRED HEAT PUMP

2.1 BACKGROUND

General Electric began development of a gas-fired heat pump, with the support of the American Gas Association (AGA), in January 1975. In 1976, the Department of Energy (DOE) joined General Electric and the AGA in the AGA program. The development program was undertaken in a series of distinct stages as shown in Figure D-4. Phase I of the program, Product Evaluation, was completed in December 1975. Phase II, Prototype Development, began in February 1976.

Phase I concentrated on the analytical evaluation of the gas heat pump as a viable business venture. Evaluations of possible heat activated heat pump concepts narrowed the choice to either the Stirling/Rankine or the absorption cycle as the most promising candidate for commercial development. Following a more detailed Business evaluation (design, cost, performance, price), and after consultation with AGA and gas industry representatives, the Stirling/Rankine concept was selected as the most promising approach.

Phase II prototype development was designed to demonstrate whether performance predictions drawn from Phase I could in fact be achieved within specified cost goals. Two prototype iterations were planned. The major effort to date is directed toward Prototype 1. Design work on Prototype 2 is presently in its beginning stages.

Component and subsystem development have dominated the prototype development program thus far. Five major subsystems have been developed and Prototype 1 hardware has been fabricated and assembled for the natural gas combustor, the Stirling engine,

the inertia compressor, controls, and air handlers. The development of the inertia compressor and the integration of the compressor with the free-piston Stirling engine proved to be the most technically challenging task.

Following several months of engine/compressor integrated testing, the Prototype 1 system was successfully started in June 1978. System level testing has taken place with the engine/ compressor/ combustor assembly installed in an outdoor unit air handler. Early testing uncovered an engine/ compressor performance sensitivity to any minor mismatch of the two subsystems. Although the first prototype has operated successfully, performance goals have not been attained.

2.2 CURRENT STATUS

Throughout the performance of the case study, the problem of proprietary data or information was an ever present barrier. This barrier was surmounted through the use of government and industry data wherever possible. Most of the information appearing in this section was extracted from Reference 5, "Commercialization Readiness Assessment For Heat Activated Heat Pump", December 1978, obtained from the Oak Ridge National Laboratory. According to the information available, General Electric is the prime contractor and the only firm involved in a major way in the product development and follow-on commercialization of the Stirling/Rankine gas-fired heat pump.

2.2.1 Engineering/Technical

Successful operation of the first Stirling/Rankine Gas Heat Pump has been demonstrated. Testing of the first of two prototype configurations under a wide range of conditions has been completed. Subsystem goals and test results are shown in Table D-3. Component tests and complete system tests of the second prototype were scheduled to begin in 1979. Optimization of this unit for

residential applications (with a 3-ton (cooling) rating) will result in a pre-production configuration.

TABLE D-3. SUBSYSTEM PERFORMANCE-MEASURED AND PREDICTED

<u>Subsystem</u>	<u>Product Goals</u>	Prototype 1	Prototype 2
		<u>Tests Results</u>	<u>Prediction</u>
Combustor	80%	84%	85%
Engine	32%	30%	35%
Refrigeration			
Loop Coefficient of Performance	3.5	3.2	3.5

Source: Reference 6

2.2.2 Marketing/Economic

The gas-fired heat pump (GFHP) is projected to be sold to all markets presently being served by space conditioning equipment which provides both heating and air conditioning. Competitive products include electric heat pumps, gas and oil fired furnaces, electric air conditioners, electric resistance furnaces, and combination furnace/air conditioner units. Studies indicate that there are very few areas of the country where the GFHP cannot be an attractive alternative to presently available systems.

Life cycle analyses conducted by G.E. have shown that the GFHP enjoys a substantial annual cost savings in locales with relatively high energy costs and high average heating to cooling load ratios (such as in Philadelphia), and a positive savings even in less favorable locales (such as Nashville).

GFHP market assessment studies identify the uncertainty of gas supply as the most serious potential threat to its acceptance.

2.2.3 Environmental

The GFHP is projected to produce lower levels of unburned hydrocarbons and contaminants than those emitted by current oil and gas furnaces. Operating noise levels do not appear to be a problem.

2.2.4 Institutional

Industry education and training is necessary to support the sale and servicing of the GFHP. Particular attention will have to be paid to the Stirling engine, because of its newness to the industry.

Possible modification of existing pressure vessel codes may be required, particularly the need for a licensed stationary engineer, to exempt the GFHP from certain requirements.* Standard specifications and safety requirements should be readily dealt with by existing organizations - such as ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), Underwriters Laboratories, AGA, etc.

*ASME Boiler and Pressure Code provides that any fired boiler with pressures over 15 p.s.i.g. is subject to the ASME design code.

CHAPTER 3

STUDY METHODOLOGY AND INPUT DATA

3.1 STUDY METHODOLOGY

Analyzing the commercial viability of a new venture undertaken by a large multidivision/multiproduct corporation requires intimate knowledge of corporate financial data, corporate risk attitudes, current product life cycles, corporate investment criteria, corporate diversification policy, etc. Due to proprietary considerations, it was impossible to obtain the detailed data necessary to conduct a facsimile corporate venture analysis. However, industry financial data is generally available in the form of financial ratios and averages. Commerce Department publications also provide useful generic industry data.

As a result of this data limitation, the gas-fired heat pump venture was assumed to occur as a start-up situation; i.e., a completely new, distinct operation with its own financing. Thus, the analysis concentrated on the concept of venture commercial viability as distinct from corporate commercial viability. Possible interactions with other product lines (particularly electric heat pumps and electric air conditioners) could conceivably impact the corporate viability of the venture, but these considerations are beyond the scope of the present study.

Commercial viability is a function of a number of variables. The most important are end-user acceptance of and demand for the product and the ability of the producer(s) to function under financially acceptable conditions (as determined by performance measures such as profit, cash flow, return on investment, etc.). Many of the critical parameters which determine the financial acceptability of the venture are highly uncertain. Risk analysis deals with this problem by requiring

quantitative estimates of uncertainty to be made of basic probabilistic input data and by converting these quantities into risk profiles of performance data.

The risk model used for the case study is a general financial simulation model which uses Monte Carlo simulation techniques to convert a combination of deterministic and probabilistic input data describing the venture being analyzed into risk profiles. These risk profiles indicate the chance that various performance measures such as profit, cash flow, and return on investment, (ROI) will exceed various levels.

Deterministic input data consist of quantities such as number of years of the venture, number of products to be considered, tax rates, form of venture, etc. Probabilistic input data consists of uncertain parameters whose specification requires subjective estimates of the range of likely values and the form of the uncertainty (i.e., the probability distribution of those values) associated with each uncertain variable. Uncertain variables include unit price, unit sales, market share, time of start of sales, magnitude of capital expenditures, and various expense items. Outputs from the model include risk profiles of annual revenue, expenses, capital expenditures, profit, cash flow, cumulative cash flow, return on assets, present worth (at a number of different discount rates), and payback period.

The basic structure of the risk model is shown in Figure D-6. Calculations proceed in the following manner: Revenue less the sum of fixed and variable expenses yields before-tax profit from which, after multiplication by one minus the tax rate, carry-forward losses are subtracted to yield after-tax profit (Reference 7). Revenues and expenses are adjusted in time in accordance with the random value of the time delay. The time delay is an uncertainty variable which reflects the uncertainty in the time of getting to the market-place. All revenue, expense and capital expenditures are adjusted in time according to this variable.

* I refers to the I th time period.

FIGURE D-6. MODEL STRUCTURE OF RISK MODEL

Fixed and variable depreciations are added to the after-tax profit, as is the change in balance sheet items. Fixed and variable capital expenditures are then subtracted from this amount to yield annual cash flow. Book values of the fixed and variable capital expenditure items are added to the other balance sheet items to produce total assets. Total assets are divided into after-tax profit to yield return-on-assets.

Fixed capital expenditures refer to those capital items which are anticipated to be independent of production level. Variable capital expenditures refer to those capital items which are production level dependent and are thus random variables because their magnitude and timing depend upon unit sales which is a random variable.

Revenue may also be developed by considering unit selling price, unit sales and market share; i.e., the disaggregate case, illustrated in Figure D-7. In this instance, multiple related products may be considered with total revenue being the sum of the individual product revenues. Individual product revenues are based upon establishing (through random sampling) unit selling prices which then, via demand curves established from input data, yield unit sales. The product of unit selling price, unit sales, and market share yields revenue.

The computer analysis phase of the case study revolved around the creation of and generation of results from a base case. The base case was designed to reflect the gas-fired heat pump venture as perceived by a manufacturing entity possessing typical industry (air conditioning and warm air-heating equipment--manufacturer: machinery, except electrical) and firm (G.E.) financial parameters. Learning-experience curve behavior was not considered in the base case analysis.

In order that the full impact of possible policy options could be measured without clouding the analysis with tax

FIGURE D-7. REVENUE STRUCTURE OF RISK MODEL

ramifications such as investment tax credits, the base case was modeled on a before-tax basis. It should be noted that from a corporate standpoint, it is common practice for divisions to consider potential projects on a before-tax basis. For comparison purposes, an after-tax modification of the base case was completed and will be presented.

The base case was used as a datum for conducting an analysis of the sensitivity of the model outputs to various input variables. Possible government policy options designed to improve the acceptability of the venture to the private sector were modelled by modifying the base case.

3.2 BASIS FOR COMPUTER MODEL INPUT DATA

The venture was modelled using both public and private sources of data. Some of the private sources participated only on a not for attribution basis.

Data requiring specific explanation is contained in Table D-4. For a definition of the model input variables to accompany the symbols shown in Table D-4, see the RISK User's Manual (DOE Adaptation), April 1977. Several points concerning base case input data require further clarification. First, the base case was run assuming liquidation of the venture at the end of 18 years of sales in order to maintain compatibility between the energy savings analysis and the basic venture analysis. The model is capable of performing the complete analysis on a venture of a total life of up to 20 years. An after-tax earnings growth rate can be specified beyond that period for present worth calculations; however, the model restricts this rate to a value less than the discount rate during the extended period. G. E. experienced an after-tax earnings growth rate of approximately 13% last year, which is greater than discount rates generally used in analyzing government projects. Separate venture runs were made assuming various growth rates for comparison purposes.

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL

BASE CASE DATA:			
Section	Variable	Assumptions	Source/Reference
1	END=Y	Requirement of program in order to have compatibility between energy savings runs and rest of analysis.	(8)
1	CASE=2	Venture is a separate corporation. Funding occurs as required--all losses are carried forward for tax purposes. (Venture would be dwarfed within G.E. corporate structure. G. E. Company funded research and development for 1978 was \$520.8 million).	(9) and (10)
	DELMIN=0.0 DELMAX=1.0	Maximum anticipated time delay for start of sales of 1 year.	DOE Threshold Data, June 15, 1979
2		Standard uncertainty profiles used.	
3		This section was not used in the analysis.	
4	TIMEP=1.0	Venture initiated in 1983.	(4)
5	PRICEO PMINO PMAXO	Manufacturer's cost assumed to be between \$800 and \$1200 (1979 dollars at venture initiation). Markup to 1st. line distributor = 30%. Inflation rate = 7%/year.	Conversation with knowledgeable industry representative
	SHAREO SMINO SMAXO	Lead manufacturer assumed to have 100% of market.	

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL (Continued)

BASE CASE DATA:			
Section	Variable	Assumptions	Source/Reference
5	UNO UMINO UMAXO	Market penetration data was collected from three sources and distribution formed.	Letter from P.D.Fairchild-Oak Ridge National Laboratory, March 6, 1979. Market Data on Gas-Fired Heat Pump (11) Exhibit 10-12, p. 283 DOE Threshold Data, June 15, 1979
	CHU 10 CHU 20	GFHP is assumed to be price inelastic.	
7	UCMINO UCMAXO	Cost of sales (minus depreciation).	(12) Air Conditioning and Warm Air Heating Equipment and Refrigeration Equipment, SIC #3585 (9) and (10) (13)
7	CHUC10 CHUC20	Cost of sales assumed independent of production volume. Volume relationship considered in Learning-Experience Curve section.	
9	EXPMIO EXPMAO	Advertising and sales promotion assumed 7% of sales in first year with budget expanding with sales, but requiring 3-4% of sales 5 years after introduction.	(4)

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL (Continued)

Section	Variable	Assumptions	Source/Reference
9			(14) Machinery, Except Electrical (9) and (10)
	EXPMI 1 EXPMA 1	Selling expense assumed between 5.0-5.5% for first five years of venture.	Discussion of the Business Aspects of New Product Development Presented to DOE by Donald D. Colosimo - MTI - July 1978.
	EXPMI2 EXPMA2		(14)
	EXPMI3 EXPMA3		(14)
	EXPMI4 EXPMA4		(14)
	EXPMI5 EXPMA5	G.E. has had corporate selling and G&A experience as percent of sales of 17%, 18%, 17% for last 3 years.	(9) and (10)
10	CPY	Model limitations required that the private R&D expenditure be lumped together in the first year of the venture. Other capital expenditures assumed to occur as specified in Reference (4).	(4)

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL (Continued)

BASE CASE DATA:

Section	Variable	Assumptions	Source/Reference
10	CPT	"Costs of R&D activities conducted under a contractual arrangement are not covered by FASB Statement No. 2 and, therefore, may be capitalized and deferred rather than expensed when incurred; this would include projects under government contract." Assumed straight line depreciation. G.E. uses an accelerated depreciation method, based principally on a sum-of-the-years digits formula, to depreciate the original cost of manufacturing plant and equipment purchased and installed in the U.S. subsequent to 1960.	(15) p. 41
	CPL	A depreciation life of 7 years was assumed for R&D and equipment. 20 years was assumed for manufacturing plant.	(9) p. 36
	CAPMIN CAPMAX	Private R&D was lumped in the first year of the venture (assumed 1979 dollars).	DOE Threshold Data, June 15, 1979
		Ref.(4) presents cumulative capital investment in 1978 dollars. Assumed 11% inflation rate to convert to 1979 dollars. Capital expenditure nos. 2 and 4 were assumed to be for equipment; while no. 3 was assumed to be for manufacturing plant.	(4)
12	CSMP RECP PAYP	Balance sheet data percentages assumed equivalent to parent corporation percentages. Includes cash & marketable securities.	(9)

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL (Continued)

BASE CASE DATA:

Section	Variable	Assumptions	Source/Reference
12	INVPP	96 days average level of inventory.	(12)
13	CSHEX INVEX RECEX PAYEX	Existing balance sheet items are assumed to be equal to zero. Actual venture would have working capital account.	
14	ESAVPN ESAVPX	Annual gas energy savings = 31 MMBTU, Annual electricity energy savings = 34 MMBTU. min,max $\pm$ 10%.	DOE Threshold Data, June 15, 1979
	EPI	Developed curve based on recent government forecast. Due to recent oil price increase, modified forecast to reflect more realistic values for both gas and electricity.	
15	CC	16.7%=weighted average marginal cost of capital; 18.0%=return required on retained earnings.	(16) p. 613
		16.5%=tax adjusted composite marginal cost of capital.	(17) p. 143
		23.0%, 25.0%, 30.0% - reasonable G.E. corporate hurdle rates.	(18) p. 4.115

TABLE D-4. BASE CASE DATA REQUIREMENTS AND SOURCES FOR RISK MODEL (Concluded)

BASE CASE DATA:

Section	Variable	Assumptions	Source/Reference
15	PROFC=BT	Considering venture from manufacturer's perspective. Analysis within firm likely to be done on a before-tax basis.	
	TAXR1 TAXR6	Normal corporate tax rates.	
	TCIR1 = 9	The Revenue Act of 1978 increases the amount of tax that may be offset by the investment credit. "Under prior law, taxpayers were generally limited in the use of the credit to offset the first \$25,000 of tax, plus 50 percent of the tax in excess of \$25,000. The act gradually increases the 50 percent limitation to 90 percent over a four-year period beginning in 1979." For equipment with depreciable life ≥ 7 years, the investment tax credit = 100% cost of equipment x 10%.	(19) p. 9

Second, in arriving at the ranges assumed for variables, an attempt was made to be as conservative as possible. This had a direct influence on the distributions chosen for the base case, since it was not desirable to be unduly conservative. Sensitivity analysis was undertaken to gauge the impact of perceived uncertainty (i.e., choice of distributions) on the venture's outcome.

