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DEVELOPMENT OF A RISK-ANALYSIS MODEL

Final Report

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October 1979

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

Dynatrend Incorporated
Arlington, Virginia

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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FINAL REPORT
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TABLE OF CONTENTS

	Page
Chapter 1. EXECUTIVE SUMMARY.	1-1
Chapter 2. INTRODUCTION	2-1
2.1 Conservation in Buildings and Community Systems	2-1
2.2 Contract Objectives	2-4
2.3 Objectives and Organization of the Report	2-5
2.3.1 Lay Audience Orientation.	2-5
2.3.2 Final Report Organization	2-6
Chapter 3. RISK ANALYSIS OVERVIEW	3-1
3.1 Risk Analysis in the Private Sector	3-1
3.1.1 Financial Measures of Investments	3-2
3.1.2 Qualitative Approaches to Risk Analysis	3-12
3.1.3 Quantitative Approaches to Risk Analysis.	3-16
3.2 Risk Analysis in the Public and Utility Sector.	3-33
3.2.1 Public Sector Risk Analysis	3-34
3.2.2 Risk Analysis in a Regulated Environment.	3-35
3.3 The Role of Risk Analysis in Venture Decisions	3-38
3.4 Summary	3-41
Chapter 4. BCS RISK ANALYSIS REQUIREMENTS	4-1
4.1 The Role of Government in Risk Reduction.	4-2
4.2 Governmental Risk	4-8
4.3 Risk Analysis Impacts on BCS Policy Formation	4-9
4.3.1 Risk Analysis Framework	4-9
4.3.2 Policy Development Procedure.	4-10
4.4 Risk Analysis Data Considerations	4-22

TABLE OF CONTENTS (Concluded)

Chapter 5.	REVIEW OF EXISTING RISK ANALYSIS MODELS.	5-1
5.1	Selection Criteria.	5-1
5.2	Overview of Available Models.	5-2
5.3	Programming Systems	5-3
5.4	MATHRISK.	5-8
5.5	Risk Model - ECON	5-11
5.6	Evaluation.	5-15
5.7	Conclusions	5-16
Chapter 6.	RECOMMENDED METHODOLOGY.	6-1
6.1	Model Features.	6-1
6.2	Proposed Enhancements	6-5
6.3	Application of the Methodology.	6-10
6.3.1	Idea Evaluation/Project Selection	6-11
6.3.2	Funding Strategy Analysis	6-14
6.3.3	In-Process Evaluation	6-15
6.3.4	Budget Impact Analysis.	6-15
6.4	Data Requirements	6-16
Chapter 7.	CONCLUSIONS AND RECOMMENDATIONS.	7-1
7.1	Conclusions	7-1
7.2	Recommendations	7-3
APPENDIX A	BIBLIOGRAPHY.	A-1
APPENDIX B	GLOSSARY OF TERMS	B-1
APPENDIX C*	RISK ANALYSIS METHODOLOGY	C-1
APPENDIX D*	GAS FIRED HEAT PUMP CASE STUDY.	D-1
APPENDIX E*	1,000 TON PER DAY ANAEROBIC DIGESTION PLANT CASE STUDY:	E-1
APPENDIX F*	DISTRICT HEATING AND COOLING SYSTEM CASE STUDY.	F-1

*Separately bound

LIST OF TABLES

<u>Table</u>	<u>Page</u>
2-1	Obstacles to Successful Commercialization. . . 2-3
3-1	Payback Period Versus Cash Flow. 3-9
3-2	Project Selection IRR vs. NPV. 3-13
3-3	Summary of Investment Criteria 3-14
3-4	Sales of Firms Using Corporate Models. 3-15
3-5	Financial Criteria Used to Evaluate Capital Investment 3-17
5-1	Programming Systems Reviewed 5-6
5-2	Input Variables - Econ Risk Model. 5-13
6-1	Base Case Present Worth of Electricity Energy Savings 6-7

LIST OF FIGURES

<u>Figures</u>	<u>Page</u>
3-1	Simplified Cash Flow Computation. 3-3
3-2	Cash Flow Graph 3-6
3-3	Cash Flow - Indebtedness Graph. 3-7
3-4	Heat Pump Unit Price Range. 3-20
3-5	Heat Pump Unit Price Range. 3-20
3-6	Ranking of Unit Price Intervals 3-20
3-7	Relative Likelihood of Unit Price Intervals . 3-21
3-8	Unit Price Probability Density Function . . 3-22
3-9	Monte Carlo Wheel of Change 3-25
3-10	Cash Flow Probability 3-27
3-11	NPV Risk Assessment Mean, Standard Deviation Plane 3-29
3-12	Hypothetical Decision Tree. 3-32
3-13	Federal Incentives for Innovation 3-39
3-14	Unit Price Probability Density Function . . 3-40
4-1	Overview of Risk Analysis Case Study Methodology 4-12
5-1	Programming System Function Flow Chart. . . 5-4
5-2	Sample Mathrisk Input Structure 5-10

CHAPTER 1

EXECUTIVE SUMMARY

This report constitutes the final deliverable item for the Department of Energy contract with DYNATREND Incorporated entitled "Development of a Risk Analysis Model" (DE-AC03-77CS20158) and the subsequent modifications to that contract. The report consists of a main body, which provides a presentation of risk analysis and its general and specific application to the needs of the Office of Buildings and Community Systems of the Department of Energy; and several case studies employing the risk analysis model developed under this contract.

The highlights of the main report include a discussion of how risk analysis is currently used in the private, regulated, and public sectors and how this methodology can be employed to meet the policy analysis needs of the Office of Buildings and Community Systems of the Department of Energy (BCS/DOE). After a review of the primary methodologies available for risk analysis, it was determined that Monte Carlo simulation techniques provide the greatest degree of visibility into uncertainty in the decision making process. Although the data collection requirements can be demanding, the benefits, when compared to other methods, are substantial. The data collection problem can be significantly reduced, without sacrificing proprietary information rights, if prior arrangements are made with RD&D contractors to provide responses to reasonable requests for base case data.

To set the framework for risk analysis, a review and presentation of the primary financial measures of investments is made. This begins with an introduction to a typical cash flow representation, similar to that which is developed in the risk model used in the case studies (Appendices D-F). The primary financial measures investigated include: payback period, accounting rate of return, net present value (NPV), and internal rate of return

(IRR). A summary of each measure, with its advantages and disadvantages is provided on page 3-14 (Table 3-3).

One of the early tasks of this contract was to investigate the currently available risk analysis models and provide a recommendation on the use of the most appropriate one for BCS. This resulted in the selection of a discounted cash flow model employing the Monte Carlo methodology, the details of which are presented in Chapter 6 of this report. The model was enhanced to include several adaptations for BCS needs, including the expansion of the time horizon from ten to twenty years and the discounted value of energy savings over the life of the venture. The model was then installed on the DOE computer to perform actual case studies.

A total of three case studies were performed on BCS technologies. The first two cases (Gas Fired Heat Pump and a 1,000 ton per day Anaerobic Digestion Plant) were selected after an extensive review of the current portfolio to determine which technologies were of greatest interest to BCS management and would also demonstrate capabilities of the model. The Gas Fired Heat Pump case study was performed by establishing a facsimile venture of the Sterling/ Rankin Gas Fired Heat Pump, currently under development by General Electric. The input data set was established from existing reports and general industry financial ratios of heating, ventilating, and air conditioning (HVAC) manufacturers. The base case was first modeled without any federal policy options, to determine the stand-alone merits of the venture. This revealed that the venture passes the basic performance criteria for both General Electric and the HVAC industry. However, the subsequent evaluation of policy options shows that increased market penetration can be realized, which will result in further energy savings beyond the base case. The detailed results of these options and their impact are presented in the policy analysis table of Appendix D.

The second case study explored the financial ramifications to a municipal entity of the construction and operation of a 1000 ton per day anaerobic digestion plant. The plant is designed to process urban waste. The process used results in the production of methane and carbon dioxide, as well as a decreased volume of waste for disposal. Most of the data for the computer simulations were secured during a meeting with Waste Management, Inc., the designers and operators of the Pompano Beach pilot facility. Modelling of the base case proceeded with the following assumptions: the plant was assumed to be owned by a municipal entity which floated revenue bonds for the planning, design, and construction. The actual design, construction, and operation of the plant was assumed to be the responsibility of a full service contractor. An analysis of the results of the base case computer simulation indicates that a municipality could experience positive financial results from the venture. There are many qualifications which must be recognized with a site dependant technology like anaerobic digestion of urban waste. A detailed discussion of this case may be found in Appendix E.

The District Heating and Cooling Systems (DHCS) case study, presented in Appendix F, was a two-fold effort. Initially, a site specific case was performed using Washington, D.C. and Potomac Electric Power Company. This effort was presented in a briefing to BCS management, at which time several major areas were identified for future analysis. This led to a second case study using the Minneapolis/St. Paul area as a DHCS site. This was done primarily due to the level of interest of DHCS at this location and the data base which existed as a result of other evaluation studies. This effort deals largely with issues related to the regulated business environment of the electric utility, and their impact on DHCS development. The form of private ownership/operation for DHCS must overcome the constraints imposed by the current regulatory process and the competitive products of oil and gas. It is the common practice of most regulatory commissions to review the rate of return on an

annual basis, which does not allow for carry-forward losses when the venture is incurring negative returns in its early years. However, the high degree of risk for this particular capital intensive venture can be significantly reduced by changes in regulation or legislation. If returns were computed by the commission over an extended time period, the venture would become increasingly viable. Other conclusions are presented in Appendix F.

In conclusion, it was determined that risk analysis provides an extremely valuable insight to the financial and energy savings attributes of a wide range of BCS technologies. It is an effective tool to examine policy options for optimum support of those technologies. The importance of this type of analysis is underscored by the fact that industry generally perceives technological barriers, toward which a large share of government RD&D funds are directed, to be far less important to commercialization than market, capital, and regulatory barriers. This is reflected in the results of several studies. Table 2-1 of the main report, for example, indicates that only 11.5% of product failures are due to technological problems, while the market, management, capital and government regulations areas accounted for a combined 78% of product failures. It is precisely these areas that can be isolated in the risk analysis methodology, and which can be examined using various policy options. This quantitative approach not only provides a clear representation of key measures for a given venture, but also fosters an executive type of insight to a given venture for those who participate in the study formulation and analysis.

As a means of additionally improving the productivity and cost effectiveness of the current DOE risk analysis model, several modeling recommendations are presented. The first group of recommendations, in the area of regulated business ventures, results from the experience gained in the two DHCS case studies:

- o Allowed Rate of Return Constraint (Annual): This improvement is aimed at increasing the ability of the model to evaluate regulated ventures. The improvement would provide the capability of specifying allowed annual return on investment, which would then be used to establish the appropriate price which could be charged and not exceed the allowable constraint.
- o Allowed Rate of Return Constraint (Discounted): This improvement is also aimed at increasing the ability of the model to evaluate regulated ventures and to consider alternative regulatory constraints. The improvement would provide the capability of specifying allowed rate of return (i.e., the discounted return on investment or internal rate of return--that rate that makes the net present value equal to zero) on investment which would then be used to establish the appropriate price which could be charged and not exceed the allowable constraint. It should be noted that this constraint is not an annual constraint but measured over an extended period of time.
- o Competitive Pricing Constraint (Multiple Products): This improvement is aimed at increasing the ability of the model to evaluate both regulated and unregulated district heating and cooling business ventures. Multiple competitive products would be considered with price forecasts input for each. The minimum price would result in a market constraint placed upon the pricing of thermal products from the DHCS. The market price constraint could be used in conjunction with the return on investment regulatory constraints to accurately model the regulated DHCS business environment.
- o Minimum Revenue Requirement Risk Model: This is a significant modification aimed at developing a risk model that simulates the utility minimum revenue requirements method computational procedures.

Other general enhancements include:

- o Energy Savings by Year: The model has been modified so that the risk profile of the present value of energy savings (by product and energy type) is established. The risk profiles, or at the minimum, the expected value and standard deviation of energy savings (by product and energy type) should be provided for each year of the time horizon. The energy savings computations need to be modified to accomplish this.
- o Sales Forecast Subroutine: Currently, the model requires input data to be provided in the form of a sales forecast (i.e., number of units sold as a function of time including ranges of uncertainty). It is recommended that a sales forecast subroutine be developed that has two levels of capability. The first level of capability would allow the potential market to be specified (for example, number of residential units) in a disaggregated fashion together with market penetration rate for the products in each market segment. These would be provided as uncertainty variables so that the resulting sales forecast would be in the form of a range of uncertainty together with the form of the uncertainty. The second level of capability would allow the sales forecast to be established in terms of user economics. The sales forecast, done at a disaggregate level, would take into account consumer economics in terms of annual savings and initial purchase price and develop performance measures such as payback period. The sales forecast would then be related to the number of consumers having different payback periods where both the potential number of purchasers and the rate of purchase are related to payback period.