Third, it must be reemphasized that the base case was not intended to be a facsimile of a G. E. venture analysis. It was designed to incorporate reasonable industry and firm parameters into a defined model structure and to arrive at reasonable financial measures of project worth.

CHAPTER 4

DISCUSSION OF BASE CASE RISK ANALYSIS

4.1 VENTURE EVALUATION CONSIDERATIONS

Before proceeding with a detailed discussion of the results of the base case, it is instructive to include a brief discussion of General Electric's method of project evaluation within its strategic planning organization. G.E. is organized into 44 Strategic Business Units (SBU's), with each individual SBU serving as the point in the organization where all business functions, resources, and environmental perspectives come together to develop an effective strategic plan. The planning process proceeds in the following manner (Reference 20, p. 48):

1. January - February: Review of environmental trends to pinpoint problems, opportunities, and strategic issues. Corporate and SBU level issues are combined in planning guidelines for the year.
2. February - June: SBU General Managers, together with their planning and functional staffs, formulate or update the business' strategic plan.
3. June - August: Each business strategic plan involving significant change is reviewed for validity, consistency and effectiveness in coping with environmental conditions.
4. September: The priorities for resource allocation are reviewed at the corporate level and consideration given to alternative objectives or strategies. Guidelines on short-term operating goals are set.

5. October - November: SBU's prepare their operating plans and detailed budgets.
6. December: Final budget reviews are made and the total corporate budget is tested for consistency with overall strategic priorities.

Philosophically, G.E. believes in the concept of formulating long-range strategy first; only later fitting short-range operating goals into the longer-term plan.

Throughout the planning process, strategy development to meet objectives is carried out on a decentralized basis. Due to the size and great diversity of G.E.'s product lines, decentralization is employed as a key managerial concept, especially with regard to operating decisions. "However, investment decisions in equipment, structures, and land have traditionally had much tighter controls, with appropriations above certain amounts requiring successive approval by management levels up to the Board of Directors. Thus, the new product decision-making process may be quickly responsive to perceived trends in its early stages but require searching review when capital appropriations for a new factory or production line are required." (Reference 18, p.4.114). The gas-fired heat pump will eventually require new facilities for the production of its components, particularly the Stirling engine/compressor unit.

Reference 18, p. 4.114 and 4.115 provided further insight into the G.E. new product decision-making process. For instance, G.E. managers expressed the following:

1. To be attractive, a new business should involve creative ideas, patentable or proprietary, that cannot quickly be matched by many other companies.

2. G.E. regards itself as an equipment supplier rather than a systems integrator.
3. Continuing production of a product line with continuing improvements is preferred to one-of-a-kind custom products with very high design content.
4. It was difficult to get any single number as "the required return on investment". One manager was willing to say that 15 to 20 percent was perhaps an average expected return on investment.
5. In making venture decisions that must go upward to Group, Sector, or Board of Directors, use of DCRR (discounted cash rate of return) formulation of the expected return is customary, with 10 to 40 percent being the acceptability limit depending on other factors important in each case.

Note that the gas-fired heat pump (GFHP) venture satisfies conditions 1, 2, 3, and 5. The venture is characterized by: use of a patentable device, the Stirling engine/compressor; production of equipment; extension of an existing product line (electric heat pumps); and, decision-making usually requiring discounted cash flow analysis.

In addition to the above considerations, G.E. utilizes an investment summary and a decision matrix approach in arriving at strategic investment decisions. The investment summary encompasses a number of factors including: (1) market factors, (2) competition factors, (3) financial and economic factors, (4) technological factors, and (5) sociopolitical factors. These last two factors must not be forgotten in any thorough consideration of new product investments.

In practice, the investment summary forces a systematic consideration of the attractiveness of an industry and the firm's relative position in that industry. An example might appear as shown in Table D-5 (Reference 21, p. 151):

TABLE D-5. HYPOTHETICAL INVESTMENT SUMMARY

	Attractiveness of Heating and Air Conditioning In- dustry Environment	Firm's Position
Market	High	Strong
Competition	Low	Strong
Financial & Economic Factors	High	Strong
Technological Factors	High	Strong
Sociopolitical Factors	Low	Medium
Overall	Medium	Strong

Once these judgments have been made, a graphic aid (decision matrix) is often used to assist in conceptualizing the investment decision within the corporate/division/product line framework.

4.2 BASE CASE RISK ANALYSIS RESULTS

Given this background, it is now possible to assess the results of the base case run. The approach used in this assessment will rely upon generally available "non-proprietary" information, and will focus on the financial aspects of the venture. Industry data coupled with selected G.E. corporate data will provide the value model used for comparison. It must be emphasized that the risk model possesses the capability of analyzing the impacts of certain market factors, competition factors, and sociopolitical factors on the venture.

From a theoretical standpoint, the present worth (net present value) method of project evaluation is the most valid. Therefore, the value model utilized in assessing the base case emphasizes this approach. The basic net present value model used by a firm in assessing an investment may be stated as:

NPV > 0 @ Discount Rate Undertake Venture
NPV < 0 @ Discount Rate Don't Undertake Venture
NPV = 0 @ Discount Rate Decision Immaterial

In addition, the net present value approach requires the establishment of a discount rate, usually defined as the firm's marginal cost of capital. Calculations based on G.E.'s 1978 capital structure provided the following results:

Tax adjusted composite marginal cost of capital =	16.5%
Weighted average marginal cost of capital =	16.7%
Marginal cost of retained earnings =	18.3%

Table D-6 and Figure D-8 clearly depict the acceptability of the project based on the above criteria. Use of the marginal cost of capital as the discount rate is justified where capital rationing is non-existent. This assumption appears rational when comparing the projected total capital outlay for the project (maximum of \$35.3 million over 8 years) with the yearly G.E.-funded research and development budget (\$520.8 million in 1978). On an after-tax basis, the base case continued to satisfy the postulated value model (see Table D-7).

It is possible to use other theoretically less valid value models for assessing project acceptability. Financial ratios such as return on investment (ROI), return on assets (ROA), return on sales (ROS) and return on stockholder's equity (ROE) are often used as both project measurement devices and as measures of managerial performance. ROA and ROS for the gas-fired heat pump are compared with G.E. corporate and industry values in

TABLE D-6. PRESENT WORTH RISK PROFILE
BASE CASE BEFORE-TAX

PRESENT WORTH
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

0	170498.8	85710.9	32821.8	19652.4	- 2413.5
4	158552.7	80201.1	24317.4	10971.4	-10347.1
8	150540.7	74575.1	20714.0	8304.7	-12202.8
12	146979.8	70074.2	18912.3	6399.9	-13773.0
16	142973.8	66136.1	16209.7	4876.0	-14629.5
20	138611.7	62117.5	13957.5	2133.1	-15628.8
24	133626.6	59706.3	11930.6	304.5	-16770.8
28	127395.0	57521.2	9565.8	- 1001.6	-18697.9
32	124279.2	55411.4	8214.5	- 2267.0	-18554.4
36	121163.5	53301.7	6993.2	- 3409.8	-20410.9
40	119086.2	51191.9	6161.6	- 4552.7	-21267.4
44	117009.1	49513.7	5330.0	- 5695.6	-22195.3
48	114931.9	47979.3	4498.5	- 6879.3	-23337.3
52	110777.6	46444.9	1795.9	- 8185.5	-24265.2
56	106207.7	43069.3	714.9	- 9254.1	-25121.7
60	101689.9	40417.0	- 366.2	-10085.3	-25978.2
64	98574.2	38005.9	-10816.2	-20267.3	-27187.8
68	94679.4	34630.3	- 3609.3	-13410.1	-27782.9
72	88447.9	29566.8	- 7212.7	-16457.7	-28761.8
76	82735.7	24292.4	-10816.2	-20267.3	-32187.8
80	78581.4	22182.6	-13744.0	-22095.9	-34243.4
84	73803.8	16205.0	-17122.2	-24838.9	-35613.8
88	69234.1	13392.0	-23428.3	-32267.6	-43322.2
92	65079.7	8469.2	-27031.7	-35124.8	-46748.3
96	40153.6	- 7002.4	-36040.3	-43124.9	-49317.8
100	24910.0	-20398.5	-47212.5	-52807.3	-61901.1
	14.0	18.0	23.0	25.0	30.0

DISCOUNT RATE (PERCENT)

AVERAGE (\$1000)	107548	42462	-77	-10202	-25830
STD. DEV. (\$1000)	33113	23935	17126	15281	12011

FIGURE D-8. NPV - GAS-FIRED HEAT PUMP BASE CASE, BEFORE-TAX

TABLE D-7. PRESENT WORK RISK PROFILE
BASE CASE AFTER-TAX

PRESENT WORTH
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

0	371685.1	207353.7	113028.0	30593.9	3048.7
4	326755.7	171920.9	88837.7	16924.5	-4006.0
8	307452.0	165367.1	84465.5	15261.2	-5951.6
12	298934.6	159141.0	80311.9	14152.3	-7164.4
16	294912.2	153897.9	76814.2	12885.0	-8175.1
20	290889.9	150152.8	74628.0	11459.3	-9091.0
24	286113.4	146797.9	72441.9	9605.8	-9975.4
28	281085.4	144613.3	69943.5	7984.0	-11965.2
32	276476.6	142428.7	67632.6	6736.5	-13733.9
36	272007.3	140062.0	65883.6	5114.8	-14377.0
40	267944.3	137149.2	64134.8	2370.2	-15020.2
44	264287.7	134236.4	61823.8	53.4	-17271.3
48	260631.0	131323.6	59315.4	-1372.3	-19393.7
52	252175.0	128410.7	54953.1	-2619.8	-20808.7
56	244633.1	122767.1	51455.4	-3057.3	-21516.2
60	238599.6	114574.9	49388.5	-5530.7	-22223.7
64	234577.3	112191.7	47798.6	-6861.4	-22899.0
68	230555.0	109808.4	46200.7	-7859.4	-23542.2
72	224521.5	107084.8	43293.9	-8857.4	-24185.3
76	218376.3	103339.7	40962.0	-9966.3	-25230.5
80	213907.1	100156.4	39213.1	-11075.2	-26367.5
84	209437.8	97534.9	37464.3	-11976.2	-27378.2
88	201393.1	94913.4	34965.8	-12807.8	-28237.3
92	194354.0	89670.3	32363.3	-13639.5	-28944.8
96	184298.2	83444.2	29448.5	-19669.2	-29652.2
100	160987.3	67646.2	18419.2	-27246.3	-41936.7

10.0 14.0 18.0 25.0 30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	253268	127257	57386	-405	-18254
STD.DEV.(\$1000)	42340	27459	18965	11497	8911

Figures D-9, D-10 and D-11. These figures indicate that the base case exhibits commercially acceptable ratio values. Due to differences in accounting practices, even within industries, it is difficult to make definitive statements regarding ratio analysis.

The median payback period for the base case occurs in quarter 4 of year 11. However, this figure is somewhat misleading due to the schedule of capital expenditures. Model limitations required lumping of R&D expenditures into year 1. Moreover, major capital expenditures were assumed to take place in years 3 and 8. It should be noted that despite these occurrences, the median payback period is not unusually long for investments in manufacturing plant and equipment by most industry standards, where 10-year payback periods for equipment are not uncommon. In light of this fact, it is interesting to consider the cash flow projection, Figure D-12. Note that the large cash flow at year 18 is due to the assumption of liquidation occurring at year 18.

Upon examination of the results of the base case, one is able to make the following points:

- o Noting the limitations on data, it appears that from a financial perspective the GFHP is commercially viable without further governmental assistance.
- o Through the use of industry and firm financial data it is possible to model the financial effects of a new product introduction on a firm.
- o Risk analysis cannot exist in isolation; consideration must be given to other investment factors, particularly: (1) market, (2) competition, (3) financial and economic, (4) technological, and (5) sociopolitical.

FIGURE D-9. RETURN ON ASSETS, GAS HEAT PUMP VS
GENERAL ELECTRIC CORPORATE AVERAGE

FIGURE D-10. RETURN ON ASSETS, GAS HEAT PUMP VS INDUSTRY VALUES

FIGURE D-11. RETURN ON SALES, GAS-FIRED HEAT PUMP VS. GENERAL ELECTRIC AVERAGES VS. INDUSTRY VALUE

FIGURED D-12. ANNUAL GAS-FIRED HEAT PUMP CASH FLOW PROJECTION

A thorough analysis must be made of the assumptions used to model the venture and the impact of changing those assumptions in order to truly understand the nature of the risk analysis.

CHAPTER 5

DISCUSSION OF SENSITIVITY ANALYSIS AND RESULTS

Sensitivity analysis is generally performed, in a deterministic analysis, by holding all variables constant except for the one uncertain variable under study. The variable under study is then varied to examine the impact of its uncertainty on the final evaluation criteria. This procedure highlights areas where effort should be expended to obtain the greatest benefit.

Risk analysis presents a unique situation with regard to conducting a sensitivity analysis. In the risk analysis, uncertainty is explicitly dealt with in arriving at input data by the selection of the range (maximum and minimum values) and the uncertainty profile, which depicts the subjective probabilities of the variable occurring at particular values within that range. Because the selected range encompassed all probable values, the sensitivity analysis performed for this case study consisted of determining the effect of the choice of probability distributions, or uncertainty profiles, on the venture's outcome. The uncertainty profiles used are illustrated in Figure D-13.

Table D-8 presents a compilation of the results of the sensitivity analysis. Figure D-14 through D-19 illustrate the impacts, for the selected variables, of the uncertainty profile choices on venture evaluation criteria.

Based on the results of the sensitivity analysis, as shown in Table D-8 and the accompanying figures, it is possible to make the following observations:

1. The financial outcome of the venture appears to be very sensitive to the uncertainty profiles chosen to represent unit selling price, units sold, and unit cost of sales.

PROFILE
NUMBER

1

2

3

4

5

6

7

PROFILE
NUMBER

11

12

13

14

15

16

17

PROFILE
NUMBER

21

22

23

24

25

26

27

FIGURE D-13. UNCERTAINTY PROFILES

TABLE D-8. SENSITIVITY ANALYSIS RESULTS

Impact on Venture											
Section	Variable Considered	Base Uncer. Profile *	Uncertainty Profiles Investigated*	Present Worth			Median Pay-back Period	Return on Assets (ROA)		Average 1st Positive Cash Flow	
				Discount Rate	18%	23%	25%		Year Max 9		
				Base Case	Avg(\$K)	42462	-77	-10202	Quarter 4	Avg(%) 17 19	Year 5
					σ(\$K)	23935	17126	15281	Year 11	σ(%) 6 5	
5	Unit Selling Price	23	1		Avg(\$K)	-84303	-86097	-84912	No Payback in	Avg(%) 3 7	Year 7
					σ(\$K)	26345	20429	18805	18 Years	σ(%) 9 7	
			21		Avg(\$K)	50739	5487	-5388	Quarter 3	Avg(%) 18 20	Year 5
					σ(\$K)	24896	17732	15784	Year 11	σ(%) 6 5	
5	Units Sold	23	1		Avg(\$K)	17384	-6371	-11944	Quarter 1	Avg(%) 16 19	Year 5
					σ(\$K)	15031	10724	9608	Year 3	σ(%) 6 5	
		21	21		Avg(\$K)	44249	349	-10102	Quarter 3	Avg(%) 17 19	Year 5
					σ(\$K)	24702	17668	15763	Year 11	σ(%) 6 5	
7	Unit Cost of Sales	5	1		Avg(\$K)	61422	13286	1570	Quarter 3	Avg(%) 19 21	Year 5
					σ(\$K)	25385	18110	16120	Year 11	σ(%) 6 5	
			21		Avg(\$K)	-35303	-55158	-58824	Quarter 3	Avg(%) 10 12	Year 5
					σ(\$K)	24586	18440	16805	Year 17	σ(%) 7 5	

*See Figure D-13.

FIGURE D-14. SENSITIVITY OF CASH FLOW TO UNIT SELLING PRICE UNCERTAINTY PROFILE

FIGURE D-15. SENSITIVITY OF NPV TO UNIT SELLING PRICE UNCERTAINTY PROFILE

FIGURE D-16. SENSITIVITY OF CASH FLOW TO UNITS SOLD UNCERTAINTY PROFILE

FIGURE D-17. SENSITIVITY OF NPV TO UNITS SOLD UNCERTAINTY PROFILE

FIGURE D-18. SENSITIVITY OF CASH FLOW TO UNIT COST OF SALES
UNCERTAINTY PROFILE

FIGURE D-19. SENSITIVITY OF NPV TO UNIT COST OF SALES UNCERTAINTY PROFILE

2. Unit selling price stands out as the most sensitive variable to the choice of the uncertainty profile while units sold appears to be the least sensitive.
3. Net present value appears to provide a more discriminating criterion for judging sensitivity than either median payback period or return on assets.

CHAPTER 6

POSSIBLE FEDERAL POLICY OPTIONS/STRATEGIES

Successful commercialization of a new technology will occur only if it can be marketed successfully at a cost which provides an acceptable rate of return on invested capital.

It is generally accepted that Federal efforts designed to promote or accelerate commercialization of new energy technologies will be most successful when the private sector is involved to the greatest extent possible. Thus, Federal policy should be directed at identifying and stimulating "real world" end-users and manufacturers so that the product is regularly manufactured and purchased. Additional attention must be paid to potential barriers to commercialization in the areas of capital markets; social, legal, regulatory and political constraints; and environmental concerns.

Table D-9 presents a compilation of potential barriers to successful commercialization of the GFHP, by sector, and possible DOE/BCS policy options or strategies to overcome these obstacles. The strategies noted include both the policy options open directly to BCS and other Federal policy options, action on which could be initiated based on BCS recommendations. Careful analysis is required to determine potential critical barriers and to design the most cost-effective strategies for the desired impact on commercialization.

TABLE D-9. POTENTIAL BARRIERS TO SUCCESSFUL COMMERCIALIZATION
VS.
POSSIBLE PCS STRATEGIES

POTENTIAL BARRIERS TO SUCCESSFUL
COMMERCIALIZATION

End Market and Buying
Behavior Barriers

End Markets - Single Family, Multifamily

- General Contractors, Subcon-
tractors, Craft Unions

- Builders/Developers

Lending Institutions

Utilities

POSSIBLE PCS STRATEGY

Consumer Education Programs (Including
Gas Availability vs. Price; and
Life Cycle Costing)
Federal PR Campaigns (Inertia Removal)
Federal Performance Standards
Federal Guaranteed Warranty Protection
Insurance
Federal Income Tax Credits
Sales Tax Exemptions
Local Property Tax Increases Forbidden
for Energy Conserving Devices (E.C.D.)

Education Programs - Regional Trade Fairs
Federally Sponsored or Subsidized Service
and Maintenance Courses (Prime Mover)
Tax Incentives

Education Programs - Conferences/Symposia
Direct Manufacturer Purchase Program
(Remove Distributor Markup)
Tax Incentives

Encourage - Subsidize Loans and Mortgages
Involving E.C.D.
Guaranteed Low Interest Loans for E.C.D.
(Economic Cycle Insurance)

Provide for Utility Financing (Leasing)
Provide Utility Interaction in Sales/Service

TABLE D-9. POTENTIAL BARRIERS TO SUCCESSFUL COMMERCIALIZATION
VS.
POSSIBLE BCS STRATEGIES (Continued)

POTENTIAL BARRIERS TO SUCCESSFUL
COMMERCIALIZATION

Local Government Codes and Regulations

Market/Industrial System Barriers

Firm Specific - Similiarity to and Effect on
Present Product Line

- Non-Recurring Costs:
 - Initial Product R&D
 - Initial Warranty Costs for
Correcting Potential
Defencies
 - Development of Manufactur-
ing Technology

- Product Profitability

POSSIBLE BCS STRATEGY

Uniform National Code for Allowed
Operation (Special Attention to
Working Pressure)

Federally Mandated and Supported In-
itial Marketing Programs
Favorable Tax Treatment of Revenue From
Energy Conserving Product Lines -
Tax Deferrals
Favorable Tax Treatment for Production
Plant and Equipment for Manufacturing
Energy Conserving Products
Special Tax Treatment for "Outmoded"
Plant and Equipment

Federal Cost Sharing - Subsidies
Legislation to Allow and Encourage
Joint Ventures
Federal Laboratory Assistance in Manu-
facturing Technology R&D
Grants or Contracts in Support of Non-
Recurring Costs
Subsidy to Eliminate Start-up Manufac-
turing Losses
Short-Term Lease Arrangement for Initial
Pilot Manufacturing Facility

Government Price Guarantees - Until "Bugs"
Removed from Manufacturing Process

TABLE D-9. POTENTIAL BARRIERS TO SUCCESSFUL COMMERCIALIZATION
VS.
POSSIBLE ECS STRATEGIES (Continued)

POTENTIAL BARRIERS TO SUCCESSFUL
COMMERCIALIZATION

POSSIBLE BCS STRATEGY

Industrial System

- Foreign Competition

Market System

Investment Tax Credit - Increase % on
Product Equipment
Accelerated Depreciation - on Production
Equipment
Government Subsidized Marketing Programs -
Special Tax Treatment
Priority Rights Clauses - Guaranteed
Exclusively until Recoup Initial
Investment
Operating Risk Insurance - Guarantee
that a Company will Experience
No Loss from Approved Innovation
Investments

Encourage Innovation in the Traditional
Manufacturer, Distributors, Builders/
Developers, General Contractors,
Architect/Engineer Relationship
Ensure Against Price Cutting by Foreign
Competition (Tariffs)

Guaranteed Long-Term Procurement Contracts
With Price Guarantees
Long-Term Procurement Contracts With
Fixed Price Plus Fund for Differences
With Market Price
Joint Marketing Venture - Government/Industry
Market Catastrophe Insurance - Cover
Financial Failure With Technologically
Successful Innovations Because of
Unforeseen Market Conditions

TABLD D-9. POTENTIAL BARRIERS TO SUCCESSFUL COMMERCIALIZATION
VS.
POSSIBLE BCS STRATEGIES (Concluded)

POTENTIAL BARRIERS TO SUCCESSFUL
COMMERCIALIZATION

POSSIBLE BCS STRATEGY

Financial/Capital Market Barriers

End Market

Guaranteed Low Interest Loans for Buyers
of E.C.D.
Encourage Use of Alternate Financing
Schemes - Leasing, Installment
Purchases, etc.
Government Guaranteed Low Interest Loans for
Builders/Developers Using E.C.D.

Social/Legal-Regulatory/Political Barriers

Gas Availability and Price Vs.
Alternative Energy Sources

Consumer Education with respect to
Supply, Price, Allocation Schemes

Gas Deregulation Scenario

Develop Long-Term Policy

Gas Appliance Performance Standards

Propose National Legislation - Performance
Standards on Gas Appliances

Tax Treatment for Energy Conserving
Device - End Use

Promote Consistent Favorable Treatment
Across Sectors - Federal, State, Local

High Internal Working Pressure of Stirling
Engine-Building Codes

Incorporate Into National Performance
Standards

Environmental Barriers

None Identified

CHAPTER 7

IMPACT OF FEDERAL STRATEGIES ON RISK ANALYSIS RESULTS

One of the more powerful aspects of risk analysis is its ability to portray the impact of possible Federal programs on both the perceived risk of and the expected return from new product ventures.

Selected policy options or strategies were modelled to demonstrate the capability for policy analysis. The process followed in performing this policy analysis began by considering each section of the model with regard to possible policy variables. Each policy variable identified in each section was varied separately according to a prescribed scenario and the resulting impact on the base case recorded. Once again, the base case was used as a datum in order to gauge the effect of each variable on the financial outcome of the venture. Possible policy options or strategies and their resulting probable impacts were then correlated with each variable. This analysis was conducted to demonstrate the capability of the risk analysis to model the impact of possible Federal policy options on the venture as it is perceived by a firm. It is not intended to be an exhaustive treatment of possible federal intervention and its resulting impact. An exhaustive treatment would require even more detailed scenario development, additional program modification - possibly varying more than one variable at a time, and the development of an effectiveness criteria-policy ranking scheme. Such treatment is beyond the scope of the present study. Among the Federal strategies which were considered in this initial policy analysis are:

- a. Federal public relations campaign - decreasing advertising expense of firm.
- b. Federal guaranteed warranty protection - insurance.
- c. Direct manufacturer purchase program for builders/developers - removing distributor markup.

- d. Federally mandated and supported initial marketing programs.
- e. Favorable tax treatment of revenue from energy conserving product lines.
- f. Favorable depreciation schedules for production plant and equipment used for manufacturing energy conserving products.
- g. Special tax treatment for "outmoded" plant and equipment.
- h. Grants or contracts in support of non-recurring costs.
- i. Subsidy to eliminate start-up manufacturing losses.
- j. Short-term lease arrangement for initial pilot manufacturing facility.
- k. Increase investment tax credit on production equipment.
- l. Operating risk insurance - guarantee that a company will experience no loss from approved investments.
- m. Market catastrophe insurance - cover financial failure with technologically successful innovations because of unforeseen market conditions.
- n. Government guaranteed low interest loans.
- o. Priority rights clauses - guaranteed exclusivity until recoup initial investment.

Table D-10 presents the results of the policy analysis. A discussion of the results immediately follows the table.

TABLE D-10. POLICY ANALYSIS - IMPACT ON VENTURE

Section	Policy Variable Considered	Policy Variable Δ Base Case	Federal Policy Option/Strategy	Impact on Venture							
				Present Worth			Median Pay-back Period	Return on Assets (ROA)		Average 1st Positive Cash Flow	
				Discount Rate	18%	23%		25%	Year 9		Max
				BASE CASE	Avg(\$K) 42462 σ (\$K) 23935	-77 11126	-10202 15281	Quarter 4 Year 11	Avg(%) 17 σ (%) 6	19 5	Year 5
1	Min. Delay Start Sales	No Possible Time Delay	Increase Level of RD&D Funding; Operating Risk Insurance; Market Catastrophe Insurance	Avg(\$K)	47059	+1357	-9704	Quarter 4	Avg(%) 18	20	Year 4
				σ (\$K)	20148	14535	13012	Year 11	σ (%) 7	7	
	Max. Delay Start Sales	One Year Advance		Avg(\$K)	47764	1166	-10126	Quarter 2	Avg(%) 17	20	Year 4
				σ (\$K)	26362	18817	16828	Year 11	σ (%) 6	5	
1	Growth Rate After Tax Earnings	Venture Continues 4%	Increase Growth Rate After Tax Earnings By:	Avg(\$K)	32972	-8919	-17713	Quarter 4	Avg(%) 17	19	Year 5
				σ (\$K)	54029	25350	19983	Year 11	σ (%) 6	5	
		Venture Continues 13%	Favorable Tax Treatment - Revenue From Energy	Avg(\$K)	94454	2016	-11501	Quarter 4	Avg(%) 17	19	Year 5
			Conserving Product Lines;	σ (\$K)	134564	37504	26331	Year 11	σ (%) 6	5	
		Venture Continues 20%	Special Tax Treatment - "Outmoded" Plant and Equipment;	Avg(\$K) *	55884	8791		Quarter 4	Avg(%) 17	19	Year 5
			Increase Investment Credit - Production Equipment	σ (\$K)	108217	51589		Year 11	σ (%) 6	5	
5	Unit Selling Price	25% Markup	Government Price Supports; Direct Manufacturer Purchase Program - Builders/Developers	Avg(\$K)	39777	-969	-10655	Quarter 4	Avg(%) 17	19	Year 5
				σ (\$K)	22799	16287	14524	Year 11	σ (%) 6	5	
		35% Markup		Avg(\$K)	43590	-355	-10776	Quarter 4	Avg(%) 17	19	Year 5
				σ (\$K)	24570	17545	15644	Year 11	σ (%) 6	5	
5	Market Share	100% to Year 4 Declining Linearly	Priority Rights - Guaranteed Exclusivity Until Recoup	Avg(\$K)	20072	-7181	-13973	Quarter 2	Avg(%) 16	19	Year 5
				σ (\$K)	18087	13869	12671	Year 10	σ (%) 6	5	
5	Units Sold	Min. Units Guaranteed	Govt. Guaranteed Purchase	Avg(\$K)	1764	-9563	-12157	Quarter 1	Avg(%) 15	19	Year 7
				σ (\$K)	5229	3553	3119	Year 13	σ (%) 5	6	
		Max. Units Guaranteed		Avg(\$K)	60898	5174	-8186	Quarter 3	Avg(%) 18	19	Year 5
				σ (\$K)	25114	17836	15913	Year 11	σ (%) 8	6	
		Most Likely Guaranteed		Avg(\$K)	9777	-7418	-11401	Quarter 2	Avg(%) 15	19	Year 4
				σ (\$K)	1526	5071	4464	Year 14	σ (%) 5	6	
5	Units Sold	Increase Penetration, 10%	Consumer Programs - Tax Credits, Low Interest Loans; Gas Utility Programs; Federally Guaranteed Warranty Protection Insurance; Federally Mandated and Supported Initial Marketing Programs	Avg(\$K)	48176	1324	-9835	Quarter 4	Avg(%) 17	19	Year 5
				σ (\$K)	26310	18820	16791	Year 11	σ (%) 6	5	
		20%		Avg(\$K)	51885	2723	-9471	Quarter 3	Avg(%) 17	19	Year 5
				σ (\$K)	28686	20516	18302	Year 11	σ (%) 6	5	
		50%		Avg(\$K)	71092	6969	-8337	Quarter 3	Avg(%) 17	20	Year 5
				σ (\$K)	35813	25598	22832	Year 11	σ (%) 6	5	