In order to maximize the effectiveness of these modeling efforts, it is necessary to coordinate several procedural items which will increase the availability and utility of risk analysis to BCS management. The most significant item is the data collection for model inputs. This phase can be the most rigorous of any given case study, as well as most costly, if secondary sources and extrapolation are employed. Because the model inputs require subjective range estimates and probability distributions, it is important to have estimates which are generated from sources which are very close to the technology and the environment in which it is being produced. The opinions of persons who are familiar with the specific corporate value model and the fundamental parameters of the technology are desired. By employing various interviewing techniques, the attitudes of these individuals toward risk can be captured and applied. Ideally, these people should represent the decision makers in both the private and public areas of a venture. Through this approach, data collection can be a fairly straightforward matter. Contractual agreement should be made on the procedure to be followed, in order that the firm can be assured that disclosure of proprietary information which could weaken its competitive situation will be prevented.

It is the conclusion of this effort, based on the overall research of risk analysis, and the case study experience, that the risk analysis methodology has significant potential as a policy evaluation tool within BCS. Furthermore, a substantial framework for the initiation of the evaluation of the other BCS technologies has been established with the model installation, its demonstration in these studies, and its availability for DOE use. Future development to realize the full potential of the methodology should be minor relative to that accomplished to date.

CHAPTER 2

INTRODUCTION

2.1 CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

Residential and commercial buildings account for approximately one-third of the nation's total energy demand. This demand is a function of a myriad of energy consuming devices ranging from complex heating ventilating and cooling systems to common household appliances. Each of these devices consumes energy with variable efficiency as a result of its design, age, function, and operating procedure. Moreover, as the developed environment expands the demand for energy correspondingly increases. In spite of the complexities inherent in the energy component of this sector, national goals focusing on reducing the nation's dependence on foreign oil necessitate the introduction of conservation technologies and procedures if the problem is to be conquered.

The Department of Energy's Office of Buildings and Community Systems (BCS) has been charged with improving the efficiency of energy utilization in the nation's buildings and communities. Specifically, the BCS Five Year Plan identifies the following major program goals:

- o Reduce the consumption of scarce fuels (oil & gas) in new buildings by 35 percent by 1985 and 60 percent by 2000 over 1975 consumption;
- o Reduce the consumption of scarce fuels in existing buildings by 20 percent by 1985 and by 30 percent by 2000 over 1975;
- o Decrease the consumption of scarce fuel resources in the built environment by 5000 barrels of oil equivalent per day (BDOE) by 1985 and by 1,500,000 BDOE by 2000 through the use of community systems which allow for the direct substitution of waste heat for scarce fuels;

- o Decrease the consumption of scarce fuels an additional 130,000 BDOE by 1985 and 750,000 BDOE by 2000 through the recovery of energy from municipal waste.

Attainment of these goals requires BCS to assume several roles in the research, development, demonstration, commercialization, and implementation of conservation technologies and procedures which will foster, complement, or accelerate private sector efforts in this field.

Program strategies in support of BCS roles focus on removing the technological, economic, and institutional barriers associated with meeting the office's goals. Removal of these barriers is a formidable task as each is recognized by both government and industry as being major commercialization obstacles in their own right. Although the relative importance of each barrier is dependent on the specific program being considered, institutional and economic factors generally take precedence over technical barriers in most projects. An analysis of major barriers to commercialization reveals that non-technology related items are the primary reasons for commercialization failure (Table 2-1). Therefore, an influx of funds to eliminate technical problems will not always result in a successful program. BCS has recognized the importance of understanding the economic and institutional factors associated with conservation technologies and has required that all potential projects be evaluated on their economic merits.

Towards this end, a Threshold Evaluation System, incorporating key measures of a project's economic worth, was developed and is currently maintained and applied to all potential and existing conservation projects. The system identifies the economic attractiveness of a project's product to the end user of the

TABLE 2-1. OBSTACLES TO SUCCESSFUL COMMERCIALIZATION

FAILURE CAUSE	% FAILING
MARKET	27.5
MANAGEMENT	23.5
CAPITAL	15.0
GOVERNMENT REGULATIONS	12.0
TECHNOLOGY	11.5
ANTI-TRUST/PATENTS	5.5
OTHERS	4.5

Source: Myers and Sweezy, Technology Review

technology; dollar value of energy savings in comparison to the level of investment required by the government; and value of the energy saved by accelerating introduction of the technology into the marketplace versus the level of investment made by the government. Each project must meet pre-defined thresholds on each of the criteria to be further considered for Federal assistance. In addition, a Resource Allocation System was developed to further strengthen the selection of economically viable projects. This system evaluates the synergistic aspects of each project on other similar projects such that the impact of a group of projects will be maximized. Thus, the resultant group of projects, or portfolio, will be more effective than a group of projects selected on their individual merits alone.

In accordance with the office's policy to integrate finance and economics into the the project evaluation and selection process, a need for a systematic methodology to assess the risk confronting the manufacturers of conservation technologies was identified. These manufacturers are confronted by a number of risk issues even after technical and production feasibility have been established. For example, the firm would have to commit resources to purchase and/or modify the plant and equipment

needed to produce the product; establish marketing programs; and develop distribution networks. However, since experience in the new products is insufficient to determine if the rewards are at a level consistent with the investment, the manufacturer might reject the product. Consistent evaluation of risk through the use of a standard methodology, which would in addition provide a more thorough evaluation of the manufacturers' risk, was established as a goal.

2.2 CONTRACT OBJECTIVES

DYNATREND Incorporated was selected in 1977 to review the current methods employed to evaluate risk to the manufacturer and develop a methodology which would indentify the risk levels associated with BCS projects. Moreover, the methodology was to provide a framework for the development of specific policy options aimed at reducing the risk to the manufacturer, thereby improving the likelihood of the technology contributing to the conservation of energy.

The effort was carried out in accordance with the Statement of Work of contract EC-77-C-03-1470 and subsequent modifications. Identification and review of commercially available risk models which were appropriate for use within BCS were followed by review of the BCS energy technology portfolio for potential case studies which would demonstrate the application of the risk model on BCS projects. Application of the selected risk model to one of the technologies, a district energy system using cogeneration, led to a contract modification. The modification to the contract centered on enhancing the model for BCS use and installing it on the DOE computer. This was followed by a second review of the active portfolio and selection of two additional cases for analysis. Results of the analyses are presented in this report.

2.3 OBJECTIVES AND ORGANIZATION OF THE REPORT

This report presents the results of the risk analysis model selection, enhancement, and application to selected technologies now being fostered by DOE/BCS. Additional documentation submitted during the course of the contract is referenced where appropriate. This report additionally serves other objectives. First, it is intended to present the reader (the contract-specified lay audience) with an overview of current risk analysis practices. A review of this nature provides a common foundation for the evaluation of alternative methodologies. Second, the report affords a review and evaluation of risk assessment information requirements of BCS management. BCS must develop and implement programs which will attain the energy conservation goals. To enable optimum selections of policies and programs, the information on which decisions are based must be improved. This report is intended to provide additional insight to the data required. Accomplishment of the preceding objectives should result in the application of procedures which will significantly strengthen broad divisional policy analysis and improve specific strategies within each project.

2.3.1 LAY AUDIENCE ORIENTATION

The major intent of the research conducted under this contract was to develop a risk analysis methodology for the evaluation of risk within BCS conservation projects. Therefore, most of the work involved economic and financial issues associated with the development, commercialization, and implementation of conservation technologies. Although most of the financial and economic issues are common knowledge to practitioners and academics in the field, the terminology and concepts employed in risk analysis restrain individuals not intimately associated with the discipline from applying risk analysis to current decisions. It is of prime importance that the terminology and the basic concepts be understood by the BCS managers involved.

The risk analysis background information and the description of the methodology which have been included in this report can provide the needed common base of knowledge for evaluating conservation ventures and determining the impact of policy options intended to foster the success of those ventures.

This report has been prepared for assimilation by individuals with a general background in economics and finance. All concepts beyond that basic foundation are defined whenever possible within the body of the report. In order to further eliminate ambiguities a glossary is included in an appendix.

Through the application of the general guideline to prepare the report for a lay audience and the inclusion of a glossary, the value of risk analysis in fostering energy conservation technologies in buildings and community systems will hopefully be enhanced.

2.3.2 FINAL REPORT ORGANIZATION

The report has been segmented into seven chapters with the first two chapters containing the executive summary and introduction respectively. Chapter 3 presents an overview of risk analysis procedures employed in the private, public, and utility sectors. The material presents the current state-of-the-art of risk analysis as employed by firms and organizations in the aforementioned sector. The contents of this chapter reflect the results of the literature review and interviews which were conducted to provide a foundation for selecting a model appropriate for BCS needs.

Chapter 4 concentrates on the risk analysis requirements of BCS. Therefore, specific attention is given to the role of government in risk reduction and risk sharing as well as to the risks to the government in funding technology development programs. A framework for applying risk analysis procedures to policy development is offered and the chapter concludes with a

discussion of the data considerations inherent in the conduct of a risk analysis.

The succeeding chapter presents a review of available risk analysis methodologies based on the overview of the state-of-the-art and specific BCS requirements. In addition to technical issues, the time, data, and resource requirements of each methodology are analyzed. Moreover, acquisition and operation costs of each methodology are addressed.

As a result of the above analysis, the recommended risk analysis model is presented in Chapter 6. This discussion focuses on:

- o Features resulting in the selection of the model;
- o Enhancements required to meet all specifications;
- o A framework for applying the model in BCS; and
- o Data requirements.

The final chapter, Chapter 7, presents the conclusions and recommendations reached as a result of the total effort. The content of this chapter reflects the experiences and insights gained in selecting the model as well as those obtained from application of the selected model to three active BCS projects.

Six appendices are included with the report. A bibliography of major reference materials employed in the study is contained in Appendix A, listed in alphabetical order by author or authoring organization. Appendix B is a glossary of terminology employed in the report to assist the reader in understanding the economic and financial terminology associated with risk analysis.

Appendices C-F are bound individually. Appendix C provides additional detail on the model used, its inputs and outputs. Appendices D, E, and F present the results of three case studies conducted to test and evaluate the selected model. The BCS projects evaluated with the model were:

- o Gas-fired Heat Pumps;
- o 1,000 TPD Anaerobic Digestion Plant; and
- o District Heating & Cooling Systems (Cogeneration).

Excerpts of the results of the case studies are used for illustration purposes in the main report; however, each case study is more technically oriented than the body of this report. Therefore, readers unfamiliar with risk analysis concepts are urged to read the following chapters before embarking on the case study reports.

CHAPTER 3

RISK ANALYSIS OVERVIEW

3.1 RISK ANALYSIS IN THE PRIVATE SECTOR

The success of a business rests on a firm's ability to make a profit on the goods and services offered for sale to the consumer. To make a product or service available to consumers the firm must commit some of its resources in anticipation of receiving rewards (profit) at some time in the future. The commitment of resources or funds with the expectation of receiving rewards in the future is commonly referred to as a business venture. Furthermore, the process which attempts to predict or forecast the amount of resources required for the venture and the rate and level of expected rewards is referred to as venture analysis. Since the conduct of a venture analysis requires predicting future events which cannot be exactly determined, the comprehensive range of possibilities both in the commitment of resources and level of rewards must be considered if an informed decision on any potential venture is to be made. The range of potential resource requirements is referred to as uncertainty while the range of potential outcomes is designated as risk. Risk analysis is the technique by which the decision-maker can quantitatively account for the venture's uncertainty and risk.

This section presents the components of risk analysis and reviews how they are applied in a private sector firm's value model. A firm's value model is a representation of its philosophical, financial and economic stance toward new investments. It includes, for example, the firm's discount rate, internal rate of return threshold, payback period requirements, as well as its philosophy on entering new markets, product diversification, etc. Private sector firms are defined to include all businesses which have as one of their primary goals the realization of a profit on their products and services. Furthermore, private sector firms also strive to insure an adequate return

to their investors. Subsequent to reviewing the financial measures of profitability employed in risk analysis techniques, specific qualitative and quantitative approaches to risk analysis will be presented in this chapter.

3.1.1 FINANCIAL MEASURES OF INVESTMENTS

The evaluation of a potential investment can be performed with a variety of procedures and techniques depending on the objective of the firm. In most circumstances the firm's primary objective is to maximize profits; however, other objectives such as securing a larger market are also included depending on the firm's value model. In order to determine if the profit maximization objective will be met the firm must account for all costs which will be incurred in the venture and all benefits which will be received. The determination of costs and benefits varies across industries and within firms in each industry. This is especially true when defining benefits. For example, benefits can take the form of non-monetary attributes such as enhancing the firm's reputation within a product line, as well as secondary impacts such as other new product spin-offs. Due to the diversity of non-quantitative benefits, and the assumption that the secondary impacts of most BCS initiatives are positive, only monetary benefits (returns) are addressed herein. Therefore, the criteria to determine which venture best accomplishes the firm's objectives will be financial measures of profitability.