*Growth Rate is greater than Discount Rate

TABLE D-10. POLICY ANALYSIS - IMPACT ON VENTURE (Continued)

Section	Policy Variable Considered	Policy Variable Δ Base Case	Federal Policy Option/Strategy	Impact on Venture								
				Present Worth			Median Pay-back Period	Return on Assets (ROA)		Average 1st Positive Cash Flow		
				Discount Rate	18%	23%		25%	Year 9		Max	
5	Price Elasticity of Demand	Price Elastic	Federal Programs - Competing Products; Federal Programs - Competing Energy Sources	Avg(\$K) σ (\$K)	32546 22475	-4985 16767	-13839 15197	Quarter 4 Year 11	Avg(%) σ (%)	17 6	19 5	Year 5
7	Unit Cost of Sales	Abnormal Product Warranty Costs	Federal Guaranteed Warranty Protection - Insurance	Avg(\$K) σ (\$K)	11837 25813	-27290 19691	-36215 18077	Quarter 4 Year 12	Avg(%) σ (%)	17 6	19 5	Year 5
	Cost vs. Volume	See Learning Curve Section										
9	Advt. Expense	Eliminate New Product Excess Exp.	Federal Public Relations Campaign	Avg(\$K) σ (\$K)	43180 24103	556 17141	-9598 15289	Quarter 4 Year 11	Avg(%) σ (%)	17 6	19 5	Year 5
		Reduce by 50%		Avg(\$K) σ (\$K)	47325 24103	3414 17211	-7102 15339	Quarter 3 Year 11	Avg(%) σ (%)	17 6	20 5	Year 5
9	Selling Exp.	Eliminate New Product Excess Exp.	Federally Mandated and Supported Initial Marketing	Avg(\$K) σ (\$K)	49473 24315	6109 17347	-4306 15439	Quarter 3 Year 11	Avg(%) σ (%)	17 6	19 5	Year 5
		Reduce by 50%		Avg(\$K) σ (\$K)	59391 24615	12484 17509	1083 15565	Quarter 2 Year 11	Avg(%) σ (%)	18 6	20 5	Year 5
9	Taxes(Edited)	Reduce by 50%	Reduce State, Local, Social Security	Avg(\$K) σ (\$K)	56839 24427	10062 17382	-1267 15464	Quarter 2 Year 11	Avg(%) σ (%)	18 6	21 5	Year 5
9	G&A Expense	Reduce by 50%		Avg(\$K) σ (\$K)	60635 24584	12735 17482	1085 15547	Quarter 1 Year 11	Avg(%) σ (%)	19 6	21 5	Year 5
9	Interest Exp.	Reduce by 50%	Govt. Guaranteed Low Interest Loans	Avg(\$K) σ (\$K)	44262 23997	1195 17157	-9080 15303	Quarter 3 Year 11	Avg(%) σ (%)	17 6	20 5	Year 5
9	Other Expenses	Reduce by 50%		Avg(\$K) σ (\$K)	50214 24084	5386 17197	-5389 15328	Quarter 3 Year 11	Avg(%) σ (%)	18 6	20 5	Year 5
10	Depreciation Type	Double Declining Balance (exc. R&D)	Favorable Depreciation Schedules for Production Plant and Equipment Used for Manufacturing Energy Conserving Products	Avg(\$K) σ (\$K)	42580 23948	-84 17126	-10230 15279	Quarter 4 Year 11	Avg(%) σ (%)	17 6	20 4	Year 5
		All Straight Line		Avg(\$K) σ (\$K)	41776 23924	-722 17116	-10824 15272	Quarter 4 Year 11	Avg(%) σ (%)	17 6	19 5	Year 5
10	Depreciation	Life of Plant = 10	Favorable Depreciation Schedules for Plant	Avg(\$K) σ (\$K)	43124 23950	524 17141	-9627 15295	Quarter 4 Year 11	Avg(%) σ (%)	17 6	20 5	Year 5
10	Capital Expenditures	Eliminate Private R&D; Eliminate Pilot Plant	Grants or Contracts in Support of Non-Recurring Costs; Subsidy to Eliminate Start-up Manufacturing Losses; Short-Term Lease for Pilot Manufacturing Facility	Avg(\$K) σ (\$K)	44710 18232	1748 12824	-8608 11414	Quarter 4 Year 11	Avg(%) σ (%)	18 6	21 6	Year 5
		Decrease Expenditures 36% by 50%	Grants or Contracts in Support of Non-Recurring Costs	Avg(\$K) σ (\$K)	46252 23911	3338 17103	-6926 15259	Quarter 3 Year 11	Avg(%) σ (%)	17 6	20 5	Year 5

TABLE D-10. POLICY ANALYSIS - IMPACT ON VENTURE (Continued)

Section	Policy Variable Considered	Policy Variable Δ Base Case	Federal Policy Option/Strategy	Impact on Venture								
				Present Worth			Median Pay-back Period	Return on Assets (ROA)		Average 1st Positive Cash Flow		
				Discount Rate	18%	23%		25%	Year 9		Max	
15	Corporate Tax Rates	Decrease Tax Rates 1%	Favorable Tax Treatment of Revenue from Energy Conserving Product Lines	Avg(\$K)	75870	23652	10751	Quarter 4	Avg(%)	20	23	Year 5
				σ (\$K)	21069	14438	12712	Year 10	σ (%)	5	5	
				After Tax Base Case:								
				Avg(\$K)	57386	10885	-405	Quarter 2	Avg(%)	19	21	Year 5
				σ (\$K)	18965	13024	11497	Year 11	σ (%)	5	5	

Table D-10 demonstrates that the model has considerable flexibility with regard to modelling policy options. It is possible to model the venture from both a before-tax and an after-tax perspective, an especially useful feature for analyzing Federal options. In addition, there are several depreciation options available in considering capital expenditure items. The model also allows one to extend the venture beyond the twenty year time frame and to gauge the resulting financial impact.

Consideration of the net present value of the venture versus various policy options seems to provide greater discrimination capability with regard to judging policy impact than the other measures listed. Note from examination of Table D-10 that a reliance upon either median payback period or return on assets would not allow for an accurate appraisal of the effects of a possible strategy. Raising the average internal rate of return of the venture to 25% appears to require Federal programs designed to significantly reduce major operating expense items or to reduce the overall corporate tax rate. A number of possible strategies may result in an increase in the internal rate of return of the venture to approximately 23%; these range from accelerating start of sales by one year to eliminating the burden of new product advertising expense from the firm.

It is interesting to note the relative insensitivity of the venture results to changes in the assumed price elasticity of demand and the assumed depreciation schedule for capital items. Decreasing the depreciation period from 20 years to 10 years for one major capital expenditure item resulted in a greater positive impact than changing the method of depreciation for all items from the sum of the years digits method to the double declining balance method.

Finally, extending the venture beyond the year 2000 could have varying results depending on the growth rate of after-tax

earnings. A 4% growth rate in after-tax earnings results in a negative impact relative to the liquidation case (base case); whereas a growth rate of 13% or 20% would provide increasingly positive results.

Several policy options and strategies were chosen from Table D-9 in order to present in more detail the capabilities of risk analysis in the areas of policy formulation and analysis. The first policy option explored involved the impact of extraordinary product warranty costs associated with new product introduction. Based on industry experience with the electric heat pump, this cost could have a significant impact on the viability of the GFHP venture.

The base case was modified to account for extraordinary warranty and product support costs in the early years after product introduction. Figure D-20 was assumed to be representative of the history of new product warranty costs. Given this model, the base case unit cost of sales was adjusted upward for the first six years after product introduction. The risk model was then run with the adjusted data.

It is essential that Federal policy analysts have some indication of how a potential policy would be perceived by the firm. Figure D-21 portrays the impact of abnormal product warranty costs on the annual average cash flow derived from the venture. The difference between the two cash flow streams represents the potential Federal outlay for a program designed to lessen the impact of warranty costs on the firm. Relieving the burden of abnormal product warranty costs from the firm results in an improved perception of the venture. Figure D-22 depicts the impact of the policy option on the perceived NPV of the venture.

Government guaranteed purchases have been effective in the past in promoting new defense related technologies, with resulting

Source: Reference 8

FIGURE D-20. WARRANTY AND PRODUCT SUPPORT AS A PERCENTAGE OF COST OF SALES

FIGURE D-21. ANNUAL AVERAGE CASH FLOW - BASE CASE (NORMAL PRODUCT SUPPORT COSTS) VS. ABNORMAL PRODUCT WARRANTY COSTS

FIGURE D-22. POTENTIAL IMPACT OF PROTECTION FROM ABNORMAL PRODUCT WARRANTY COSTS FROM PERCEPTION OF FIRM.

spin-offs into the civilian sector (e.g., integrated circuits). In order to examine the effect of guaranteeing a certain purchase level of GFHP's, three separate computer runs were made -- each assuming a deterministic level of market penetration (maximum, minimum, and most likely). These runs were then compared with the results of the base case. The cash flow impact of guaranteed-buy programs is shown in Figure D-23. The impact of a guaranteed-buy on the perception of the firm is somewhat more clouded than the product warranty case. Figure D-24 seems to suggest that the firm would prefer a probabilistic market penetration to a guaranteed market at the most likely level. (Note that this is due to the magnitude of the most likely value and uncertainty profile assumed in the base case). However, when the maximum market penetration is guaranteed (Figure D-25), the improved perception of the venture is quite evident. This suggests that Federal guaranteed-buy programs must be aware of the firm's market perception in order to be of maximum effectiveness. Programs designed in isolation may prove to be unneeded or, worse, counterproductive.

Recently, there has been increasing discussion at the Congressional level concerning the possibility of a further decrease in corporate tax rates. With this in mind, two computer runs were made. The first run was essentially the base case on an after-tax basis, while the second run assumed a 1% decrease in the corporate tax rate at each income bracket. The positive impact of the tax cut on both the average annual cash flow from the venture and the perceived net present value of the venture are evident from an examination of Figures D-26 and D-27. With the tax cut, there is about a 20% probability of a positive net present value at a discount rate of 30%.

Energy savings analysis was performed for those policy options which impacted the base case energy savings calculations. The base case energy savings are presented in Tables D-11 and D-12.

FIGURE D-23. ANNUAL AVERAGE CASH FLOW - MAXIMUM MARKET PENETRATION GUARANTEED VS. BASE CASE VS. MOST LIKELY PENETRATION GUARANTEED

FIGURE D-24. POTENTIAL IMPACT OF GUARANTEE OF MOST LIKELY MARKET PENETRATION FROM PERCEPTION OF FIRM

FIGURE D-25. POTENTIAL IMPACT OF GUARANTEE OF MAXIMUM MARKET PENETRATION FROM PERCEPTION OF FIRM

FIGURE D-26. IMPACT ON ANNUAL AVERAGE CASH FLOW OF 1% DECREASE IN CORPORATE TAX RATES

FIGURE D-27. POTENTIAL IMPACT OF 1% DECREASE IN CORPORATE TAX RATES FROM PERCEPTION OF FIRM

TABLE D-11. PRESENT WORTH OF GAS ENERGY SAVINGS

BASE CASE
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	4332040.0	2667792.0	2126763.0	1709884.0	1388382.0
8	4304890.0	2652049.0	2114985.0	1698703.0	1378362.0
12	4277740.0	2636305.0	2103206.0	1687522.0	1367786.0
16	4252677.0	2617020.0	2085538.0	1672614.0	1355540.0
20	4227616.0	2596553.0	2061981.0	1657706.0	1343295.0
24	4202554.0	2575518.0	2044849.0	1643915.0	1331049.0
28	4161382.0	2552778.0	2029858.0	1630497.0	1318803.0
32	4114839.0	2530038.0	2014867.0	1616242.0	1305408.0
36	4074113.0	2500800.0	1987382.0	1599470.0	1291632.0
40	4033388.0	2470345.0	1961862.0	1578506.0	1271656.0
44	3951938.0	2436234.0	1938305.0	1546640.0	1251449.0
48	3886777.0	2376541.0	1891190.0	1519806.0	1233081.0
52	3835580.0	2342430.0	1870577.0	1503033.0	1217336.0
56	3789037.0	2308319.0	1849965.0	1486262.0	1198639.0
60	3422509.0	2274209.0	1816985.0	1459427.0	1168789.0
64	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
68	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
72	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
76	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
80	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
84	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
88	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
92	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
96	3422509.0	2274209.0	1602613.0	1318546.0	1040207.6
100	3415696.0	2059039.0	1621904.0	1289625.0	1034872.8
	2.0	6.0	8.0	10.0	12.0
	DISCOUNT RATE (PERCENT)				
AVERAGE(\$1000)	4291526	2628009	2087133	1673505	1354398
STD.DEV.(\$1000)	335616	214027	173937	142961	110788

TABLE D-12. PRESENT WORTH OF ELECTRICITY ENERGY SAVINGS

BASE CASE
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	4397755.0	2744162.0	2203692.0	1784590.0	1458517.0
8	4373893.0	2726374.0	2190362.0	1771672.0	1445446.0
12	4350031.0	2708586.0	2177031.0	1757543.0	1429575.0
16	4319541.0	2681903.0	2159257.0	1739781.0	1412770.0
20	4282422.0	2655221.0	2140002.0	1722908.0	1401006.0
24	4246232.0	2635815.0	2121710.0	1708698.0	1389242.0
28	4212826.0	2616410.0	2104380.0	1694489.0	1377478.0
32	4179419.0	2594232.0	2087051.0	1677615.0	1365714.0
36	4135275.0	2563738.0	2058168.0	1659853.0	1353951.0
40	4087552.0	2530701.0	2026397.0	1634098.0	1320340.0
44	4020738.0	2495125.0	1993182.0	1608047.0	1303535.0
48	3920519.0	2441760.0	1964299.0	1584365.0	1285330.0
52	3883400.0	2415077.0	1940832.0	1564066.0	1265724.0
56	3846282.0	2388395.0	1919170.0	1539960.0	1242196.0
60	3753486.0	2345703.0	1881262.0	1501476.0	1214258.0
64	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
68	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
72	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
76	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
80	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
84	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
88	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
92	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
96	3753486.0	2068204.0	1697135.0	1335699.0	1089269.0
100	3424544.0	2089142.0	1656071.0	1325449.0	1070821.0

2.0

6.0

8.0

10.0

12.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	4340994	2692890	2153210	1738530	1417031
STD.DEV.(\$1000)	347408	225749	185255	153763	129019

The schedule of energy prices used in the calculations are a conservative extrapolation of DOE projections. Updated projections were not available at the time of analysis. Furthermore, the model considers energy savings on a societal basis. Thus, consideration is given to the total market; not just the particular market share of the manufacturer being studied.

A refinement of the energy savings calculation should be considered in any future studies. Particular attention should be paid to refining the program such that: more than one type of energy savings (i.e., gas and electricity, or gas, oil, and electricity) can be considered in a single run; separate discount rates can be input for the net present value energy savings calculation; and more sophisticated policy options can be modelled (i.e., policy impacts price - price impacts market penetration - market penetration impacts energy savings).

Tables D-11 and D-12 indicate that the energy savings calculation also provides one with a probabilistic breakdown at selected discount rates. There is considerable controversy over the proper societal discount rate to use for present worth calculations (OMB advocates the use of 10 percent). The program thus allows the analyst to measure the impact of various discount rates. Table D-13 presents the results, in energy savings, of a partial analysis of the changes which could result from following the selected strategies. It provides the analyst with an essential component for arriving at an overall measure of policy effectiveness.

Having completed the essential elements of the risk analysis, it is worthwhile to reconsider the framework of the problem under study and the steps that are involved in arriving at a "solution," as well as to indicate future steps which might be added. This activity is presented in flow chart form, Figure D-28.

TABLE D-13. POLICY ANALYSIS - ENERGY SAVINGS

Section	Policy Variable Considered	Policy Variable/ Δ Base Case	Energy Savings Impact of Venture									
			Gas Present Worth					Electricity Present Worth				
			Discount Rate	2%	6%	8%	10%	Discount Rate	2%	6%	8%	10%
BASE CASE			Avg(\$K)	4291526	3628009	2087133	1673505	Avg(\$K)	4340994	2692890	2153210	17385301
			σ(\$K)	335616	214027	173937	142961	σ(\$K)	347408	225749	185255	153763
1	Min. Delay Start Sales	No Possible Time Delay	Avg(\$K)	4553891	2804377	2234202	1797455	Avg(\$K)	4621514	2885196	2315141	1876323
			σ(\$K)	300965	188990	152242	123955	σ(\$K)	308625	197007	160075	131487
	Max. Delay Start Sales	One Year Advance	Avg(\$K)	4565923	2812562	2241106	1803361	Avg(\$K)	4634509	2894308	2322945	1883100
			σ(\$K)	391615	256235	211096	175949	σ(\$K)	411721	275130	229103	193006
1	Growth Rate After Tax	Venture Continues at 4%	Avg(\$K)	*	17227227	7251040	4124222	Avg(\$K)	*	16103276	6896614	3989682
			σ(\$K)		1231922	518889	299521	σ(\$K)		1152520	496667	294554
5	Units Sold	Min. Units Guaranteed	Avg(\$K)	1156623	701987	554812	442603	Avg(\$K)	1163989	715013	568706	450095
			σ(\$K)	47156	30807	25339	21072	σ(\$K)	49546	33008	27417	23023
		Max. Units Guaranteed	Avg(\$K)	5679700	3481952	2766996	2220039	Avg(\$K)	5748847	3570603	2856902	2308278
			σ(\$K)	216997	144213	119731	100550	σ(\$K)	230401	156451	131279	111403
		Most Likely Units Guaranteed	Avg(\$K)	1687473	1026199	812388	649462	Avg(\$K)	1700474	1047883	835410	672741
			σ(\$K)	71335	46240	37925	31476	σ(\$K)	74641	49422	40981	34387
5	Units Sold	Increase Penetration 10%	Avg(\$K)	4720681	2890811	2295847	1840856	Avg(\$K)	4775095	2962180	2368532	1912383
			σ(\$K)	369176	235430	191331	157258	σ(\$K)	382149	248325	203781	169140
		20%	Avg(\$K)	5173144	3181756	3527564	2027173	Avg(\$K)	5254513	3261303	2608395	2106600
			σ(\$K)	392440	350265	203287	167081	σ(\$K)	406130	263847	216521	179730
		50%	Avg(\$K)	6435270	3940640	3129548	2509284	Avg(\$K)	6509319	4037831	3228544	2606710
			σ(\$K)	504119	321517	261311	214788	σ(\$K)	521869	339151	278334	231032

*Growth Rate is greater than Discount Rate

FIGURE D-28. RISK ANALYSIS CASE STUDY FRAMEWORK

It is evident that the model and procedure used are equally applicable to the analysis of other energy-conserving products and technologies. The results of the analysis are rigorously calculated measures of financial and energy savings performance which can provide the basis for the selection of the optimum DOE/BCS strategy or policy option.

CHAPTER 8

INTRODUCTION TO LEARNING - EXPERIENCE CURVES

8.1 THE LEARNING-EXPERIENCE CURVE CONCEPT

The idea that "practice makes perfect" is nothing new to most people. However, the fact that this basic premise has been found to be widely applicable and quantitatively predictable in business organizations provides additional insight to the process of product introduction. This chapter highlights the findings of an extensive literature search on the learning-experience curve phenomena which was conducted to provide the basis for the examination of the relationship of the phenomenon to new product commercialization. The bibliography applicable to this learning-experience curve literature search is made up of References 22 through 40.

Learning curve performance patterns for manufacturing operations were first observed in aircraft production (Wright-Patterson Air Force Base in Ohio, 1925). Historical data have shown that air frame manufacture (a standardized product) commonly involves a labor split of three-fourths assembly work and one-fourth machine work. A marked improvement in the direct labor hours required to manufacture the tenth plane compared to the first plane (a reduction of more than one-half) was noted. This observation resulted in increased attention being paid to the phenomenon. However, it was not until 1936 that the learning curve concept was publicly reported (Reference 22) by the manager of the Buffalo plant of Curtiss-Wright Corporation. Since its disclosure, the learning curve concept has been studied extensively and has been widely used.

The basic learning curve concept is that manufacturing labor costs per unit fall as cumulative volume rises. Learning curve theory has been extended beyond the prediction of labor costs

to the development of the experience curve theory. Experience curve theory postulates that the total cost of a product line declines over extended periods of time as volume grows. Learning-experience curves are most often depicted graphically as straight lines. This is the result of restating the basic cost relationships in terms of logarithms. By plotting the data on log-log paper, one is able to produce a linear relationship. Figures D-29 and D-30 illustrate the relationship.

8.2 SUMMARY DESCRIPTION OF THE STATE-OF-THE-ART

Learning curve theory has been widely used in cost estimating, scheduling, manpower planning, budgeting, purchasing, and pricing. Experience curve theory has extended the applicability of the basic learning relationship to the full range of product costs including development costs, capital investment, distribution costs, and overhead (Reference 23).

The reliability and quantifiable aspects of the volume/cost relationship underlying the experience curve concept have been used for long-range strategic business planning. Reference 23 discusses its application in the areas of marketing, financial planning, and production. Evidence has clearly shown that the cost of a wide spectrum of products, ranging from semi-conductors, petrochemicals, power tools, automobiles, and synthetic fibers to gas ranges and facial tissues decline by a constant and predictable percentage of their total product cost each time their production volume doubles. It has been postulated that a corporation whose strategy seeks the largest possible market share at the earliest possible date can gain a distinct advantage over any possible competitor through this inherent cost advantage.

It must be stressed that there are a number of subtleties underlying the experience curve; it is not a law of nature. Producers cut costs through a concerted program including:

FIGURE D-29. TYPICAL VOLUME VS. COST LEARNING-EXPERIENCE RELATIONSHIP

FIGURE D-30. LEARNING-EXPERIENCE CURVE LINEAR DEPICTION

spreading overhead over larger volume, reducing inventory costs by decreasing throughput time, cutting labor costs with process improvements, and achieving a greater division of labor. The relationship between higher volumes and lower costs is very fragile and hinges on certain key ingredients including: a significant production growth rate*, high quality and stability in the labor force, planned technological change, careful product redesign, cautious product standardization, and a common product experience base.

8.3 APPLICABILITY OF THE LEARNING-EXPERIENCE CURVE CONCEPT TO VENTURE ANALYSIS AND NEW PRODUCT INTRODUCTION

Projecting the future financial effects of a new product introduction, from a corporate perspective, relies heavily on the accurate portrayal of certain key quantities. Included in these quantities are the elements comprising product cost.

Most cost projections are based on some derived average cost, assuming some level of production. However, if some form of learning-experience effect is present, use of constant average cost will underestimate actual unit cost in the early stages of production and overestimate actual unit cost in later stages.

Ideally, product price would be set above cost (Figure D-31a). In the classical case of new product introduction, however, prices are generally set below cost in order to establish an initial market. If there is a severe threat from competition, the lead firm may extend the duration of this stage. As production continues, costs fall below the initial market price to a point where the industry leader could reduce the market price. However, he often maintains a price significantly

* When the production growth rate is slow, inflation can have a significant effect on the experience curve. Inflation at 3% annually can completely offset the experience effect of approximately a 6% annual increase in volume with costs declining on a 70% slope.

a. IDEAL RELATIONSHIP

b. USUAL STRATEGY

FIGURE D-31. NEW PRODUCT COST/PRICE RELATIONSHIP

greater than his costs, as a result permitting higher cost producers to enter the market and increase their market share (the industry leader trades future market share for current profits). Following the establishment of increased competition, the leader lowers his profit margin to maintain his market share (see Figure D-31b). New product evaluations consider this process. Product cost behavior must be accurately portrayed in order to arrive at an informed judgement about the financial outcome of a venture. Possible corporate pricing/competitive strategy should also be considered.

These ideas are particularly relevant to a governmental agency considering its proper role in promoting commercialization of new technologies. Governmental funding based on analyses using average costs is sure to be different from funding based on analyses assuming experience curve behavior. An additional benefit of this approach could evolve from the increased efficiency implied by linking the level of governmental assistance to projected experience curve behavior. Gains in efficiency and productivity would be encouraged from the very beginning of a project. Additionally, Federal incentives could be directly tied to the achievement of certain cost goals, thereby increasing productivity, lowering inflationary pressures, and promoting market penetration of the technology through lower initial costs.

CHAPTER 9
APPLICATION OF LEARNING-EXPERIENCE CURVES TO CASE STUDY
OF THE GAS-FIRED HEAT PUMP

9.1 CONSIDERATION OF THE MANUFACTURING ACTIVITY

An experience curve is a formal model for relating the behavior of a product's unit cost to cumulative manufacturing experience, or the total number of units produced. Costs included in the formulation of the experience curve encompass all costs that are part of the value added by the production work over which the experience accumulates and are therefore largely dependent on the manufacturing processes selected.

A detailed analysis of the manufacturing activity which is required provides not only a vital input for determining venture viability, but also provides the information required to make informed judgments concerning future product costs.

Consideration of the manufacturability of a new product should commence at the initial stages of product design. Figure D-32 shows the linkages between the product planning system and the manufacturing process planning system. The product design provides the starting point for development of technical specifications for production. The final specifications (including working drawings for each part and subassembly and bills of material for each component and assembly) are critical to the production process since they affect the cost of manufacturing as well as the marketability, and therefore expected sales volume, of the product.

After the final product design has been completed, the manufacturing process plan is finalized. Manufacturing process planning is concerned with the work that ultimately results in conversion of materials into products. Development of manufacturing plans establishes operating time requirements for the

Source: Production Handbook, 3rd Edition, by Carson, Bolz, and Young, Ronald Press Company, N.Y., N.Y.

FIGURE D-32. NEW PRODUCT DESIGN AND FABRICATION PLANS

required machinery and equipment. Before a final decision is made to produce the product, these time requirements are evaluated against available capacity and against the cost of acquiring new machines and equipment that may be needed.

Process planning consists of two parts: process design and operation design. Process design establishes the overall sequence of operations to meet product specifications, specifies the type of work stations to be used, and defines quantities of machines and equipment required. Operation design defines the makeup of individual manufacturing operations and is not concerned with interrelationships between operations. It specifies how much man or machine time is required for each unit of production. It should be noted that most products can be produced under a wide variety of alternative conversion processes which involve operations performed at different work stations. The selection of work stations (highly dependent on expected sales volume) for the process is primarily based on an economic comparison between several man-machine systems, each possessing the necessary technological capability (see Figure D-33 for typical breakeven chart for work station selection).

Following completion of process design, operation design, and work flow analysis (to ensure the efficient handling of material), the process engineer typically sets production standards, usually in terms of hours per piece, based on time-study analyses or past experience. Thus, performance of the manufacturing operations may be tracked by comparing actual hours expended versus standard hours allowed.

Manufacturing analysis is one of the pivotal elements of any venture analysis. Production costs are a direct measure of the ability of a firm to design and control the manufacturing process. They are a key determinant of venture financial viability (see Figure D-34). In addition, manufacturing analysis is a necessary preliminary to any consideration of

Source: Production Handbook, 3rd Edition, by Carson, Bolz and Young, Ronald Press Company, N.Y., N.Y.