Before proceeding to a discussion of investment criteria, several variables employed in computing the criteria must be explained. First, the flow of costs and revenues associated with a product over time must be determined. This flow of expenses and revenues is referred to as the firm's cash flow.

Figure 3-1 presents a flow diagram of the components which determine cash flow. It should be noted that this is a simplified representation and could be expanded, if necessary, to

FIGURE 3-1. SIMPLIFIED CASH FLOW COMPUTATION

include greater detail. Initially the revenue received from the good or service is calculated based on the expected level of sales (unit sales) in the total market and the estimated price per unit produced (unit selling price). The product of these two items is adjusted by the amount of the total available market for the product the firm expects to capture (market share). For example if the firm were evaluating the potential of entering the heat pump market it would multiply the expected price of a heat pump by the total number of heat pumps expected to be purchased in the year under study and adjust this figure to include only that portion of total heat pump sales the firm expects to capture.

The expenses incurred in producing the product for sale are based on three items. Variable costs represent those expenses related to the level of product production. An example of variable costs would be raw materials used to produce heat pumps. The second component of expenses is fixed costs. Fixed costs are those expenditures which remain constant over varying production volumes. Typically these costs, such as insurance, are those incurred regardless of the rate of sales. Finally, the costs of plant and equipment, or capital expenditures, must be accounted for when computing expenses. These costs are usually distributed over time (depreciation) until the asset's useful life has expired. Total expenses for any year are thus the sum of the total operating costs and the depreciation realized from capital expenditures.

The firm's profit or loss before taxes is the difference between revenue and expenses less any allowable previous losses if present. After performing this step, taxes are subtracted and the after-tax profit is obtained. At this juncture additional changes in the firm's assets and liabilities such as the level of inventory, outstanding receivables, outstanding payables, etc., can be subtracted from capital expenditures not related to the production of the good or service and added to the after

tax profit. The resultant sum is the cash flow for the year under analysis. While it is realized that individual ventures within a firm are not separated for normal tax calculations, this is done for purposes of modeling an individual venture, to determine the individual strengths and weaknesses of a given business situation.

The cash flow procedure is repeated for each year of the venture's expected life. For example, if the firm contemplating production of a more energy efficient heat pump expected to produce the pump for 10 years, the procedure would be iterated ten times. The resultant figures for each year can be plotted to evaluate the cash flow stream. Figure 3-2 presents an example of such a plot. A negative cash flow represents the amount of funds the venture will require to cover the costs incurred in each year. Once this curve passes through the horizontal axis a positive cash flow is realized and the venture begins to replenish the funds used in the initial years. An additional dimension can be added to this plot to represent the level of indebtedness (Figure 3-3). Indebtedness is the cumulative negative cash flow invested in the venture. When this line crosses the horizontal axis the firm has recouped its initial investment.

The above explanation of a firm's cash flow does not include provision for the value of money over time, referred to as discounting. Money can be invested in a variety of ways to provide future returns. For example, money deposited in a bank today will accrue interest at the bank's rate until a future point in time when the money would be withdrawn. If the bank offered 4% interest on your money with a promise to pay \$10.00 at the end of two years, you would deposit \$9.25 today which is referred to as the present value of your funds at a 4% discount rate. The level of the discount rate varies between industries; however, it is usually set at approximately the level of interest a firm would have to pay to obtain the funds to make an investment.

FIGURE 3-2. CASH FLOW GRAPH

FIGURE 3-3. CASH FLOW-INDEBTEDNESS GRAPH

The firm's cash flow and discount rate(s) are integral inputs to the determination of the values of two of the three most important investment criteria: net present worth and internal rate of return. The third criterion, payback period, does not consider discounting cash flow over time. Many other investment criteria are available, such as the simple rate of return. However, criteria such as the simple rate of return ignore the value of money over time. Application of these simplified criteria would not result in an accurate and comprehensive treatment of the venture.

The use of the payback period as an investment criteria in a firm's value model is extremely popular. This can be attributed, in part, to its computational ease and conceptually simple basis. The payback period is the amount of time which will elapse before the net revenues from a venture return the costs incurred. Therefore, it can be concluded that a firm entering a venture must remain committed to its decision until it has met the payback period requirements. At the end of the payback period, the investor could, theoretically, liquidate the assets of the venture and the firm would not be adversely impacted. However, use of the payback period alone as a measure of a venture's profitability can be misleading.

The hidden problems associated with the use of the payback period in investment analysis are noted by Maxim and Cook in the American Management Association publication Financial Risk Analysis (Reference 28 of Appendix A). First, two ventures could display identical payback periods but also have markedly different cash flows. A firm with the objective to recover its investment rapidly to avert a cash flow problem would view the two ventures as equal if only the payback period were employed in the analysis. If the two cash flow streams were examined, one venture may recover 70 to 80% of the investment in the first two years of a six year venture, whereas the other alternative would only recover 10% in the first two years. An

example of two cash flow streams with identical payback periods is presented in Table 3-1. A firm ignoring the cash flow stream would view the investments as identical. However, investment option 2 will recover approximately 70% of the initial outlay in the first two years while option 1 recovers only 8% in the same time frame. Selection of option 1 by a firm which must recover investments rapidly to maintain an adequate cash flow could prove disastrous.

TABLE 3-1
PAYBACK PERIOD VERSUS CASH FLOW

INVESTMENT OPTION	OUTLAY	NET CASH FLOW (\$) IN YEAR						PAYBACK PERIOD
		1	2	3	4	5	6	
1	60,000	2,000	3,000	5,000	7,000	13,000	30,000	6
2	60,000	30,000	13,000	7,000	5,000	3,000	2,000	6

Clearly, reliance on the payback period alone in this hypothetical venture could produce serious cash flow problems.

Application of the payback period as a profitability measure in the firm's value model has similar shortcomings. Payback periods do not account for the total useful life of an investment. Thus, a firm would not know if one venture would have a similar life span in comparison to another. This could result in rejection of a long-term profitable venture. The establishment of a payback period threshold has several drawbacks analagous to the problems associated with using payback periods as liquidity measures. Rejection of a venture on the premise that the payback period exceeds the firm's threshold could result in a loss of long-term profits exceeding those of a comparable venture with a shorter payback period. In spite of these problems, proper use of the payback period in conjunction with the two investment criteria discussed below can result in a well-informed investment decision.

Frequently it is advantageous to evaluate an investment employing a single figure of merit. A firm which can define its discount rate (cost of capital) can employ an investment criteria known as the net present value of an investment (NPV) or also referred to as the net present worth (within this document both are synonymous and NPV will be employed). NPV includes the cash flow situation of the venture over time, and the discount rate. Computationally the NPV is the present value of the summation of net cash flows for each year of the venture, discounted at the firm's discount rate. The resultant amount represents the amount of money the firm could afford to pay above its investment in the venture under consideration and still earn the required rate of interest (discount rate). The following general rules guide investors when interpreting the NPV:

IF NPV > 0	-	undertake the venture
IF NPV < 0	-	reject the venture
IF NPV = 0	-	decision is immaterial.

When NPV is zero, the venture will provide a rate of return at the cost of capital and, therefore, would not have any adverse effect on the firm. An NPV less than zero implies that the venture will not provide returns which will match the firm's marginal cost of capital. Thus, the firm will lose money and the venture should be rejected. Any NPV above zero indicates that the firm could invest additional funds, up to the value of NPV, and not be adversely impacted. Firms employing the NPV as an investment criteria usually seek ventures which will maximize the value of NPV.

The major drawback encountered when using NPV is the definition of a discount rate. A firm must decide the basis for selecting the value of the discount rate from a number of choices, including the average cost of all capital resources, or from an economic viewpoint, the cost of capital. An incorrect discount rate could result in an incorrect investment decision. Furthermore,

Haz and Wiig (Reference 22) caution that the discount rate should not be increased to accommodate expected uncertainties in the cost of capital since the values of the cash flows over time could not be realistically interpreted. A venture's NPV is very sensitive to the discount rate. Generally, increases in the discount rate lowers the venture's NPV, however, the timing of the cash flow could serve to offset the impact of high discount rates. Procedures for evaluating investments at varying discount rates will be presented later in this report.

The final investment criterion to be examined is the internal rate of return (IRR). This criterion establishes the discount rate at the point where the NPV of the investment equals zero. The computational procedure for determining the IRR requires the NPV equation to be iterated, changing the value of the discount rate until the NPV is at zero. If a potential investment produced an IRR equivalent to or greater than the cost of capital available to the firm, the venture should be undertaken since the firm would be favorably impacted. Often a cutoff value is established (similar to the BCS Threshold Evaluation System) for acceptance of a venture.

In spite of the fact that the IRR and NPV are similar they will not result in the same investment decision in all circumstances. Many investment options require commitments of funds beyond the initial outlay in the first year such that the cash flow alternates between positive and negative values over the course of the venture. A situation such as this could produce more than one rate of return.

Naturally, many rates of return serve to complicate the investment decision. Moreover, comparisons between competing ventures are equally as difficult when using the IRR. Specifically, if two projects of unequal lives are competing for funds and the project with the shorter life is selected on the basis of a higher rate of return, the firm could be rejecting long term

profits. This is true since one assumption underlying the use of the IRR is that the funds remaining at the end of the short life project are reinvested at the same IRR. Table 3-2 illustrates this problem. Project 1 selected on the basis of IRR would only be advantageous in comparison to project 2 if the firm could reinvest the earned funds in another project in year 4 which would also yield a 20% IRR.

In summary, the application of NPV for investment analysis, with profit maximization as a goal, is superior over other criteria. However, proper use of each criteria can result in better informed investment decisions. A summary of profitability measures and their benefits and drawbacks is presented in Table 3-3. These profitability measures and the financial variables employed as inputs to the criteria form the foundation for the majority of quantitative risk analysis methodologies.

3.1.2 QUALITATIVE APPROACHES TO RISK ANALYSIS

The consideration of uncertainty and risk analysis is a component of all investment decisions. Irrespective of a firm's size, target market, or age, the decision-maker draws upon prior experience with uncertainty to formulate an investment decision. Naylor (Reference 32), in a survey of 346 firms which use corporate models, illustrated a relationship between the sales volume and the employment of modeling practices, as shown in Table 3-4. The use of quantitative models, in this group of firms, increases with sales volume, as might be expected.

TABLE 3-2
PROJECT SELECTION*
IRR vs. NPV

<u>YEAR</u>	<u>PROJECT 1</u>	<u>PROJECT 2</u>
INITIAL		
OUTLAY	(\$1,000)	(\$1,000)
1	474	265
2	474	265
3	474	265
4		265
5		265
6		265
UNADJUSTED NET	\$ 422	\$ 590
IRR	20%	15%
NPV (5%)	\$ 289	\$ 346

*Source: Managerial Accounting, Copeland & Dascher, Wiley/Hamilton,
Santa Barbara, California 1978.

TABLE 3-3

SUMMARY OF INVESTMENT CRITERIA

METHOD	DEFINITION	COMPUTATION	ADVANTAGES	DISADVANTAGES
Payback Period	Number of years until investment is recouped	If rate of flow is constant, $\text{Payback} = \frac{\text{Investment}}{\text{Net Cash Flow}}$ otherwise, the payback is determined by adding up the expected cash inflows until the total equals the initial investment	<ol style="list-style-type: none"> 1. Simple to use and understand 2. Makes allowances for risk attitudes 3. Commonly known and used 4. Useful as a constraint 	<ol style="list-style-type: none"> 1. Ignores cash flow beyond payback period 2. Ignores timing within payback period 3. Overemphasizes liquidity as investment criterion
Accounting (or Unadjusted) Rate of Return	Ratio of average annual income after depreciation to the average book value of the investment	$\frac{\text{Average Annual Cash Inflow} - \frac{1}{2} \text{ Initial Investment}}{\text{Average annual Depreciation}}$	<ol style="list-style-type: none"> 1. Easy to compute and understand 2. Commonly known and used 	Ignores timing of cash flows
Net Present Value (NPV)	Difference between cash inflows and outflows discounted to the present at a given interest rate	$\text{NPV} = \sum_{t=1}^T \frac{F_t}{(1+i)^t}$ where F_t = net cash flow at time period t i = discount rate T = planning horizon	<ol style="list-style-type: none"> 1. Takes time value of money into account 2. Easier to compute than IRR 	<ol style="list-style-type: none"> 1. Requires definition of a discount rate 2. Less intuitive than IRR
IRR/ROI (Rate of Return of the Investment, or Internal Rate of Return)	Discount rate which makes the net present value of inflows and outflows equal to zero	<p>The IRR is determined by solving the equation</p> $\sum_{t=1}^T \frac{F_t}{(1+i)^t} = 0$ <p>where i is the rate of return of the investment</p>	<ol style="list-style-type: none"> 1. Takes time value of money into account 2. Does not require definition of a cut-off 3. Intuitively appealing 	<ol style="list-style-type: none"> 1. Computationally complex (requires trial and error) 2. Assumes other investment opportunities exist at same IRR 3. Does not consider size of scale of the investment 4. Occasionally provides more than one discount rate, or none

TABLE 3-4
SALES OF FIRMS USING CORPORATE MODELS

SALES	PERCENTAGE
UNDER \$50 MILLION	7
\$50 MILLION - \$100 MILLION	3
\$100 MILLION - \$250 MILLION	8
\$250 MILLION - \$500 MILLION	16
\$500 MILLION - \$1 BILLION	21
OVER \$1 BILLION	38
NO RESPONSE	<u>7</u>
TOTAL	100

Firms with larger sales volumes have the resources available to support the staff necessary to perform more rigorous corporate modeling. BCS is currently engaged in conservation RD&D with firms and individuals across the entire spectrum of sales volumes, therefore the risk considerations of smaller firms must be addressed.

The importance of maintaining an adequate cash flow, especially in a small firm embarking on a new venture, cannot be over-estimated. The Denver Research Institute (DRI) report Federal Incentives for Innovation (Reference 13) reported that access to funds to support new ventures in general and especially ventures in smaller firms is a major barrier to innovation. Furthermore, DRI made the logical assumption that firms recognized as being successful in prior ventures are more likely to obtain the funds required to support future efforts at innovation. Many firms not actively engaged in innovation will therefore, have to rely more heavily on internal sources of funds. The drain on internally generated capital places stress on the firm's cash flow which could result in financial collapse. Therefore, a promising technological innovation could fail strictly due to economic conditions. This element of risk, the timing and fluctuations of the firm's cash flow due to venture-capital requirements, is of paramount concern to the small firm.

The second fundamental risk concern of smaller firms is the size of the potential market. Again, a lack of available resources to support a market analysis group eliminates the availability of reliable market estimates. This area of exposure could impact production planning and ultimately unit price.

For the most part, risk is assessed intuitively by upper management in firms of all sizes. The experiences of the firm's executives in similar ventures serves as the risk analysis "model." These qualitative assessments of risk are not, however, conducted without the benefit of any financial criteria. Table 3-5 illustrates the use made of specific financial criteria by firms according to annual capital budgets.

Among the smaller firms the discounted rate of return and payback period are the dominant financial criteria applied to investment decisions.

3.1.3 QUANTITATIVE APPROACHES TO RISK ANALYSIS

The growing concern by upper management with respect to the uncertainties associated with new ventures, given the relatively large capital and time commitments required of the firm, has produced an expanding variety of quantitative techniques to deal with uncertainty. Moreover, recent efforts in risk analysis are focusing on the integration of quantitative measures of uncertainty with qualitative assessments of the decision-maker's risk attitudes (utility theory). This section illustrates those techniques currently employed within the private sector on a routine basis.

3.1.3.1 Three Estimate Approach

Perhaps one of the most straightforward approaches to dealing with the range of uncertainty in venture analysis is the use of three estimates representing the most likely value of the base

TABLE 3-5. FINANCIAL CRITERIA USED TO EVALUATE CAPITAL INVESTMENTS *

SIZE OF ANNUAL CAPITAL BUDGET	DISCOUNTED RATE OF RETURN		NET PRESENT VALUE		PRESENT VALUE INDEX		PAYBACK PERIOD		SIMPLE RATE OF RETURN		OTHER	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
● GENERAL CRITERIA												
OVER \$100M	45	78	20	34	5	9	42	72	35	60	8	14
\$50-\$100M	23	79	6	21	3	10	18	62	16	55	1	3
\$10-\$50M	42	64	9	14	1	2	45	68	29	44	7	11
\$5-\$10M	9	82	0	--	1	9	6	55	3	27	0	--
<\$5M	5	50	0	--	0	--	5	50	4	40	0	--
NO SIZE INDICATED	2	67	1	33	0	--	2	67	0	--	1	33
TOTAL BUSINESS	126	71	36	20	10	6	118	67	87	49	17	10
● PRIMARY CRITERIA												
OVER \$100M	20	34	3	5	0	--	1	2	18	31	4	7
\$50-\$100M	11	38	2	7	1	3	2	7	4	14	0	--
\$10-\$50M	26	39	2	3	0	--	15	23	12	18	3	5
\$5-\$10M	6	55	0	--	1	9	1	9	3	27	0	--
<\$5M	4	40	0	--	0	--	4	40	2	20	0	--
NO SIZE INDICATED	0	--	0	--	0	--	1	33	0	--	1	33
TOTAL BUSINESS	67	38	7	4	2	1	24	14	39	22	8	5

* SOURCE: FREMGEN, J. M., A SURVEY OF CAPITAL BUDGETING PRACTICES IN BUSINESS FIRMS AND MILITARY ACTIVITY, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIFORNIA, NPS-55FM72101A, OCTOBER 11, 1972.

case, an optimistic estimate, and a pessimistic estimate of each investment criteria. The analyst will request three estimates of the data on each of the variables input to the calculation of the financial criteria. Subsequently, three estimates of the net present value of the cash flow stream, IRR, and payback period are produced. The values of the extreme estimates can then be used by management as measures of the upper and lower bounds of the investment's potential profitability. Although this approach is easy to implement and represents an expansion of the data over single figures of profitability, it could inadvertently mislead the decision-maker. If the analysts supplying the input data failed to note, for example, that there was an 80% chance of the pessimistic estimate prevailing over the others, top management could select the venture based on the most-likely case. Moreover, this approach does not identify to what degree each estimate could vary. An investment with a pessimistic NPV within the corporate threshold value model specifications could be selected. However, if the variance of the pessimistic NPV were known to be large, the venture would be rejected. The value of the three estimate approach can be considerable, especially when the investment is small in magnitude, and if the end user of the information is cognizant of its limitations.

3.1.3.2 Monte Carlo Approach

Application of simulation techniques employing the computer has produced a new dimension in evaluating uncertainty in potential investments. Top management and planning analysts now have the ability to simulate the life of a venture varying all relevant input parameters to arrive at the potential range of outcomes expressed in terms of probability distributions. Therefore, the decision-maker can evaluate the mean, standard deviation, and confidence level associated with a number of possible outcomes of a venture. This procedure eliminates many of the detrimental features of single point and three estimate analyses.

However, the application of this technique requires an understanding of subjective probability and Monte Carlo sampling techniques.

Subjective probability is a derivative of probability theory. Probability theory rests on the assumption that there is an underlying regular pattern of events over a long period of time. True probability estimates are derived using data collected from actual occurrences of the event under study (empirical data) and are repeatable. Since a venture cannot be conducted a large number of times with the venture's characteristics being varied for each unique attempt to derive the empirical data necessary to develop true probability estimates, subjective probability is employed.

Subjective probability is the quantification of an individual's judgement on the potential of a specific event occurring. For example, a market analyst attempting to define the total heat pump market potential would not express the high level of sales in 1985 to be 200,000 units, rather the analyst would state that there is a 65% chance of the total heat pump market reaching a sales level of 200,000 units in 1985. Expressing the characteristics of a venture in this manner enables application of Monte Carlo techniques to simulate the venture. Before proceeding to the attributes of the Monte Carlo method the procedure for arriving at subjective probability distributions is worth noting.

The use of subjective probability is valuable beyond its application in simulation. It encourages the actors in venture-analysis to realistically assess the possible attributes of all financial parameters. Again borrowing from the heat pump example, the financial analyst requires unit selling price as an input to the cash flow computation. The analyst would most likely query members of the executive staff involved in the effort to obtain the data. Initially, the high and low estimates of the heat

pump's unit price would be requested. If the upper bound was \$1560 and the lower limit \$1040 a continuum such as the one in Figure 3-4 would be drawn. The next step would involve segmenting

FIGURE 3-4
HEAT PUMP UNIT PRICE RANGE

this range into intervals. Since five intervals are more easily understood (e.g., a median and two intervals on each side) the range could take the appearance of Figure 3-5. It is not necessary to use equal intervals.

FIGURE 3-5
HEAT PUMP UNIT PRICE RANGE

The interviewee would then be requested to rank the likelihood of the unit price falling within each interval (Figure 3-6). This establishes the general shape of the uncertainty profile (i.e., skewed right, central, etc.). The likelihood of the unit price falling into any one of the five intervals is then estimated in relation to the likelihood of it falling into the other intervals. For example, the relative likelihood

FIGURE 3-6
RANKING OF UNIT PRICE INTERVALS

of the unit price falling between \$1456 and \$1560, P_2 , is equal to $\frac{P_1}{2}$; the chance of falling in the range of \$1248 to \$1352, P_3 , is equal to $\frac{P_2}{2}$; etc. as shown in Figure 3-7.

FIGURE 3-7
RELATIVE LIKELIHOOD OF UNIT PRICE INTERVALS

The determination of the likelihood of falling into each interval in quantitative terms (probability estimates) can be easily derived. Since the unit price range represents the entire spectrum of uncertainty, the chance of falling within the range of \$1040 to \$1560 is 1. Therefore, the relationships in Figure 3-7 could be used with those in the equation $P_1 + P_2 + P_3 + P_4 + P_5 = 1$ to solve for the probability estimates.

This produces the following values for each interval:

$$\begin{aligned} P_1 &= 0.52 \\ P_2 &= 0.26 \\ P_3 &= 0.13 \\ P_4 &= 0.06 \\ P_5 &= 0.03 \end{aligned}$$

A histogram or probability density function (Figure 3-8) can now be drawn with the addition of a vertical axis representing the probability of occurrence. It should be noted that the probability of a given interval in the histogram is indicated by the total area, not height, accounted for by the bar as a fraction of the total

area of all the bars. This is particularly important when one is interpreting the graph visually.

FIGURE 3-8
UNIT PRICE PROBABILITY DENSITY FUNCTION

This procedure would be repeated for each financial parameter employed in the risk analysis.

At this point some comments on data collection procedures are warranted. Since the derivation of the probability distributions is a subjective process, care must be exercised in the selection of data sources. Typically, the analyst will solicit data from the departments in an organization which are best qualified to develop the estimates. Therefore, potential sales levels, the cost of sales, and marketing costs are obtained from marketing personnel; unit costs, production costs and maintenance expenditures are derived from the project engineering team; and so on. It is not uncommon, however, to obtain estimates which reflect the source's individual biases. An engineer with a personal interest in seeing a project advance to the production stage may skew

unit costs, for example, to insure the project is not cancelled on the basis of its financial attributes. Several procedures to minimize either conscious or unconscious skewing of the data are available. Among the most popular is the Delphi technique. This procedure involves the collection of data from a number of individuals knowledgeable in the parameter under examination. Each individual prepares an estimate without the knowledge of what other team members are preparing and all estimates are compiled and statistical summaries distributed to each member. This procedure is iterated until the group has resolved any data extremes. Although this expands the time required to collect data, greater confidence can be placed in the input data and financial figures of merit derived from the analysis.

Once the probabilities associated with the input data have been collected, a financial simulation can be performed employing the Monte Carlo method. The basic financial measures, such as NPV, are calculated a large number of times with the input parameters varying according to the subjective probability distributions.

The number of iterations selected for the Monte Carlo simulation has a direct bearing on the accuracy of the model's results. Under normal circumstances, approximately 100 iterations will produce results which reflect the majority of possible venture outcomes. A venture characterized by a wide range of values, or a large standard deviation as indicated by the uncertainty profile, for the major uncertainty variables should be iterated from 250 to 500 times. This will produce results which portray the impact of a large number of possible outcomes. Furthermore, the number of iterations should be based on the shapes of the probability distributions attached to each uncertainty variable. Uncertainty profiles skewed toward high or low extremes of the range with no pattern across all uncertainty variables is also cause to increase the number of iterations to capture all possible outcomes in the simulation. Under most circumstances

the amount of accuracy gained in simulations with greater than 500 iterations is nominal and not worth the additional data processing costs.

A Monte Carlo simulation of a venture's cash flow would be conducted in the following manner for approximately 100 iterations:

1. The simulation will first look at the probability distributions of each variable entered in the cash flow computation. Based on this distribution it will randomly select a value for each input parameter such as unit cost. The selection of a random value is within the confines of the probability distribution. An easy way of visualizing this concept is to develop a wheel of chance such as that shown in Figure 3-9. Since there is a 52% chance of the unit cost falling in the range of 1352 - 1456, 52% of the wheel is devoted to values within that range. Spinning the wheel would result in random values of unit cost to use in the computations. All other probabilistic variables are treated in a similar manner. In order to assure the values selected for each variable are consistent from year to year within one scenario the correlation between years is examined and values interpolated if necessary.
2. At the end of each venture scenario the risk analysis model stores the relevant figures of merit such as the cash flow stream, net present value, payback period, etc.
3. Once all iterations are complete the model calculates statistics on each of the figures of merit to provide the analyst with the mean and standard deviation for each value. Moreover, the frequency at which the values occurred across all iterations is computed to determine the probability of a venture meeting or exceeding that value.

FIGURE 3-9. MONTE CARLO WHEEL OF CHANCE FOR UNIT PRICE

4. Risk profiles are produced as output from the Monte Carlo simulation for use by the decision maker.

Therefore, Monte Carlo techniques can simulate one venture under a variety of circumstances to evaluate the merits of the venture under uncertainty.