FIGURE D-33. BREAKEVEN CHART FOR WORK STATION SELECTION

FIGURE D-34. ROLE OF MANUFACTURING ANALYSIS IN RISK ANALYSIS

possible learning-experience curve behavior. The manufacturing analysis should be conducted to provide some level of breakdown of the manufacturing process, an estimate of the amount of manual labor required, assembly time, machine time, etc.

Before proceeding with a discussion of the development of the learning-experience curve, factors relating to a manufacturing analysis of the Gas-Fired Heat Pump (GFHP) should be considered. Many of the components of the GFHP are similar to those currently being produced for air conditioners, heat pumps, and gas appliances. It is predicted that those components not currently in production, particularly the free piston Stirling engine, can be manufactured using conventional materials, machine tools, and labor skills (similar to those used in the volume production of small internal combustion engines). However, the production process will have to accommodate special requirements for engine reliability and close tolerances on the engine/compressor/combustor assembly. These requirements could impact both the cost and the flow of the production process.

9.2 DEVELOPMENT OF A LEARNING-EXPERIENCE CURVE

As stated previously, learning-experience curve theory provides a model of cost performance which relates the cost of a given unit to its position in the cumulative production sequence. Thus, for standardized products using established manufacturing processes, learning-experience curves provide a means of using historical cost patterns to project the cost of future units.

New products represent a somewhat different problem, often requiring projections of costs resulting from entirely new manufacturing operations or entirely new combinations of operations. This section describes a methodology for developing (estimating) learning-experience curves for new products. It should be noted that different levels of analytical sophistication are

possible ranging from a detailed breakdown of the manufacturing processes to a general comparison of the differences between old and new products. Both of these approaches will be considered here. It will also be necessary to delineate more carefully between learning curve effects and experience curve effects. Learning curve effects will be assumed to be due to worker learning through repetition, layout of task, equipment used, crew assignment, supervision, and support services. Experience curve effects, meanwhile, will be assumed to be the result of design changes, methods improvement, lot size increases, materials substitution, new processes, mechanization of existing processes, lowered quality standards, and simplified design.

Figure D-32 pointed out the interaction required between product planning and manufacturing process planning. Development of a learning-experience curve for a new product must begin with an assumed final product design and an assumed production schedule based on marketing studies. Detailed analysis would then proceed to break down the product into its constituent parts based on the manufacturing processes most likely to be used. This breakdown may extend to work station selection, operation design, and work flow analysis. Component breakdown may be done on a number of levels (systems, sub-assemblies, parts, etc.). In long cycle operations (involving continuous production runs over a lengthy period), the primary influence on the slope of the learning curve is the type of manufacturing process used. Cochran, in Reference 24, is a source for slopes for various processes. It must be remembered that the slopes found in the literature are typical slopes and should not be construed as being normative values. In carrying out the analysis, operation design (specifying how much man or machine time is required for each unit of production) allows for quantification of the degree of mechanical versus human control exerted over the work. This, in turn, is directly related to the learning curve slope. Highly mechanized operations typically possess

little cost reduction potential due to learning. For example, the learning curve slope for a job machine shop in Reference 24 is 95%. Manual assembly operations, however, often exhibit significant learning curve cost reduction potential. The reference suggests a learning curve slope of 80% for major aircraft assembly.

Cochran postulates that the learning curve slope of a long cycle production operation is the result of two elements: (1) the contribution of manual labor learning, assumed to be 70 percent and, (2) the degree of mechanical control involved in the department or process. It is thus possible to express the overall slope by the formula:

$$s = 70 + 30p.$$

where s = actual long-term slope of the operation

70 = slope resulting from "pure" worker learning (note that this number is dependent on empirical findings of a particular operation)

p = mechanical control "index" $0 \leq p \leq 1$

When $p = 0$ (no mechanical control) the formula specifies a slope of 70 percent. A purely mechanical operation, $p = 1$, leads to a slope of 100 percent, indicating there is no cost reduction potential due to pure learning. Note that the use of a mechanical control "index" does not mean that the particular operation is p percent mechanically controlled. It is used merely for predictive purposes.

Predicting the degree of mechanical control is best accomplished by starting with an operation for which the slope is known and deriving a composite index of control. Careful breakdown of operations affecting the slope will allow accurate future predictions. Details of a procedure for developing a mechanical control index are provided on pages 215, 216, and 217 of Reference 24.

The intermediate result of the analysis discussed is a detailed breakdown of the product which provides estimated labor hours and machine time by major components; major equipment used (degree of mechanization); and major operations performed (fabrication, assembly, inspection), with learning curve slopes. The level of detail is a direct function of the accuracy required, amount of information available, time, and costs. A detailed analysis of this type is, essentially, a standard cost analysis as conducted by manufacturing companies.

Where detailed information is difficult (or costly) to acquire, an alternative method, consisting primarily of a comparison of a "new" product with a comparable "old" product may be used. If no comparable product has been manufactured, it is possible to apply the method to major components of the new product for which analogues can be found in previous experience.

In Reference 24, Cochran describes the use of a method called complexity analysis to perform the comparison of old and new products. This method assumes that product complexity can be divided into three factors: a design factor, reflecting any difference in component configuration; a methods factor, reflecting any improvement in method or equipment to be used; and a make factor, reflecting the decision to make more or less of a particular component.

A composite complexity factor is developed by expressing each factor as a ratio of the cost in time or dollars of the new product to the cost of the original product and multiplying them together. An example of its application for a new product where the design is considered 15 percent more complex, the methods are 10 percent less complex, and 15 percent more of the work will be done in-house results in a composite complexity factor of $1.15 \times .90 \times 1.15 = 1.19$. This composite complexity factor indicates that the new product is 19 percent more complex than the old product and requires 19 percent more labor hours per unit.

This method is best applied by people who know the product's design, the manufacturing methods required to produce it, and the firm's make vs. buy decision. The analysis must be supported by drawings or sketches, descriptions of the material processes, and tooling to be used (Reference 24, p. 254 and 255).

Two other methods are commonly used to develop cost and slope estimates for a new product: use of standards, and development of formulas. Standards are often developed for both elemental operations of individual workers and for larger blocks of work performed frequently (e.g., riveting, milling, grinding, drilling, assembly, or test operations). Cost estimates require combining standards according to the process requirements of the product manufacture. It is essential that actual experience be used in order to determine at what point in the production experience the standard will be achieved.

In practice, standards are often estimated on a major component basis by using some form of complexity analysis. The accuracy of the estimate depends on the judgment and experience of those conducting the analysis. The cost estimate is the starting point for application of the learning curve. Cochran points out one area where care should be taken in considering estimates (Reference 24):

"However, in long cycle operations the estimator must "calibrate" his experience to tie it to a definite point in the unit sequence, or to a definite lot size. Unfortunately, experienced estimators often apply their experience without proper regard for the quantities involved, which generates serious errors. It is well to subject them to a periodic check of their accuracy in relating costs to specific unit quantities, such as a time study man is periodically tested on his rating technique."

Formulas have been developed for cases in which detailed cost data is limited and labor hours can be related to certain selected product characteristics such as weight, shape, physical complexity, or performance specifications. Data for formula development may be extracted from analysis of historical patterns or from an analysis of detailed design characteristics. (Note: the relationships developed may be used for an entire product or its major components.)

However, the use of formulas for new product cost estimating has several weaknesses. First, the technology required to produce a new product may require totally different combinations of production processes than those used previously (negating the reliability of estimates based on previous formulas). Second, the size and specifications of the new design may be beyond the range used in developing the old formula.

An example of a formula using both performance and size characteristics for complete aircraft (Reference 24 p. 267) is the following:

$$\log k = \log a + \log v + b \log w$$

k = total unit cost

w = measure of size (empty weight)

v = measure of performance (cruising speed)

Utilizing the ideas propounded by Cochran, a general procedure for developing cost and slope estimates for a new product is proposed, proceeding as follows:

I. Review cost history

- A. Develop historic learning-experience curve
- B. Estimate base unit cost of "old" product

- C. Break down processes to obtain mechanical control index
- D. Attempt to distinguish between learning curve slope and experience curve slope.
 - 1. $S_1 = S_2 \times S_3$ S_1 = composite slope; S_2 = learning curve slope; S_3 = experience curve slope
 - 2. Learning curve slope = $70 + 30p$ where p = index of mechanical control. 70 and 30 may be revised based on empirical evidence.
 - 3. In long cycle operations, cost changes due to experience curve effects are often identified by the irregular nature of the cost trend. This is usually preceded and followed by relatively stable periods of pure learning slope.
 - 4. Compare actual slope vs. predicted slope - determine estimation error.

II. Determine cost of new unit

- A. Complexity analysis
- B. Standard cost analyses
- C. Formulas

III. Compare "old" and "new" products

- A. Compare products - overall, component, subassembly, etc.
- B. Judge similarities vs. differences
- C. Break down manufacturing processes of dissimilar items
 - 1. Obtain mechanical control index for "new" product processes
 - 2. Estimate composite slope
 - 3. Attempt to distinguish between learning curve slope and experience curve slope

IV. Compute values for "new" product

- A. Manhours, machine time, cost
- B. Learning curve
- C. Experience curve
- D. Composite curve

9.3 GAS-FIRED HEAT PUMP LEARNING-EXPERIENCE CURVE DEVELOPMENT

9.3.1 Review of Cost History - Develop Historic Learning - Experience Curves

In the process of developing the learning-experience curve for the GFHP, the cost histories of three related products, the electric room air conditioner, the electric heat pump, and the small internal combustion engine, were reviewed and a learning-experience curve was developed for each of them. These three products were chosen for their component similarities to elements of the gas-fired heat pump (GFHP). It is assumed that the GFHP will use many components currently being produced for air conditioners and electric heat pumps. Furthermore, it is predicted that the free piston Stirling engine/compressor will be produced using conventional materials, machine tools, and labor skills--similar to those used in volume production of small internal combustion engines.

Data were gathered on a generic product basis (due to the lack of product size delineation in early year statistics) using Department of Commerce (Bureau of the Census) data for the air conditioner and the electric heat pump as found in Facts for Industry and, after 1959, in Current Industrial Reports. Data from Briggs & Stratton Corporation were used to develop a curve for volume production of small internal combustion engines.

Bureau of Census data reflect the annual quantity and value (valued at the point of production) of shipments of various products. These data were used to derive estimates for unit cost vs. cumulative production volume (i.e. average value/unit vs. cumulative quantity of shipments). All costs were converted to 1958 dollars using the GNP deflator. It is recognized that there are deficiencies in using this procedure. Strictly speaking, learning-experience curves should reflect the behavior of the value added by the production work over which experience accumulates.

Where accurate cost data have not been available, price data have generally been used as the principal means to examine the applicability of experience curve relationships across product types and individual products. This assumes that cost curves have the same slopes as price curves due to competitive pressures.

Lacking the detailed information required to perform a value-added cost analysis, it was deemed acceptable to consider the cost history of the product by using average product cost values. Tables D-14 and D-15 present a compilation of this data for the electric heat pump and the electric room air conditioner.

From a manufacturing cost standpoint, major uncertainty surrounds the evolution of the Stirling engine/compressor. To gain some insight into the cost history of a "similar" product, Briggs & Stratton Corporation was contacted for information on the cost history of their small internal combustion engines. This information appears in Table D-16.

Data appearing in the tables was plotted on log-log paper to arrive at learning-experience curves for the three products. Figure D-35 depicts the cost history of the electric heat pump. The average value/unit shipped shown in the figure is given in

TABLE D-14. COST HISTORY OF ELECTRIC HEAT PUMPS

Year	Quantity of Shipments (Year)	Shipments (Cumulative)	Value of Shipments (\$)	Avg. Value/ Unit (\$)	GNP Deflator	Avg. Value/ Units (\$1958)
77	528,397	2,277,975	303,433,000	574.25	2.085	275.42
76	320,043	1,749,578	179,489,000	560.83	1.952	287.31
75	160,485	1,429,535	88,175,000	549.43	1.857	295.87
74	122,561	1,269,050	70,208,000	572.84	1.698	337.36
73	104,267	1,146,489	56,302,000	539.98	1.544	349.73
72	80,843	1,042,222	41,181,000	509.39	1.459	349.14
71	74,944	961,379	38,630,000	515.45	1.416	364.02
70	88,180	886,435	42,935,000	486.90	1.353	359.87
69	90,865	798,255	44,703,000	481.97	1.282	383.75
68	78,792	707,390	38,274,000	485.76	1.218	398.82
67	73,089	628,598	34,593,000	473.30	1.173	403.50
66	81,992	555,509	40,498,000	493.93	1.139	433.65
65	72,275	473,517	34,936,000	483.38	1.109	435.87
64	76,785	401,242	38,326,000	499.13	1.088	458.76
63	76,380	324,457	40,375,000	528.61	1.071	493.57
62	61,813	248,071	33,294,000	538.62	1.057	509.57
61	51,049	186,264	29,413,000	576.17	1.045	551.36
60	47,501	135,215	29,903,000	629.52	1.032	610.00
59	40,907	87,714	28,846,000	705.16	1.016	694.06
58	25,461	46,807	18,847,000	740.23	1.000	740.23
57	10,163	21,346	10,706,000	1,053.43	.974	1,081.55
56	4,746	11,183	5,595,000	1,178.89	.939	1,255.47

TABLE D-14. COST HISTORY OF ELECTRIC HEAT PUMPS (Concluded)

<u>Year</u>	<u>Quantity of Shipments</u> <u>(Year) (Cumulative)</u>		<u>Value of Shipments</u> <u>(\$)</u>	<u>Avg. Value/ Unit</u> <u>(\$)</u>	<u>GNP Deflator</u>	<u>Avg. Value/ Unit</u> <u>(\$1958)</u>
55	3,551	6,437	5,353,000	1,507.46	.908	1,660.20
54	1,900	2,886	2,881,000	1,516.32	.896	1,692.32
53	986		1,613,000	1,635.90	.883	1,852.66

Sources: References 41 and 42.