The output of a Monte Carlo risk analysis provides a clear portrait of the effects of uncertainty. Two examples of the application of Monte Carlo risk analysis results are presented. First, the cash flow over each year of the venture's life can be plotted from the tabular output. Usually, the cash flow in each analysis year is listed according to its probability of occurrence. A hypothetical cash flow stream is presented in Figure 3-10. The horizontal axis represents each year of the venture's life and the vertical axis is the actual value of the cash flow in each year. For each level of probability the cash flow is plotted by year. Based on the level of risk the decision maker is prepared to assume the cash flow impact on the firm can be assessed. Risk averse investors will probably evaluate the cash flow stream at the 80% and 100% levels. Thus the investor will be reasonably sure of experiencing a cash flow projected at that level. Conversely, a risk seeking investor would evaluate the cash flow stream at a lower level of probability. These trade-offs complicate the investment decision; however, the magnitude of uncertainty represented in the various levels of cash flow can be explicitly viewed, thereby partially eliminating ambiguity in the process.

The availability of a mean and standard deviation value for each financial figure of merit enables an assessment of different investment options within a venture. The mean of an investment figure of merit such as NPV is computed as the sum of the NPV produced from each iteration of simulation, divided by the total number of iterations. It represents the average NPV which can be expected from the venture. The standard deviation

FIGURE 3-10. CASH FLOW PROBABILITY

of each figure of merit measures the dispersion of values about the mean. The lower the standard deviation is, for a given distribution of NPV, the more certain a decision maker can be that the actual outcome will approach the mean NPV value. Therefore, a lower standard deviation implies lower risk for the financial measure under consideration.

By virtue of the Monte Carlo method most distributions of values, such as NPV, take a normal shape (Gaussian) which enables a graph similar to the one in Figure 3-11 to be constructed. In this example, alternatives 1 and 2 have the same level of risk since the standard deviation of the NPV is equivalent. Alternative 2 is preferable, however, since it will realize a higher NPV. The same conclusions as above could be drawn for alternatives 3 and 4. An investor with the objective of minimizing risk while simultaneously maximizing the NPV (profit) would select alternative 3 as the "best" option among the four available. From this example it can be seen that the risk premium associated with a project under alternative funding and marketing scenarios can be easily identified. Financial criteria with large standard deviations have a high level of risk. The firm's goal is to reduce the standard deviation, increase the mean to offset the high risk, or a combination of both. Financial, marketing, or production changes can be tested in the simulation to determine their effectiveness in reducing risk or providing greater returns to compensate for the risk.

Similar analyses can be performed employing data from a Monte Carlo based risk analysis. Other outputs typically obtainable from this approach are risk profiles for:

FIGURE 3-11. NPV RISK ASSESSMENT-MEAN, STANDARD DEVIATION PLANE

- o Revenue;
- o Expenses;
- o Capital Expenditures;
- o Profit;
- o Cumulative cash flow;
- o Return on assets; and
- o Payback period.

Some Monte Carlo approaches perform the risk analysis at various discount rates to assist the investor in making a decision when the discount rate or cost of capital cannot be exactly defined, thereby accounting for potential variations in the discount rate.

In summary, use of Monte Carlo risk analysis approaches provides one of the most comprehensive means of explicitly understanding the uncertainty associated with a venture. It is frequently employed in actual venture analysis in the business community.

3.1.3.3 Decision Tree Analysis

More often than not an investment decision is not confined to options within a single venture but rather an interrelated decision involving events which are directly or indirectly related to the venture under investigation.

A method of formalizing the relationships between interrelated events, enabling the investor to evaluate the economic consequence of each option, is the decision tree. Decision trees are useful in the evaluation of potential events within a venture and/or events occurring exogeneous to the venture.

Each decision tree is comprised of two components: decisions, represented by squares, and chance events represented by circles. For illustrative purposes a hypothetical decision tree will be employed relating the development of building performance

standards and the gas-fired heat pump. The developmental process and ultimate commercialization of the gas-fired heat pump project could benefit from the implementation of performance standards for new buildings. This would be especially important if the commercialization success of the heat pump rested on having an assured level of demand during the first five years in the market. Therefore, if the performance standards are prepared and successfully adopted and the gas-fired heat pump is ready for the market, the commercialization risk associated with the heat pump could be reduced.

Figure 3-12 presents a simplified decision tree to aid in the evaluation of the impact of Building Energy Performance Standards (BEPS) on the success of the gas-fired heat pump in terms of the NPV of energy saved under each option. At decision point 1 the options are:

1. Develop and commercialize the gas-fired heat pump in conjunction with BEPS;
2. Develop the heat pump as a stand-alone effort; and/or
3. Develop BEPS as a stand-alone effort.

The initial option leads to chance point A at which time the unit price per kWh output of the heat pump will impact future options. The numbers along each branch stemming from chance point A represent hypothetical probabilities of each possible outcome occurring. It is apparent that the evaluating team in this hypothetical situation perceives high or moderate costs per kWh to be more likely to occur. If the high cost branch is taken, decision point 2 is encountered. At this decision point the course of action taken in the BEPS effort will impact the commercialization success of the heat pump. Strict BEPS improve the likelihood of achieving a high level of demand and consequently a high NPV of energy savings. However, if minimum BEPS are implemented, the probability of realizing a low level of initial demand and associated NPV of energy savings will be

FIGURE 3-12. HYPOTHETICAL DECISION TREE

realized. The consequences of the stand-alone options can be ascertained by following the tree to the various terminal nodes.

Although this example is only hypothetical, the ramifications of each alternative course of action and the critical decision points are clearly beneficial when evaluating investment decisions.

The successful application of decision tree techniques to risk analysis problems requires management to identify the criteria to be employed in determining the course of action at each decision node and the objectives and goals of the problem. Therefore, the path through the tree would be based on, for example, selecting the branch from a decision point which has the most attractive cash flow stream with the objective of maximizing the NPV.

In conclusion it should be noted that Monte Carlo risk analysis and decision tree theory can be complementary tools in evaluating a venture's risk. Monte Carlo risk analysis can supply the requisite figures of merit which can be expected from each alternative path at various levels of probability. Moreover, both techniques foster the explicit consideration of the uncertainties associated with a venture, thereby minimizing the likelihood of neglecting a risk factor which might result in the venture's failure.

3.2 RISK ANALYSIS IN THE PUBLIC AND UTILITY SECTOR

The undertaking of a new venture by a public sector entity or a profit-making utility firm operating under a public regulatory body must also include a consideration of uncertainty. These entities approach new ventures with goals different from those in the private sector; however, the evaluation tools employed by public entities and regulated utilities are similar to those commonly applied by profit-oriented businesses. This section

identifies the major differences in public/utility sector risk analysis and the techniques available for evaluating the level of uncertainty.

3.2.1 PUBLIC SECTOR RISK ANALYSIS

BCS is actively engaged in a number of efforts which are aimed at ultimate adoption by the public sector. An example of such an effort is the Pompano Beach, Florida waste conversion demonstration plant. If the technology is proven viable as a result of this demonstration, "consumers" of the technology would be urban governments and/or regional waste treatment authorities. Adoption of the technology by municipal governments would be based on certain criteria, such as the level of capital required to construct the facility, the presence of a market to purchase the energy produced from the facility, and the level of funds required to maintain the plant. Each of these three concerns contains elements of uncertainty, hence the venture is not risk free.

The major areas of uncertainty mentioned above are well suited to the conduct of a financial risk analysis. First, the level of capital expenditures necessary to undertake the venture must be determined. The ability to obtain capital from the sale of bonds and/or internal resources is directly related to the risk associated with the venture. Revenues from operation of the facility must be realized at a level which permits retirement of the principal and interest on the bond. Therefore, the cash flow stream of the investment must be computed, which requires consideration of the level of demand for the product (units sales) and anticipated operation and maintenance costs.

Application of the Monte Carlo approach to the problem can produce the information needed to evaluate the impact of uncertainty. Subjective probability distributions based on the experiences gained in the demonstration facility would serve as the input

data. This enables ranges of likely costs for plant and equipment, operation and maintenance, and the energy product to be considered. The major deviation in this venture analysis from a private sector analysis is in the evaluation of the results produced from the Monte Carlo approach.

The public sector value model will be more inclined to pursue the venture if the probability of recovering the investment with an NPV equal to zero is high. Thus the venture can be undertaken at the cost of capital without placing additional resource requirements on the public. In some instances, however, societal benefits may outweigh the costs, at which time an NPV less than zero may be acceptable. Nevertheless, the projections of revenues and costs alone or as measured in the cash flow stream enable the municipal investment analyst to determine the impact of the venture on the finances of the public entity at various levels of confidence. Therefore, if the level of risk associated with the venture is low, the public entity should be capable of selling bonds at a rate attractive to both the public entity and investor.

Before proceeding to a discussion of risk assessment under regulation, the issue of accounting practices should be addressed. Within the public sector, accounting practices, especially the treatment of depreciation, vary. If the cash flow stream is to be properly evaluated at the Federal level to determine the need and level of risk reduction assistance, the venture should be simulated under alternative accounting schemes. This additional effort will foster a more realistic treatment of the venture's risk

3.2.2 RISK ANALYSIS IN A REGULATED ENVIRONMENT

The evaluation of a potential venture within a firm operating under constraints emanating from a public regulatory body complicates the process of risk analysis. Specifically, regulated

firms strive to maximize profits; however, the rate of return to the firm is limited. This situation can result in a barrier to the adoption of technologies with high risk, since investors normally will only accept higher risk if, simultaneously, a higher rate of return is made available on the investment. Recent consumer attitudes have further complicated the investment decision process due to increased pressure on Public Utility Commissions (PUC's) to reduce the frequency and magnitude of rate increases, which reduces the utilities' willingness to accept moderate to high risk ventures. By virtue of its charter, BCS has the ability to offer incentives for the adoption of conservation technologies while minimizing the need for rate increases.

All ventures considered by a regulated firm with a limited rate of return are evaluated according to the venture's impact on the value of the firm as a whole. Therefore, the normal risk analysis procedure employed outside of the regulated environment is reversed. The analyst would start with the allowable rate of return and then determine the likelihood of the different price levels allowing the established rate of return to be achieved. A price which would lower the firm's rate of return would discourage investors from making the capital available to the firm for the venture and/or generate the need for a rate increase. Conversely, if the price increased the rate of return above the allowable level, the PUC may either disapprove the venture or reduce the rate structure. The wide variety of techniques available and being used by regulated utilities to determine the value of the firm with the addition of a new venture are beyond the scope of this report. However, the application of traditional financial measures to a potential venture (e.g., cash flow stream, NPV, return on assets, indebtedness) can be employed to assess the impact of the venture on the firm. Financial analysis of investments within the utility sector, including risk assessment, is a time consuming and expensive exercise. In addition to the data required for a

conventional financial/risk analysis presented in this chapter, extensive data on the financial attributes of the firm, construction work in progress, and construction projects the firm is committed to implement in the future are essential to the analysis. Therefore, any risk analysis model used in the utility sector would be developed around the unique attributes of one firm. Recognizing the impracticality of developing a unique model for each firm, the analysis turned toward identifying the major risk issues which confront utility sector firms in their investment decisions.

Capital formation is the major risk obstacle to the introduction of improvements in new technologies. The utilities are faced at this time with a two-pronged problem. First, utilities are under obligation to supply adequate levels of their product in spite of the fact that earnings may not be at a level to encourage capital spending. Therefore, "the industry has only very limited discretion in timing its placements of debt and equity issues in an attempt to minimize the cost of capital. The result has been large amounts of debt sold at historically high interest rates . . ."(Reference 34). High interest rates reduce debt coverage which leads to the second prong of the problem. Bond rating firms lowered ratings on utility bonds, which again increased interest," . . . to compensate investors for the greater risk they perceived having to assume Reference 34."

Therefore, projects which can be funded with internal funds are more desirable; they represent a lower level of risk because capital costs to the firm are reduced. Conventional risk analysis can be effectively applied to determine the likelihood of requiring external financing. Utility financing personnel at a BCS seminar reinforced this conclusion by stating that most projects are evaluated on their individual merits as well as by more rigorous methods incorporating the entire financial position of the firm.

3.3 THE ROLE OF RISK ANALYSIS IN VENTURE DECISIONS

To highlight the importance of risk and financial analysis, a literature review for commercialization of high technology prepared for DOE (Reference 4), states:

"Several studies have shown that industry perceives technological barriers to be considerably less important to commercialization than market, capital, or regulatory barriers.

Thus, merely increasing the extent of R&D funding will not necessarily lead to increased commercialization."

It is for this reason that firms continually reassess the financial characteristics of a venture (including risk analysis) from the point when the idea is conceived to actual introduction in the marketplace. During each stage of the venture's maturation, its financial attributes can be better defined, thereby enabling management to reassess the venture prior to the commitment of the resources required at each stage.

An excellent example of this continued re-evaluation is presented in Figure 3-13. This flow chart illustrates the movement of an idea through the R&D cycle toward commercialization. The points of financial reassessment in the process are indicated by circles. At each of these points the information should reflect the learning process preceding it, or in risk analysis terminology, the probability density functions of each financial parameter should be revised to reflect changes in uncertainty. For example, as a result of engineering efforts in stages 4-7, the probability distribution for unit price should reflect a greater understanding of projected production costs, such as is exhibited in Figure 3-14. As the kurtosis and skewness of the distribution change, the range of uncertainty represented in the risk profiles should narrow.

FIGURE 3-13. FEDERAL INCENTIVES FOR INNOVATION
 Source: Denver Research Institute, November 1973, p.71

FIGURE 3-14. UNIT PRICE PROBABILITY DENSITY FUNCTION

Reliance on the data from the initial risk assessment could result in a venture expending corporate resources without a high probability of receiving an adequate return. Furthermore, sensitivity analyses (varying the values of input parameters) can provide insight to the critical risk factors in a venture.

3.4 SUMMARY

All major decisions have an element of risk which can dramatically impact the outcome of a new venture. Various techniques are available to incorporate uncertainty in the decision process; however, the application of Monte Carlo simulation procedures affords the greatest degree of visibility into uncertainty. The Monte Carlo approach fosters explicit consideration of uncertainty variables to minimize detrimental impacts caused by oversight. Although the approach is more demanding in terms of data collection and interpretation, the benefits are substantial. Finally, the value of executive judgment based on experience should not be discounted. Without the benefit of that input, quantitative procedures become only marginal in value.

The next chapter focuses on the risk analysis needs of BCS in order to relate the financial criteria employed in the private sector to the role of BCS in encouraging the introduction of conservation technologies into the marketplace.

CHAPTER 4

BCS RISK ANALYSIS REQUIREMENTS

The development of technology to reduce energy consumption in the nation's buildings and communities is a primary objective of the Office of Buildings and Community Systems. Successful accomplishment of the objective rests on a thorough understanding of the technological, economic, environmental, and institutional barriers confronting adoption of conservation technology. Each of these barriers is interrelated. Failure to evaluate the impact of Federal actions in one or all areas reduces the potential of attaining the overall goals present in the National Energy Plan.

Since its inception, BCS has sponsored extensive economic analysis of conservation options to determine the most economically viable projects, as well as the most effective Federal role available to ensure successful adoption of the technology. BCS, recognizing the criteria employed by industry to assess new ventures, identified the areas of risk reduction and risk sharing as necessary elements in their program. The role of risk reduction/sharing on the part of the Federal government is not a new concept. The Department of Defense and NASA have participated in risk reduction programs in many of their projects. However, one fundamental difference exists between the efforts of the aforementioned agencies and BCS. In many previous risk reduction programs the Federal government was the ultimate consumer of the venture's product, which provided the developer of a technology with the assurance of having a market, a major risk consideration in any venture. The end-consumers of energy conservation technology represent a wide gamut of individuals and organizations; namely the American consumer, industry, governmental entities and private and public utilities. Therefore, the technologies sponsored by BCS must have positive commercialization potential. As a result, the ultimate producers of conservation technologies are confronted with the entire spectrum

of risk inherent in the introduction of new products in the marketplace.

Given the components of risk outlined in the previous chapter, this chapter reviews the role of government in the reduction of risk, focusing on the specific risk issues faced by BCS. Risk reduction strategies, with particular attention to the primary areas of uncertainty in the industries directly impacted by BCS, are discussed. Since risk analysis requires varying levels of data, the issues of data requirements and availability are addressed before proceeding to a review of risk analysis methodologies available for BCS application in Chapter 5.

4.1 THE ROLE OF GOVERNMENT IN RISK REDUCTION

Often the goals of society, represented in government policy such as the National Energy Plan, are not met in the free market economy. Businesses will not innovate and commercialize new technology to meet societal goals if the uncertainty surrounding their ability to make a profit is at an unacceptable level. If the benefits of attaining the societal goal exceed the cost of the risk premium, government action is warranted. The remainder of this section illustrates the various roles government can assume to reduce risk. Moreover, the financial criteria and uncertainty parameters addressed in the previous chapter are related to each risk reduction role.

FEDERAL PROCUREMENT.

Purchase of new technology products by the government at a guaranteed level of volume and price reduces the innovator's concern over the size of the initial market and expected cash flow. As mentioned previously, this risk reduction measure is frequently employed by DoD and NASA in their R&D programs. Due to the relatively slow rate of adoption of a technology when first introduced, the firm often

experiences cash flow problems. Furthermore, low initial market penetration rates frequently result in higher unit prices which either lengthen the diffusion process or result in abandonment of the venture. Through the mechanism of the BCS programs aimed at conservation in Federally owned buildings, the office could guarantee purchases of BCS sponsored technology. As an example of reducing risk using Federal procurement, electrodeless fluorescent lamps could be installed in Federal buildings.

COST-SHARING

Amongst all mechanisms available to the government to bear part of the risk burden, cost-sharing is the most extensively used tool. The bulk of all BCS programs fall under the cost-sharing form of RD&D assistance. Cost-sharing is most effectively employed in ventures requiring a large commitment of funds for capital expense items, research, or both. The firm's vulnerability in terms of cash flow and their position in the capital markets is reduced by cost-sharing. Furthermore, cost-sharing programs are relatively straightforward to implement in comparison to the other options.

The value of cost-sharing as an effective risk reduction measure has not gone unquestioned. The literature survey on commercialization previously noted (Reference 4) cites the following issues:

1. Government funds may be directly substituting funds the firm would have committed to the effort.
2. Firms with large resources may remove their competitors from the market by bidding on high cost-sharing contracts.
3. Many firms may avoid cost-sharing to protect their patent position on innovations with a high profit

potential. Therefore, only low quality innovations would be funded.

Consideration of these issues during the project screening process can minimize the detrimental aspects of cost-sharing. If reasonably accurate data are available for the use of BCS in its Threshold Evaluation System, the impact of the aforementioned concerns will be minimized.

DIRECT SUBSIDIES AND GRANTS

The supply of funds in the form of subsidies and grants can serve to accelerate the introduction of technologies, stimulate R&D, or mitigate the impacts of regulations or other institutional barriers to product development. Examples of this type of risk reduction include:

- o Subsidies to eliminate or share the losses incurred during the initial years of production;
- o Construction of plants and purchase of equipment by the government, which can be sold or converted to loans if the venture is successful;
- o Grants to assist in complying with regulatory requirements, such as meeting minimum air pollution standards;
- o Grants to perform RD&D, cover interest expenses on loans, or purchase plants for demonstration of a technology.

Grants and subsidies are most effective in ventures with high levels of uncertainty. Therefore, if the probability of exceeding an NPV of zero is low, grants and subsidies may be more appropriate tools than cost-sharing. Drawbacks to the use of subsidies and grants as risk reduction tools include a reduction in corporate commitment due to a low or non-existent level of financial interest in the venture by the firm, and a lack of sensitivity to the forces of the market (e.g., competition and sales).

RESEARCH, DEVELOPMENT, AND DEMONSTRATION CONTRACTS

Potential ventures with questionable outcomes due to a lack of knowledge in the technology are excellent candidates for RD&D contracts. A lack of insight into the costs associated with the production of a technology may result in a firm rejecting a venture due to the high risks associated with commercialization. RD&D can reduce the uncertainty associated with the aforementioned problems and result in better definition of the venture, possibly to the extent of the private sector implementing the venture without further assistance. Past experiences with RD&D contracts indicate that success of the effort in terms of risk reduction and ultimate commercialization rests on incentives to commercialize.

Contract commercialization clauses serve to motivate the firm to conduct Federally sponsored RD&D in a manner similar to efforts funded totally with the firm's resources. Therefore, the RD&D will be conducted with commercialization as a primary objective versus a program geared to meeting only the technical requirements of the RD&D contract. Government sponsorship of RD&D often results in the contractor having to share the products of the effort with competitors. This can reduce the interest of the firm in a venture and hinder the potential commercialization of the product. Proprietary rights clauses can guarantee the firm under contract for RD&D the right to protect their findings. Therefore, the profit incentives are retained and the utility of the RD&D effort is maintained.

CAPITAL ACQUISITION

Ventures shrouded with uncertainty have difficulty attracting the capital required to proceed to full scale commercialization. Capital markets make funds available based on the level of

expected returns including the magnitude of uncertainty or risk associated with the investment. Moreover, distribution of internally generated capital is subject to the same scrutiny. Ventures requiring large amounts of capital are, therefore, good candidates for Federal assistance.

The government, recognizing the risk associated with a venture requiring large amounts of capital, can implement a number of policies, including the provision of long-term low interest loans, to improve the availability of capital to new ventures. If a venture is more likely to succeed under a lower cost of capital, or discount rate, a low interest loan may be the only Federal action required to improve the potential for commercialization. However, the provision of low interest loans may diminish the firm's commitment to the venture since failure will not have as dramatic an impact under a government loan as it would under a loan from private capital markets. The coupling of Federal capital assistance programs with other incentives can improve the prospects of success.

TAX INCENTIVES

Changes in tax policies can alter the financial portrait of a potential venture and aid in the reduction of uncertainty. Tax deductions, credits, deferrals, and exemptions aimed at the innovator/manufacturer or the consumer are examples of the potential risk reduction measures available to the government.

Tax deductions can impact a variety of expense items. Capital intensive ventures can especially benefit from tax deduction policies aimed at encouraging innovation and adoption of conservation technologies. For example, tax deductions for capital investments to retrofit buildings for cogeneration could offset the financial burden on a building's owner and enable the owner to recoup the investment

in a shorter time span. Moreover, tax deductions for conservation oriented investments can change the uncertainty and magnitude of the firm's cash flow, thereby improving the profit picture of the firm. Deductions need not be restricted to capital investments. Other applications include deductions for equity borrowing costs, initial revenues from innovations, etc. Additionally, allowance for accelerated depreciation procedures in accounting for capital required by the venture can also increase the attractiveness of the venture.

REGULATIONS AND STANDARDS

The regulatory powers available to BCS can be employed as a risk reduction tool. Development of conservation oriented building standards, for example, not only encourages conservation, but develops markets for other conservation technologies sponsored by BCS. Thus, national goals are met and the successful introduction of new technologies is fostered. This type of regulatory action can reduce the uncertainty surrounding market penetration estimates and in some instances lower the unit selling price due to anticipated production levels.

Removal of regulatory barriers can also improve a venture's risk profile. The most obvious example of the impact of deregulation is the reduction in energy price controls. As the costs of fuel rise to meet the level of demand and supply, the price of conservation technology versus the value of energy saved by the technology becomes more attractive. Again, the uncertainty parameter market penetration is impacted. Regulatory barriers created outside of DOE/BCS must also be evaluated for their impact on potential BCS sponsored ventures. Temporary relaxation of environmental barriers, anti-trust barriers, etc., can reduce a venture's likelihood of failing.

Regulations and standards must be carefully adopted. The implementation of standards to encourage conservation in one sector may have detrimental effects in another.

4.2 GOVERNMENTAL RISK

In addition to the risk borne by the innovator/manufacturer and the consumer, the government, or in this situation BCS, is also confronted with uncertainty. Even under optimal circumstances, when all BCS sponsored innovations are economically acceptable to the manufacturer and user, BCS bears the risk of not meeting national conservation goals. That is, for each dollar invested by BCS in promoting the development and commercialization of conservation technology, the return in energy savings is uncertain.

The government, in a situation analagous to a private corporation, strives to select a project or group of projects which will maximize their objectives (in this situation the NPV of energy savings) at the lowest cost and at a minimum level of risk. As it is doubtful that all BCS projects will result in successful commercialization, there is an element of uncertainty in the decision to fund RD&D efforts. One means of evaluating the uncertainty to the government is to employ the value of energy savings as an uncertainty variable in a Monte Carlo based risk analysis. This would permit examination of risk profiles of the NPV of energy savings. The government decision maker could evaluate his/her own risk taking or aversion tendencies and recommend a funding decision based on the probability of exceeding a certain NPV of energy savings. The above technique can be expanded to a collection of projects or portfolio. BCS has sponsored the development of a methodology to aid in the selection of portfolios entitled the Resource Allocation Model. Outputs from risk assessment models could significantly enhance the selection of portfolios; however, further investigation of this area is beyond the scope of this report.

4.3 RISK ANALYSIS IMPACTS ON BCS POLICY FORMATION

Risk analysis can serve as an integral tool in the formulation of BCS policy. The insights gained by examining the uncertainty associated with a venture, coupled with an appreciation of the business environment in which the venture will be implemented, can produce policies fostering successful commercialization of technology within an entire industry. Answers to questions such as what is the most effective role for BCS to assume in the residential appliance industry can be obtained. This section focuses on a systematic procedure for translating the results of a Monte Carlo based risk analysis into specific policy options.