TABLE D-15. COST HISTORY OF ELECTRIC ROOM AIR CONDITIONERS

Year	Quantity of Shipments (Year)	Quantity of Shipments (Cumulative)	Value of Shipments (\$)	Avg. Value/ Unit (\$)	GNP Deflator	Avg. Value Unit (\$1958)
77	3,289,703	72,843,781	676,726,000	205.71	2.085	98.66
76	2,805,124	69,554,078	543,195,000	193.64	1.952	99.20
75	2,648,430	66,748,954	464,481,000	175.38	1.857	94.44
74	4,494,977	64,100,524	637,026,000	141.72	1.698	83.46
73	4,937,384	59,605,547	685,634,000	138.87	1.544	89.94
72	4,423,933	54,668,163	621,472,000	140.48	1.459	96.29
71	4,931,484	50,244,230	745,533,000	151.18	1.416	106.77
70	5,364,823	45,312,746	776,033,000	144.65	1.353	106.91
69	5,115,282	39,947,923	727,142,000	142.15	1.282	110.88
68	3,887,013	34,832,641	546,651,000	140.64	1.218	115.47
67	3,941,425	30,945,628	537,950,000	136.49	1.173	116.36
66	3,269,109	27,004,203	435,233,000	133.14	1.139	116.89
65	2,867,519	23,735,094	383,286,000	133.66	1.109	120.52
64	2,592,452	20,867,575	358,009,000	138.10	1.088	126.93
63	1,990,158	18,275,123	300,721,000	151.10	1.071	141.08
62	1,627,614	16,284,965	250,711,000	154.04	1.057	145.73
61	1,561,806	14,657,351	237,763,000	152.23	1.045	145.67
60	1,523,152	13,095,445	244,209,000	160.33	1.032	155.36
59	1,773,036	11,572,293	278,942,000	157.32	1.016	154.84
58	1,674,713	9,789,257	257,679,000	153.86	1.000	153.86
57	1,586,094	8,124,544	266,788,000	168.20	.974	172.69
56	1,828,365	6,538,450	291,534,000	159.45	.939	169.81

TABLE D-15. COST HISTORY OF ELECTRIC ROOM AIR CONDITIONERS (Concluded)

Year	Quantity of Shipments		Value of Shipments	Avg. Value/ Unit	GNP Deflator	Avg. Value/ Units
	(Year)	(Cumulative)	(\$)	(\$)		(\$1958)
55	1,283,234	4,710,085	209,961,000	163.62	.908	180.20
54	1,353,204	3,426,851	241,871,000	178.74	.896	199.49
53	1,017,699	2,074,647	191,129,000	187.81	.883	212.70
52	372,064	1,055,948	70,323,000	189.01	.874	216.26
51	228,964	683,884	42,442,000	185.37	.856	209.20
50	187,224	454,920	31,373,000	167.57	.801	253.92
49	89,320	267,696	17,940,000	200.85	.791	264.82
48	73,638	178,396	15,503,000	210.53	.795	310.25
47	42,904	104,738	9,930,000	231.45	.746	295.39
46	29,835	61,834	5,869,000	196.73	.666	295.39
45	1,126	31,999	326,395	289.87	.596	486.36
44	30,873		4,584,406	148.48	.439	338.25

Sources: Reference 41 and 42.

TABLE D-16. COST HISTORY OF SMALL INTERNAL COMBUSTION ENGINES

BRIGGS AND STRATTON ENGINES

Comparison of Average Costs and Average Selling Prices

	<u>1978</u>	<u>1953*</u>	<u>% Increase or Decrease</u>
Aluminum (per 100 lbs.)	\$52.31	\$20.93	+149.9
Zinc (per 100 lbs.)	33.04	10.86	+204.2
Sheets	21.77	4.69	+364.2
Bars	32.97	5.08	+549.0
Payroll including wages and other benefits (per hour)	11.16	2.27	+391.6
Price (per engine)	56.24	30.06	+ 87.1
Horsepower (per engine)	4.38	2.15	+103.7
Price (per H.P.)	12.85	13.99	- 8.1
Units sold (increase 1978 over 1953)			+607.2

Source: Briggs and Stratton Corporation, Cost/Price Information
Package

*
Aluminum Cylinder Engines
Introduced in 1953

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FIGURE D-35. HISTORICAL LEARNING-EXPERIENCE CURVE FOR ELECTRIC HEAT PUMPS, 1953-1977

1958 dollars. The basic slope of the curve is 82.5%. An interesting feature of the curve is the abrupt change which occurs at 6400 units shipped, i.e., the rate of cost decrease seems to increase.

Figure D-36, displays learning-experience curves for electric room air conditioners. The basic slope of this curve was determined by linear regression analysis to be 88.5%. The electric room air conditioner manufacturing process appears more highly automated than that of the electric heat pump based on a comparison of their learning-experience curve slopes.

Developing the learning-experience curve for small internal combustion engines proved to be more difficult than the air conditioner or heat pump. Principal difficulty resulted from a lack of detailed published data. In order to circumvent this problem the following rationale was used. In The History of Briggs & Stratton Corporation, Briggs & Stratton states that its 100 millionth engine was produced in 1976. Aluminum cylinder engines were first introduced in 1953. It was assumed that the vast majority of these 100 million engines were produced from 1953 to 1976. Briggs & Stratton began to manufacture engines in 1925, with first year sales of 5,000 engines. The innovation of the rotary lawn mower, however, provided the impetus to develop and mass produce a light weight aluminum engine. The curves were therefore related to 1953, the year of the aluminum cylinder engine introduction. Figure D-37 graphically displays the preceding assumptions. Note that the learning-experience curve slope varies between 95% and 99% depending on whether one considers the history of price per engine or price per horsepower, indicating a high degree of automation in either case.

9.3.2 Gas-Fired Heat Pump Costs and Learning-Experience Curve

9.3.2.1 Cost

Information was available from both industry and DOE sources on

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FIGURE D-36. HISTORICAL LEARNING-EXPERIENCE CURVE FOR ELECTRIC ROOM AIR CONDITIONERS, 1940-1977

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FIGURE D-37. ASSUMED HISTORICAL LEARNING-EXPERIENCE CURVE FOR SMALL INTERNAL COMBUSTION ENGINES, 1953-1973

the projected overall cost of the new gas-fired heat pump. Discussions with numerous sources led to the conclusion that the major component difference between the current G.E. electric heat pump and the projected gas-fired heat pump resulted from the substitution of the Stirling engine/compressor unit for the existing electrically driven reciprocating compressor unit. Thus, the development of the curve proceeded from the assumption that the new unit was composed of essentially two packages: (1) a new prime mover; and, (2) standard components similar to current electric heat pump components. This assumption enabled estimates of projected costs of the Stirling engine/compressor to be made.

A retail price quotation of \$1500 (1979 dollars) for the G.E. Weathertron Electric Heat Pump, Model No. BWC036E100, was received from a G.E. regional distributor. Retail price for the compatible compressor unit was quoted at \$470. Previous discussions with industry personnel indicated that a mark-up of 2.5 to 3.0 times cost was common in transferring the product from the manufacturer to the end user. This factor was used to estimate the manufacturer's cost as follows:

G.E. Electric Heat Pump - Model No. BWC036E100 - 3 ton

Total Unit Cost to Manufacturer	$\frac{\$1500}{2.5} = \600	$\frac{\$1500}{3.0} = \500
Compressor Cost to Manufacturer	$\frac{\$470}{2.5} = \188	$\frac{\$470}{3.0} = \157
Remaining Components Cost to Manufacturer	$\$412$	$\$343$

Projections of manufacturer's cost for the gas-fired heat pump indicate a most likely value of \$1000 (1979 dollars). Proceeding with the methodology as applied to the GFHP:

G.E. Gas-Fired Heat Pump - 3 ton

Total Unit Cost to Manufacturer	\$1000	\$1000
Remaining Components Cost to Manufacturer	<u>412</u>	<u>343</u>
Stirling Engine/Compressor Cost	\$ 588	\$ 657

9.3.2.2 Learning-Experience Curve

Time and budget constraints did not permit a detailed manufacturing analysis to be performed. Therefore, it was necessary to modify the procedure presented in Section 9.2 for developing learning-experience curves (it was not possible to develop the mechanical control index).

Given the cost of the Stirling engine/compressor and remaining components, it was necessary to estimate the volume of production at which these costs would be achieved and the production volume at which to begin learning-experience curve behavior. Lacking the benefit of a manufacturing analysis, the learning-experience curve for the electric heat pump was assumed to be typical of the curve to be followed by the GFHP. It was previously mentioned that the curve for the electric heat pump exhibited a significant cost decrease at 6400 units. Realizing the unique nature of each manufacturing process (especially with regard to the volume required to achieve standard cost goals), 6400 units was used as the best available approximation for the volume required to achieve standard costs (\$657 for the Stirling engine/compressor) and the starting point for any learning-experience curve behavior related to the manufacture of the engine/compressor unit. Remaining components were assumed to continue to follow the electric heat pump curve (slope = 82.5%). Figure D-38 graphically displays these curves. Note that the slope for the engine/ compressor unit was allowed to vary between 95% and 85% in order to gauge the sensitivity of the analysis to this assumption. The total cost of the GFHP at any point in the production history is the sum of the selected engine/compressor curve and the remaining components curve.

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FIGURE D-38. COMPONENTS OF GFHP LEARNING-EXPERIENCE CURVE

9.4 IMPACT OF LEARNING-EXPERIENCE CURVE ON RISK ANALYSIS (Before Federal Programs)

Having developed the learning-experience curves for several cases, minimum and maximum values for unit cost of sales were developed for input to the risk model. Present worth risk profiles were generated for: (1) the cost learning-experience curve which results from utilizing a 95% slope for the Stirling engine/compressor unit and 82.5% slope for all other components (Table D-17), and (2) the curve which results from utilizing a 85% slope for the engine/compressor and 82.5% slope for all other components (Table D-18). Comparison of these tables to the base case risk profile, Table D-19, provides an indication of the major effect use of a learning-experience curve has on the venture. Annual average cash flow is likewise improved immensely (see Figure D-39). The enhancement of the risk analysis through the inclusion of the learning-experience curve effects indicates that the venture will likely prove to be highly successful.

It is axiomatic that any venture which provides significant financial rewards to a firm will be duplicated or imitated by other firms, resulting in a lessening of the possible returns to the first firm. The very high present worth and cash flows attained as a result of learning and experience in producing the GFHP, therefore, will likely never be achieved. The manufacturer's pricing strategy must also be included in the learning-experience consideration to enable the most realistic analysis of the venture.

Manufacturers often sell new products at prices below their initial cost in order to promote customer acceptance and build volume. This assumption was used in conducting the case study of the GFHP. It was also assumed that the lead manufacturer attempted to restrict competition by limiting his gross profit margin to 30% even as his costs decreased. Allowing this profit margin to increase would encourage the entry of new

TABLE D-17. PRESENT WORTH RISK PROFILE, BASE CASE PRICE,
COST LEARNING CURVE - 95%/82.5%

PRESENT WORTH
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	573641.5	374496.4	227464.4	187610.1	120628.9
8	564697.6	367661.4	222556.6	184254.4	114836.8
12	557542.6	362690.6	219752.1	181318.3	112519.9
16	551409.6	358252.3	216667.1	178621.8	119075.3
20	543232.4	353991.6	212740.9	176224.9	109688.2
24	532499.7	349020.7	209936.5	173828.1	108217.2
28	525344.6	341564.3	206606.2	171431.2	106562.2
32	518189.5	335350.7	202107.4	166637.4	104410.8
36	511928.8	330690.5	198835.5	164240.6	102094.0
40	506562.5	326962.3	195563.6	161604.0	99994.4
44	502090.6	323234.2	192291.7	158248.4	98546.3
48	498513.1	319506.0	189019.9	154892.7	94564.2
52	494935.5	315881.4	186361.5	151956.6	91254.4
56	488853.7	312567.4	183907.6	149335.0	89599.5
60	480880.9	309253.6	181453.7	147237.7	88128.4
64	474747.9	303288.5	178999.7	144825.9	86841.2
68	466315.2	297323.4	175932.4	141170.2	85586.3
72	458265.7	291855.5	172660.6	139606.0	84427.9
76	452899.4	286884.6	169388.7	137741.7	83269.4
80	447831.2	283570.6	166730.3	135478.1	80083.8
84	443061.1	280256.7	164276.4	133081.2	78428.8
88	437337.1	276942.8	160718.2	129725.6	76463.6
92	428751.0	273628.9	157119.1	126789.4	73567.6
96	420164.9	267001.1	153847.3	122594.9	69947.5
100	394568.3	245991.2	138452.4	110129.4	61364.2
	14.0	18.0	23.0	25.0	30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	495001	318864	189594	155077	94774
STD.DEV.(\$1000)	47779	34309	23927	20995	15553

TABLE D-18. PRESENT WORTH RISK PROFILE, BASE CASE PRICE,
COST LEARNING CURVE - 85%/82.5%

PRESENT WORTH
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	918645.1	623285.0	406037.2	342781.1	234847.9
8	902262.9	613085.1	395469.2	334194.6	228281.4
12	890795.4	607256.6	389855.0	329901.4	223591.1
16	877689.6	600553.7	385892.0	326466.9	220776.9
20	866768.1	591228.1	380145.6	321486.7	217962.7
24	856626.8	581902.4	373012.2	315991.4	215148.6
28	847265.6	574575.1	366407.2	310496.1	211865.2
32	836734.1	567914.0	361123.2	305000.7	208253.7
36	826722.8	560142.6	357600.4	301947.7	204478.0
40	819441.8	553666.4	354077.7	298894.7	201194.7
44	812160.9	548485.5	349234.1	295187.6	198263.4
48	805608.0	543304.6	344138.7	291262.4	195449.2
52	799055.1	538123.6	339609.6	286682.9	192165.9
56	791098.1	532942.7	335080.5	282103.5	188061.9
60	781736.8	523617.1	330551.3	277524.1	184193.3
64	773253.1	517400.0	326022.2	273598.7	181378.1
68	765062.1	512219.1	321493.1	269796.2	178212.2
72	756870.9	505742.9	316963.8	266361.6	175339.4
76	748679.9	497971.5	312957.3	263213.2	173697.7
80	741171.4	493732.6	310518.5	260923.6	172056.1
84	733890.4	489493.6	308079.7	258633.8	170121.4
88	723697.1	484371.6	305641.0	255199.2	167307.2
92	708407.0	476600.2	295072.9	246612.7	159744.1
96	689294.4	451343.2	284504.9	236309.1	154408.7
100	661499.6	443610.4	267277.7	220366.1	138924.6
	14.0	18.0	23.0	25.0	30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	803898	540965	343578	289817	194121
STD.DEV.(\$1000)	68097	49945	35777	31734	24150

TABLE D-19. PRESENT WORTH RISK PROFILE, BASE CASE

PRESENT WORTH

(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

0	170498.8	85710.9	32821.8	19652.4	- 2413.5
4	158552.7	80201.1	24317.4	10971.4	-10347.1
8	150540.7	74575.1	20714.0	8304.7	-12202.8
12	146979.8	70074.2	18912.3	6399.9	-13773.0
16	142973.8	66136.1	16209.7	4876.0	-14629.5
20	138611.7	62117.5	13957.5	2133.1	-15628.8
24	133626.6	59706.3	11930.6	304.5	-16770.8
28	127395.0	57521.2	9565.8	- 1001.6	-18697.9
32	124279.2	55411.4	8214.5	- 2267.0	-18554.4
36	121163.5	53301.7	6993.2	- 3409.8	-20410.9
40	119086.2	51191.9	6161.6	- 4552.7	-21267.4
44	117009.1	49513.7	5330.0	- 5695.6	-22195.3
48	114931.9	47979.3	4498.5	- 6879.3	-23337.3
52	110777.6	46444.9	1795.9	- 8185.5	-24265.2
56	106207.7	43069.3	714.9	- 9254.1	-25121.7
60	101689.9	40417.0	- 366.2	-10085.3	-25978.2
64	98574.2	38005.9	-10816.2	-20267.3	-32187.8
68	94679.4	34630.3	- 3609.3	-13410.1	-27782.9
72	88447.9	29566.8	- 7212.7	-16457.7	-28761.8
76	82735.7	24292.4	-10816.2	-20267.3	-32187.8
80	78581.4	22182.6	-13744.0	-22095.9	-34243.4
84	73803.8	16205.0	-17122.2	-24838.9	-35613.8
88	69234.1	13392.0	-23428.3	-32267.6	-43322.2
92	65079.7	8469.2	-27031.7	-35124.8	-46748.3
96	40153.6	- 7002.4	-36040.3	-43124.9	-49317.8
100	24910.0	-20398.5	-47212.5	-52807.3	-61901.1

14.0

18.0

23.0

25.0

30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000) 107548

42462

-77

-10202

-25830

STD.DEV.(\$1000) 33113

23935

17126

15281

12011

FIGURE D-39. ANNUAL AVERAGE CASH FLOW BASE CASE VS. LEARNING/EXPERIENCE CURVES (BASE CASE PRICE)

firms into the market. The resulting price curves are shown with the cost learning-experience curves in Figures D-40, D-41, and D-42. Minimum and maximum values of unit selling price were then developed as additional inputs to the risk model.