4.3.1 RISK ANALYSIS FRAMEWORK

The decision to perform a risk analysis on a potential venture typically rests on two factors, the level of investment required of the firm to undertake the venture and/or the level of perceived risk by the firm's top management. Extensive risk analysis is usually confined to ventures requiring a commitment of funds in excess of \$1 million (see Chapter 3) and/or ventures with a perceived high risk premium. If either or both requirements are fulfilled, risk analysis could be justified. At this juncture the firm's executives have three basic concerns. First, what are the capital requirements of the venture? This question encompasses not only hardware requirements but additionally includes research expenditures, management costs, etc. The second concern addressed by top management is the availability of capital to support the venture. Therefore, the ability to generate capital internally and externally must be assessed. If external sources are required, management must address the issues which will be raised in the capital markets, such as:

- o How is the firm performing in relation to other firms in the same industry which are also competing for capital?
- o At the level of capital requested are the returns and level of risk comparable to other ventures within the industry?
- o Will the firm be capable of covering its debt at a level consistent with the performance of other firms in the industry?

Acknowledgement and analysis of these issues will improve the firm's ability to attract capital. Third, if sources of capital are available, management then addresses capital budgeting. The timing and magnitude of capital expenditures impact the cash flow stream of the firm; therefore, the expected cash flow stream of the venture must be reviewed.

4.3.2 POLICY DEVELOPMENT PROCEDURE

A comprehensive procedure for the development and evaluation of BCS policy options is proposed. This procedure, unlike other BCS policy tools (macro-economic models like BECOM, BESOM, etc.), is directed at defining the nature, magnitude, and timing of potential BCS actions within one project and/or industry sector.

The proposed procedure was developed with two underlying objectives. First, the amount of data necessary for the analysis was to be kept to a minimum and available from pre-existing sources whenever possible. Second, given the capital-intensive nature of most conservation investments, the perspectives and criteria used by the sources of capital both within and outside the firm to assess the merits of potential investments were to be integrated into the procedure. Incorporation of these objectives was viewed as a means of strengthening the credibility of BCS policies.

4.3.2.1 Base Case Formulation.

Federal initiatives to foster commercialization of conservation technologies must be carefully selected so that the goals of the private sector are not compromised. Therefore, it is important to understand the financial attributes of a project strictly from the perspective of the firm. This will enable the government to target their policies for the removal of barriers to commercialization toward those areas the firm will be unable to surmount without outside assistance. For this reason, the compilation of a venture base case is the core element of the policy procedure.

A venture base case is a portrayal of the timing and magnitude of financial resources the firm requires to move the technology from the idea stage to commercialization. It includes the resources the manufacturer must commit to research and development, production process design, pilot plant demonstration and finally, full-scale production. Thus, the base case captures the essential components of the firm's value model. The expenditure pattern, accounting practices, and financial position of the firm with respect to its solvency, profitability, and liquidity are incorporated directly into the portrayal of the base case. Through explicit delineation of the financial resources required for the venture, BCS will have the ability to identify major financial barriers and evaluate the impact of Federal incentives on mitigating or removing the barriers within the confines of the firm's value model. An example of how the firm's value model is employed in the policy procedure is presented in Figure 4-1.

This stage of the policy procedure is the most data intensive and time consuming component. However, once completed, policy options can be readily tested and evaluated. The key source of data should be the firm proposing the project. For the most part, since most ventures subjected to risk analysis are large

FIGURE 4-1. OVERVIEW OF RISK ANALYSIS CASE STUDY METHODOLOGY

in magnitude, before they approach BCS the firm probably has already identified the key financial requirements needed to support the effort. Whenever possible, this data should be used in the risk analysis as it represents the most accurate assessment of the venture's resource requirements.

Other sources of data are often available to supplement information available from the firm. For example, the national laboratories are often involved in the technology before the firm or concurrently with the firm's effort. Preliminary engineering and feasibility studies afford a variety of data on the expected range of costs for R&D as well as production. This information can be employed in the simulation or used to verify data supplied by the firm. Throughout the data compilation task, national lab personnel familiar with the venture should be encouraged to evaluate the key input parameters.

After the data has been collected and verified, it should be entered in the risk analysis model to produce risk profiles. Interpretation of the profiles requires an appreciation of the firm's and industry segment's financial investment behavior. Therefore, the next component of the procedure concentrates on the identification of investment patterns, level of capital expenditures, profitability, and solvency of the firm and other firms engaged in manufacturing similar products.

4.3.2.2 Industry/Firm Financial Performance

The identification of financial barriers to successful commercialization and an appreciation for the level of risk acceptable to the firm can be derived from an understanding of the firm's past and current financial position. Moreover, additional insight on the acceptable levels of capitalization, sources of capital, and general financial position of all firms in the impacted business line broaden the understanding of how well the venture will be accepted by the private sector. Fortunately,

several readily available sources of data can be employed to ascertain this information. For example, the following sources were employed in the gas-fired heat pump venture case study:

- o Annual Statement Studies - Troy's Almanac of Business and Industrial Financial Ratios and Robert Morris Associates Annual Statement Studies are two available publications which evaluate the financial statements of various industries, resulting in a series of financial ratios. Both publications are routinely employed by lending institutions to evaluate the financial health of firms requesting funds against others in the same sector. These statistics are available for a broad spectrum of industries, including heating equipment manufacturers, under which the gas-fired heat pump venture, for example, will be produced. Furthermore, the financial ratios are segregated by sales volume, which fosters identification of the major differences in small versus large firms. This item is especially important in the evaluation of sources of capital to the industry.
- o Investment Service Reports - Most major investment service firms (Moody's, Standard & Poors, Dun & Bradstreet) publish industry and firm specific (in this situation GE) financial and economic evaluations to assist investors in their evaluation of a firm's financial performance. The Dun & Bradstreet publication Key Business Ratios is similar in nature to the annual statement studies referenced above. Fourteen ratios evaluating profitability, level of debt, sources of capital and inventory turnover are listed by industry. Similar industry wide statistics are available from the other investor services; however, for publicly held firms (open trading of stock), data on specific firms are also provided. Therefore, the firm engaged in the

venture can be compared against its competitors. Again, capital sources, which weigh heavily in the success of the venture, of the firm and other firms in the industry can be assessed. Thus, any policies derived from the risk analysis can be assured of having an impact beyond the firm engaged in the venture.

- o 10-K and Annual Reports - Each firm openly traded is required to file several financial reports annually with the Securities and Exchange Commission. One such report, referred to as the 10-K report, presents an annual summary of the firm's financial attributes. Another source of financial data is the firm's annual report. In addition to standard delineations of assets, liabilities, and earnings, these reports highlight key financial issues facing the firm. For example, the 1978 General Electric Annual Report noted two major issues facing management which have a direct bearing on the success of the gas-fired heat pump within GE. First, GE views the availability of capital in an inflationary environment as a factor which may limit growth and expansion. Second, currently allowable depreciation techniques reduce the level of internal working capital during a period of inflation. Within a capital intensive venture, BCS has the tools available to implement policies which can offset these problems and therefore improve the commercialization potential of conservation technologies.

Given the potential of this data and its availability, the following indices extracted from the above sources are proposed for this point in the policy analysis procedure:

- o Expense to Sales Ratios - Each ratio is computed by dividing the variable indicated below by net sales.

1. Selling and G&A Costs: This ratio identifies the cost of materials, maintenance, advertising, rent, research and development, etc. used to produce the firm's products.
2. Advertising: Many conservation products require advertising programs larger in magnitude than programs for normal products in order to inform the consumer of its benefits. Many conservation products have higher initial costs which are rapidly recovered; however, consumers tend to focus on first costs. If the probability is high of the expected advertising cost exceeding the ratio currently experienced by either the firm or the industry, the investment strategy could include provision for advertising assistance.
3. Interest: High interest expenses for a venture represent the capital market's perception of the risk premium. Ratios for a venture above those experienced by the firm or industry as a whole are candidates for loan policies to improve the venture's attractiveness.
4. Taxes: Taxes can dramatically impact the firm's earnings and level of internal capital. Within most Monte Carlo risk models, provision for entering different tax schemes is a standard feature. Sensitivity analyses on this variable in conjunction with depreciation methods can lead to effective policies.
5. Earnings/Profits: Any new venture to be accepted by the firm must ultimately contribute to profits if the investment is to be justified. Ventures expected to meet current levels of profits on sales will naturally be more acceptable to the firm.

6. R&D Expenditures: Examination of this ratio can lead to more effective leverage by the Federal government. The firm's commitment to a venture conducted with Federal research funds should be commensurate with their total R&D budget to sales ratio. This will encourage the firm to orient their activities toward commercialization rather than just meeting R&D contract goals.

o Investment Ratios - These ratios are commonly accepted measures of a firm's financial status and performance.

1. Current Ratio: This measure is a test of the firm's short-term solvency. It is calculated as current assets divided by current liabilities. Therefore, it measures the firm's ability to cover its current liabilities with assets that can be converted into cash. As the level of liabilities to assets increases, the firm's ability to attract creditors diminishes.

2. Profits/Working Capital: Net profits after taxes are divided by net working capital to provide a means of evaluating the firm's ability to finance its day-to-day operations.

3. Sales/Working Capital: The productivity of the firm's working capital is represented in this ratio. Calculated as net sales divided by net working capital, it is interpreted as the margin of operating funds.

4. Total Debt/Tangible Net Worth: The extent of the firm's creditors' equity in its assets is measured in this ratio. Once the ratio has exceeded 100% the equity of the creditors in the firm's assets exceeds that of the owners. Total current and long-term debt divided by tangible net worth produces the ratio.

5. Return on Assets: This figure measures the productivity of the firm's assets. Computed as net income divided by total average assets this measure is most often used to determine, in part, the profitability of the firm. Assets within a venture should offer a return in line with the firm's overall return on assets.

o Other Investment Considerations - The following factors also contribute to measuring the firm's ability to enter and succeed in a venture.

1. Depreciation Techniques: The methods employed to depreciate both inventories and plant and equipment determine, in part, the level of capital available internally. Accelerated depreciation and use of last-in-first-out (LIFO) inventory accounting techniques provide more available cash for the firm. However, both are extremely sensitive to inflation.

2. Bond Ratings: The firm's bond rating as determined by investment services impacts the availability and sources of capital to the firm. High investment, high risk ventures will not be attractive to firms actively engaged in the sale of bonds. Reductions in ratings lower the availability and increase the cost of capital available to the firm.

Once the financial measures have been collected and a general understanding of the firm's capital structure has been acquired, the measures can be compared to the same ratios within the venture.

4.3.2.3 Identify Major Financial Barriers

Once all financial indices have been compiled, a direct comparison between the venture's attributes and financial patterns of the firm/ industry can be performed. This comparison identifies where the venture deviates from the firm's investment patterns.

The potential barriers identified from these deviations can be segregated into two classes. The first class pertains to state variables, which are defined as the components of the venture over which the firm has no control. Examples of state variables include local and state taxes, interest, etc. The second type of variables are decision variables which the firm can, in part, control. Decision variables include items such as advertising and marketing costs, capital expenditures, operation and maintenance costs, etc. BCS policy can impact both types of barriers; however, in most cases, the primary focus of action should be toward reducing any detrimental effects associated with the state variables.

The evaluation of policy options is predicated on the selection of evaluation criteria. Five criteria are proposed to measure the effects of policy alternatives. They are:

- o Net Present Value at a minimum of three discount rates. Viable policy options should improve the NPV and increase the rate of return.
- o Median Payback Period. The base case median payback period should be reduced by the policy option to improve the viability of the venture.
- o Return on Assets midway through the venture's life should be increased to improve the attractiveness of the venture.

- o Maximum Return on Assets should be evaluated for changes as a result of policy actions.
- o Year of First Positive Cash Flow. This criterion identifies the amount of time elapsed before the venture will begin replenishing the initial cash outlay required to start the venture. Policy options should be evaluated according to their ability to shorten the time period before positive cash flows are realized.

4.3.2.4 Policy Options Tests

The introduction of one or more of the Federal roles presented earlier into the venture constitutes a test of the impact of Federal policy. Although the barriers and associated policy options vary between projects, the following example is offered as an illustration of selecting Federal roles according to the barriers in each project.

Base Case Barriers:

1. External capital will be required to meet capital requirements.
2. Marketing costs are above average for the firm/industry.
3. Positive cash flow does not occur soon enough to meet initial obligations.

Policy Option Roles:

1. Government procurement of a portion of the capital with buy-back rights to the firm if the venture is successful.
2. Government sponsored marketing program for the technology area.
3. Accelerated depreciation allowance for key capital expense items.