Three separate computer runs were made in order to quantify the impact of modelling the venture in this "more realistic" manner. The modelling approach used was the most conservative from the standpoint of the firm (i.e., requiring the selling price to track the cost at a constant margin). A 7% inflation rate was assumed.

Plotting annual average cost of sales, annual average revenue, and annual average cash flow for the learning curve cases versus the base case produced no surprising results (Figures D-43, D-44, and D-45). It is interesting to note that annual average cash flows for the 95% and 85% learning curves are generally greater than these of the base case up to year 9, before reverting to a level lower than the base case at year 10.

Modeling the venture according to this scenario considerably impacts the financial outcome of the venture. Even the most conservative curve (95 - 82.5 percent) results in an 88% chance of achieving a positive net present value at a discount rate of 23%, and a 56% chance of achieving a positive net present value at a 25% discount rate (see Tables D-20, D-21, and D-22)

Figure D-46 graphically depicts the impact of learning/experience curve behavior on the perceived net present value of the venture. Note the competing impacts of the two cash flow phases, resulting in the final shape of the curve.

From a policy standpoint, learning-experience curve analysis presents some interesting implications. When using the base case pricing scenario, the case study analysis indicated a

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FIGURE D-40. LEARNING-EXPERIENCE CURVE FOR GFHP VS. PRICE
 STIRLING ENGINE/COMPRESSOR SLOPE = 95%; OTHER COMPONENTS = 82.5%
 $PRICE = (1.20) (COST)$

FIGURE D-41. LEARNING-EXPERIENCE CURVE FOR GFHP VS PRICE.
STIRLING ENGINE/COMPRESSOR SLOPE = 90%; OTHER COMPONENTS = 82.5%
PRICE = (1.30) (COST)

FIGURE D-42. LEARNING-EXPERIENCE CURVE FOR GFHP VS PRICE.
 STIRLING ENGINE/COMPRESSOR SLOPE = 85%; OTHER COMPONENTS = 82.5%.
 $PRICE = (1.30)(Cost)$

FIGURE D-43. ANNUAL AVERAGE COST OF SALES WITH LEARNING-EXPERIENCE

FIGURE D-44. ANNUAL AVERAGE REVENUE WITH LEARNING-EXPERIENCE
(PRICE = 1.3 COST)

FIGURE D-45. ANNUAL AVERAGE CASH FLOW BASE CASE VS LEARNING/EXPERIENCE CURVE (PRICE = 1.3 COST)

TABLE D-20. PRESENT WORTH RISK PROFILE,
PRICE = 1.3 COST, COST LEARNING CURVE - 95%

PRESENT WORTH
(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	107646.6	56838.7	20669.7	11445.8	- 3980.4
8	106085.8	54437.0	19098.2	10328.0	- 4270.3
12	104134.9	53369.7	18260.0	9433.8	- 5321.3
16	101793.7	51501.7	17264.7	8539.6	- 5864.9
20	99452.7	49700.5	16374.2	7690.1	- 6299.8
24	97111.6	48900.0	15256.7	6974.7	- 6952.1
28	95004.6	47899.3	13335.9	4962.7	- 8256.7
32	93265.4	45898.0	12681.2	4515.6	- 9169.9
36	91927.7	44411.2	12157.2	3994.0	- 9620.6
40	90478.4	43496.3	11554.8	3397.8	- 9857.8
44	88917.7	42429.0	10716.7	2886.9	-10095.0
48	87044.8	41361.6	10018.2	2280.1	-10431.1
52	85573.2	40294.2	9249.9	1430.6	-10866.0
56	84235.5	39379.3	8446.7	715.2	-11387.8
60	83299.0	38464.4	7748.2	- 0.2	-12279.3
64	82362.6	37549.5	7224.2	- 477.1	-12714.2
68	80333.6	36451.6	6758.7	- 874.5	-13475.2
72	78549.9	35262.2	6106.8	- 1520.3	-14127.5
76	77212.2	34347.3	3906.7	- 3755.9	-14910.3
80	74480.8	31775.1	2754.2	- 4650.1	-15432.1
84	72920.1	30687.7	1811.3	- 5246.2	-16410.6
88	70774.1	28552.9	239.7	- 6140.4	-17606.5
92	68433.0	26685.0	- 1855.6	- 7332.7	-18693.7
96	65506.7	24283.4	- 3951.0	- 7332.7	-18693.7
100	54201.5	15857.7	-11257.6	-17719.3	-27654.2
	14.0	18.0	23.0	25.0	30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	86872	40862	9359	1484	-11364
STD.DEV.(\$1000)	13383	9959	7380	6676	5432

TABLE D-21. PRESENT WORTH RISK PROFILE,
PRICE = 1.3 COST, COST LEARNING CURVE - 90%

PRESENT WORTH

(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	101786.7	58178.0	25114.1	17045.6	3098.5
8	99086.4	54363.0	23634.9	15643.8	2171.2
12	95711.0	52836.9	22895.3	14882.8	1271.9
16	94360.9	51637.9	22007.8	14242.0	629.6
20	90985.5	50547.9	20907.6	13120.6	147.9
24	89635.3	48640.4	19505.5	11999.1	- 905.9
28	88285.2	47368.7	18272.8	10317.0	- 1959.7
32	86742.1	45779.1	17533.2	9616.1	- 2742.6
36	85134.8	44348.5	16054.0	9055.4	- 3224.3
40	83334.6	43394.7	15536.3	8510.2	- 3898.7
44	81727.2	42493.9	15018.6	8011.8	- 4383.5
48	80184.2	41646.2	14112.6	7513.4	- 4805.0
52	78023.9	40533.4	12947.7	6391.9	- 5163.3
56	75863.7	38625.9	11986.3	5494.8	- 5500.5
60	74012.0	36922.8	11246.7	4709.8	- 6596.5
64	72469.0	35832.7	10507.1	3962.2	- 7439.5
68	70733.1	34742.7	9767.5	3214.5	- 7921.3
72	68482.8	33652.7	8611.9	2354.8	- 8704.1
76	65332.5	30995.8	6994.0	504.4	- 9631.4
80	63442.3	29247.3	5376.1	- 710.5	-10530.7
84	62362.1	27975.6	3974.0	- 2579.6	-12160.6
88	61282.0	25368.6	1816.8	- 3981.4	-13059.8
92	57231.5	23842.6	- 340.3	- 5383.1	-15026.9
96	46430.2	19073.8	- 1742.5	- 8186.7	-15026.9
100	41756.9	10457.9	-10535.4	-15633.5	-23612.9

14.0

18.0

23.0

25.0

30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	77973	39767	12851	5940	-5643
STD.DEV.(\$1000)	15233	11488	8559	7728	6191

TABLE D-22. PRESENT WORTH RISK PROFILE,
PRICE = 1.3 COST, COST LEARNING CURVE - 85%

PRESENT WORTH

(THOUSANDS OF DOLLARS)

Percent Chance
of Exceeding
Indicated
Amount

4	86503.1	50193.0	24978.9	18322.4	6860.5
8	83193.7	48637.0	23593.6	16976.2	5421.4
12	80877.1	47275.4	22485.3	15997.1	4222.2
16	79553.4	45978.8	21377.0	15018.0	3502.6
20	77898.7	44682.1	20427.0	14039.0	2783.1
24	75383.6	42196.8	19635.4	13059.9	1823.7
28	73265.6	41332.3	17821.2	11241.6	784.3
32	71147.6	40467.9	16897.6	10542.2	- 175.1
36	69823.8	38036.6	15974.0	9755.5	- 814.7
40	68764.8	37064.1	14819.6	8531.6	- 1774.1
44	67592.4	36188.8	13588.1	7585.9	- 2200.5
48	66079.5	35410.8	12972.4	7140.9	- 2626.9
52	64264.1	34632.8	12312.7	6695.8	- 3213.1
56	61793.1	32363.6	11521.1	6083.9	- 3852.7
60	59439.7	31067.0	10201.7	5472.0	- 4492.3
64	58263.1	29909.2	9146.1	3942.1	- 5063.4
68	56851.1	28797.8	8354.5	3330.2	- 5611.6
72	54733.1	27501.1	7430.9	2208.3	- 7146.7
76	51423.7	24421.5	6045.5	576.5	- 8489.8
80	48908.5	22476.5	3274.8	- 1463.2	- 9257.3
84	46790.5	20309.4	1774.0	- 2605.5	-10024.9
88	45025.5	17127.7	42.3	- 4318.9	-11847.7
92	42378.0	15571.6	- 1689.4	- 5950.7	-13286.0
96	34876.7	13723.9	- 4113.8	- 9214.3	-16165.0
100	25317.7	2123.8	-13604.4	-17453.4	-23501.9
	14.0	18.0	23.0	25.0	30.0

DISCOUNT RATE (PERCENT)

AVERAGE(\$1000)	63366	33489	11917	6249	- 3460
STD.DEV.(\$1000)	15231	11919	9224	8431	6910

FIGURE D-46. GFHP NPV - BASE CASE VS. LEARNING-EXPERIENCE CURVE (95%/82.5%)

major improvement in financial acceptability of the venture by assuming a conservative learning-experience curve behavior pattern. A comparison of the data with the Policy Analysis Table (Table D-10) allows one to gain a better understanding of the magnitude of this improvement. The most conservative learning-experience curve resulted in a greater positive improvement to the venture than any of the before-tax policy options considered. The learning-experience effects additionally permit the adoption of competitive pricing strategies to reduce the risk to the firm.

As stated in the introduction to the learning-experience /curve section, this behavior is not a law of nature. Management must be aware of the stress required to produce a decreasing cost trend as well as the potential pitfalls of blindly following such a path. By the same token, Federal policy makers dealing in the realm of new product introductions should also know the intricacies of learning-experience curves. Inflation can quickly subvert the efforts of a competent management to implement learning-experience behavior; control of its effects is critical to the ultimate success of this strategy.

Federal policies should be developed to encourage learning-experience behavior, with particular care not to overly constrain the managerial flexibility of the firm. With this in mind, firms applying for Federal assistance in introducing new products should be required to submit long-term projections of unit production costs versus cumulative volume. Using this information, along with independent sources, Federal policy analysts can then make informed judgments concerning project funding and overall policy formulation.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

The case study of the gas-fired heat pump was undertaken with several objectives in mind. They were:

- o To demonstrate the use of risk analysis in determining the commercialization potential of an active BCS project.
- o To demonstrate that alternative sources of data are available for use in determining the commercial viability of a project (in place of corporate proprietary data).
- o To demonstrate the types of policy formulations and analyses possible using a computerized risk model.
- o To gauge the impact of learning-experience curve behavior on the viability of the venture (i.e., on the risk analysis simulation).

Each of these major objectives was accomplished. Major conclusions are:

- o Through the use of industry and corporate financial data, it is possible to model the financial effects of a new product introduction.
- o Risk analysis (financial simulation) cannot be carried out in isolation; consideration must be given to other investment factors, particularly: (1) market, (2) competition, (3) financial and economic, (4) technological, and (5) sociopolitical.
- o From a financial perspective, it appears that the gas-fired heat pump is commercially viable without further governmental assistance.

- o The financial outcome of the venture appears to be very sensitive to the distributions chosen to represent the uncertainty associated with unit selling price, units sold, and unit cost of sales. The outcome is most sensitive to the unit selling price distribution selection.
- o Net present value provides a more discriminating criterion than median payback period or return on assets for judging sensitivity and impact of policy options.
- o Federal programs designed to significantly reduce major operating expense items or reduce the overall corporate tax rate would be required to raise the average internal rate of return of the venture to 25%.
- o The impact of modelling the venture according to a learning-experience curve scenario is considerable. Even the most conservative learning-experience curve (95%-82.5%) results in an 88% chance of achieving a positive net present value at a discount rate of 23%, and a 56% chance of achieving a positive net present value at a 25% discount rate.

Major recommendations are:

- o Federal programs should be designed to remove any excessive (i.e., venture inhibiting) uncertainty associated with unit selling price, unit cost of sales, and units sold.
- o Applicants for substantial Federal assistance in the introduction of new products should be required to submit the detailed information required to run the risk model. These data should include long-term projections of unit production costs versus cumulative volume (for possible learning-experience curve applications).

- o Federal policies should be developed to encourage learning-experience curve behavior for new products, with particular care taken not to overly constrain the firm's managerial flexibility.
- o The risk model should be enhanced or expanded to allow for various policies to be ranked according to their financial impact, energy savings impact, cost-effectiveness, etc. Enhancement of various aspects of the energy savings calculations should also be undertaken.
- o Risk analysis should be developed as a tool for use in policy formulation and analysis. Criteria must be developed (project funding level, etc.) with regard to its implementation.

CHAPTER 11
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