Each of the Federal roles is introduced in the venture simulation by changing the range of values associated with each barrier. Therefore, the first option would be evaluated by lowering the upper range of selected capital expense items to represent different levels of government intervention. A five percent decrease in the range would be evaluated according to the associated percent change in each of the five criteria mentioned previously. Changes in the range of variables contributing to the presence of financial barriers can be introduced individually or in groups. The individual or group change in range(s) which results in the greatest improvement in the policy evaluation criteria represents the optimal BCS policy. However, before reaching that conclusion, one additional evaluation step should be performed to determine if the policy option not only improves the chance for a successful venture, but also improves the energy savings benefits. In order to measure the impact of those policies on energy saved, the ability of the firm to accelerate market penetration and/or increase the cumulative market penetration as a result of removing or minimizing financial barriers must be determined. Introduction of these effects must be performed subjectively, as quantitative models relating to the impact of changes in finances on market penetration are not available.

The effects of these changes in general are measured using the NPV of energy savings. A probabilistic index of the costs and benefits of such changes is proposed based on the current marginal efficiency index (MEI) used in the BCS Threshold Evaluation System. The MEI measures the costs associated with accelerating the technology (through risk reduction) against the benefits gained in terms of the value of energy saved in dollars. The probability of exceeding current minimum MEI standards should be improved to warrant implementation of the policy.

Up to this point, the uncertainty profits attached to each uncertainty variable have remained unchanged. The proposed policies were tested based on alterations in the range of possible values. Before adopting and implementing any policy the sensitivity of the venture to the selected uncertainty profiles should be determined. Employing the original value ranges, the uncertainty profiles associated with the policy impact variables should be varied systematically. Therefore, a high probability of being at the upper bound of a capital expense item should be shifted toward a normal distribution. The impact of each alteration is measured employing the same criteria used in the policy test.

4.4 RISK ANALYSIS DATA CONSIDERATIONS

The conduct of a risk analysis using procedures commonly employed by the private sector is relatively unique within government. However, most businesses engaged in RD&D with government assistance are not accustomed to providing the insight into the financial characteristics of the venture within the firm necessary to perform an adequate risk assessment. Therefore, the process of obtaining data and establishing an on-going dialogue with the firm on this topic is frequently frustrating to both participants. The data needed for a risk analysis is commonly viewed as proprietary.

The barriers to data collection are not insurmountable. A number of options are available to the government to ensure the availability of the information without jeopardizing the position of a firm with its competitors. For example, it is not unusual for the government to request a firm to include the data in their proposal. This provides the means for evaluating the economic merits of a venture before major government investments are obligated. The firm should be assured that the data will be kept confidential and only used outside the government with special permission. As the venture progresses toward commercialization, the sensitivity of the information correspondingly

increases. Thus, as the level of financial strength is refined, the firm becomes increasingly concerned about the entry of competition.

The issues of proprietary data are complex; however, they can best be resolved by informing the firm of data requirements at the onset of the venture. If public funds are to be expended in support of the venture, the firm should be obligated to transmit economic data at regular intervals throughout the project. Inclusion of a data clause in RD&D contracts will provide assurances to the government of having the information to formulate policies which will be based on a thorough analysis of the venture's economic attributes.

CHAPTER 5

REVIEW OF EXISTING RISK ANALYSIS MODELS

5.1 SELECTION CRITERIA

The selection of a methodology to meet the risk analysis requirements of BCS was predicated on fulfillment of the following conditions:

- o The methodology should incorporate the major financial decision criteria employed to evaluate the uncertainty in potential ventures in businesses impacted by BCS.
- o Additionally, the methodology should assess the risks borne by the government in entering the venture. The fundamental criteria desired is a measure of the uncertainty associated with the timing and magnitude of the federal investment in relation to the value of energy conserved by commercialization of the venture.
- o If possible, the risk analysis model should be readily available for installation on a DOE computer facility in order to minimize or eliminate developmental and de-bugging costs associated with implementation of a new model. Furthermore, the number of enhancements required to eliminate any model deficiencies should be kept to a minimum.
- o The operating characteristics of the risk analysis model should be simple to eliminate the need for extensive training in the use of the model.
- o Finally, the model should be economically viable to purchase and employ in project and policy evaluation exercises.

Based on these requirements, in conjunction with the knowledge of current state-of-the-art risk analysis procedures (Chapter 3) and the specific risk analysis requirements of BCS (Chapter 4) an inventory and analysis of commercially available models was initiated. This chapter summarizes the results of the separately

documented inventory, primarily focusing on the attributes of the two models viewed as most appropriate for BCS needs.

5.2 OVERVIEW OF AVAILABLE MODELS

Initially, the search for available risk analysis models focused on models actually employed by corporations to assess risk. Towards this end, a series of interviews, both personal and via telephone, were conducted to ascertain the types, number, and availability of corporate models. The firms contacted in this initial survey did not result in the identification of any viable models for a variety of reasons. First, internal evaluation of a venture's risk was conducted on a case by case basis. The firms either developed a model specifically geared to a single venture or adapted a general model to a specific venture. Thus, none of the models could be readily applied to the myriad of projects in progress or under evaluation by the divisions in BCS. Second, and more importantly, the planning and financial officers of the firms viewed the models as being proprietary. That is, the framework, key inputs, and evaluation variables and criteria were viewed as a corporate "edge" over competitors in the firm's market or markets. Although this perspective underscores the importance of risk analysis, it reduced significantly the prospects of acquiring an actual corporate model. Given the reluctance of firms to make their models publicly available, the inventory turned toward models and model frameworks available for lease or purchase by firms supplying investment analysis services or software development organizations.

This route of investigation proved more fruitful. Two general categories of models were discovered and investigated. General purpose financial evaluation models were available from a number of sources. These models, described in more detail later in this chapter, provided a general programming framework into which the user encodes the actual risk analysis methodology.

Therefore, most of the data processing burdens associated with defining input data structure, subroutine arguments, and report generation were pre-established for the user. The actual financial model (e.g. cash flow computation, NPV, return on assets) were programmed by the user per the requirements of the venture under study.

The second major type of risk model did not provide the user with the same degree of flexibility in defining the computations and reports. Rather, the models were complete Monte Carlo simulations of the financial attributes of the venture. Users supply the input parameters, data, and report requests from the model's repertoire of available functions and the venture is simulated to produce several risk profiles. Each of the two models in this category was based on a cash flow analysis. However, their attributes and operational flexibility were somewhat different as will be seen in greater detail later.

The evaluation, therefore, concentrated on: 1. General financial evaluation models or programming systems; 2. A Monte Carlo risk analysis model offered by MATHEMATICA entitled MATHRISK and; 3. ECON Incorporated's Monte Carlo risk model referred to as the ECON RISK Model. Each are evaluated individually below.

5.3 PROGRAMMING SYSTEMS

As stated previously, programming systems provide the general framework, with respect to data processing needs, for the application of a user defined risk model. Figure 5-1 presents a general flow chart of the functions of programming systems. The analyst defines the model to be employed in a high-level computer language such as APL or FORTRAN. Typically, the model will revolve around the cash flow computation procedure defined earlier. Therefore, the analyst must specify all relevant expense and revenue items, sales, depreciation scheme, tax structure etc. The programming system will then link the

FIGURE 5-1. PROGRAMMING SYSTEM FUNCTION FLOW CHART

user's model with the system's subroutines which establish procedures for data handling, report generation, and in some instances probability distributions, random number generators, etc. to produce a module which can be executed by the computer. Once the run module has been created, the programming system reads the control parameters for the analysis in addition to the deterministic and probabilistic data to be employed in the run. The model is then executed and reports generated per the user's requests.

Among the programming systems examined (Table 5-1), two systems (General Electric Information Services and Bonner & Moore Assoc.) were more readily adaptable to the risk analysis requirements of BCS. Both systems included pre-existing routines for the establishment of probability distributions associated with the user's uncertainty variables and sensitivity or Monte Carlo routines for simulation of the venture. The remaining programming systems would require establishment of these routines. Therefore, these two models would be more cost-effective to implement due to the pre-existence of probability functions and Monte Carlo techniques. However, the basic financial structure would still have to be defined, programmed, and de-bugged before the system could be used by BCS. Moreover, the assessment of the risk to BCS, in terms of the NPV of energy savings, would also have to be programmed within the programming systems' structures. The first two requirements of a risk model for BCS outlined in the beginning of this chapter could be fulfilled.

The third requirement for ready installation on a DOE computer facility could only be marginally met by both Bonner & Moore and GE Information Services. Each system is designed for operation on their respective firm's host computer, although the Bonner & Moore package could be leased or purchased and installed on a DOE computer. Since considerable cost savings can be realized by processing on a DOE computer, this requirement was viewed as having a large weight in the overall evaluation. Actual cost projections for the application

TABLE 5-1
PROGRAMMING SYSTEMS REVIEWED

COMPANY	SYSTEM
Automatic Data Processing Inc.	FML
Bonner & Moore Assoc., Inc.	PAUS
Computer Sciences Corporation	FLARES
Control Data Corporation	IFPS
Core & Code Inc.	BBL
General Electric Information Services	PASAl\$
Scientific Time Sharing	FPS

of either system could not be derived as a model structure would have to be defined, programmed, and executed on each system to estimate run costs. Since both systems operated primarily under an interactive time sharing environment, costs were assumed to range from moderate to high.

The final general requirement, ease of use, was judged to be a function of the time invested in programming the initial model structure. If the level of effort devoted to programming the model structure was expanded to include incorporation of user oriented features, implementation costs would be increased. Additionally, operating costs of the model would also be higher due to the added code to accommodate use of the model by individuals unfamiliar with the intricacies of data processing.

In conclusion, use of an available programming system afforded some advantages, namely, BCS could exercise more control over the definition of the model; the programming systems simplify the production of reports from the analysis; and changes to the risk model, as implemented within the programming system, would be relatively easy. The following detrimental aspects of programming systems were viewed as being significant enough to eliminate them from further consideration:

- o Level of effort and computer costs associated with defining, programming, and de-bugging a risk analysis model within the structure of a programming system;
- o Effort required to adopt the programming system for use by personnel unfamiliar with data processing;
- o Uncertain costs associated with employing the model on a routine basis for project and policy evaluation.

Since the versatility inherent in the use of a programming system risk model was not viewed as worthwhile, given the high initial effort required to establish the core model, the analysis turned to the two major pre-programmed simulation packages uncovered in the inventory.

5.4 MATHRISK

MATHRISK is a Monte Carlo based risk analysis simulation program offered by MATHEMATICA Inc. Unlike the programming systems, MATHRISK is a complete financial simulation model including the core component of cash flow analysis. Users of the model are required to provide data for three types of variables: uncertainty variables, deterministic variables, and execution variables.

There are twelve types of uncertainty variables used in the model:

o Price	o Other variable costs
o Unit sales	o Marketing Costs
o Revenues	o Fixed costs
o Capacities	o Investments
o Prime variable costs	o Salvage Value
o Transfer variable costs	o Miscellaneous variables

Furthermore, four available probability distributions can be associated with the variables (normal, triangular, rectangular, constant), as well as provision to input user defined distributions. The data required for each uncertainty variable is dependent on the type of distribution selected. Normal distributions require specification of the mean and standard deviation of the value, triangular distributions require the lower and upper bounds of the range, etc. All user defined distributions require specification of the upper and lower values of each interval, as well as the probability associated with each interval. The model selects values for each variable during each iteration of the simulation according to the probability density functions.

Deterministic variables used in the simulation supply the model with data for the tax rate, discount rate, and depreciation technique. Furthermore, the user defines the type of time

periods in the venture (for example, years) and the number of time periods to be considered.

The final set of input variables supplies the program with report requests, names to be associated with the products and report title to be printed on each page of output.

The data is input to the model via standard computer data cards. Each data item is assigned to a certain card type and the information must be punched in pre-specified columns. An example of the MATHRISK input structure is presented in Figure 5-2. It should be noted that use of fixed format input can be cumbersome to individuals unfamiliar with computer format statements. In the example contained in Figure 5-2, the number of years the venture is to be simulated is supplied on card type 3 between the columns 11 and 20. Furthermore, column 20 must contain a decimal point; otherwise, if the value of 20 was punched in columns 19 & 20, the program would interpret the number of years as 2. The opportunity for error is high when using fixed formats, therefore it must be a consideration in evaluating the model's ease of use.

MATHRISK has a variety of reports available to the user. The reports, in addition to a listing of the input data, provide the following information:

- o Expected Value Analysis - Balance sheet-type listing of revenues and costs for each period of the analysis and net and cumulative cash flow.
- o Percentiles of Measures of Project Worth - Values of net operating profit, cumulative net operating profit, net cash flow, and cumulative cash flow (both discounted and undiscounted) are provided at varying percentiles for each time period. Risk profiles of cash flow, for example, can be constructed from this report.

CARD TYPE

1. RUNID
(2x, 18A4)

This is the heading that will be printed at the top of the output report. It begins in Column 3, but can be centered so that it will be centered on the reports.

2. AIOPT, A
(10x, 2F10.0)

AIOPT is the stopping option -

- 1 - Default - Number of iterations = 250
- 2 - User Specified - Number = A
- 3 - Accuracy on the probability of a loss = A

3. AYEARS
(10x, F10.0)

Numbers of periods - Maximum = 20

4. ANYLEG
(5x, 20F3.0)

Length of the periods in months, 1 number per period

FIGURE 5-2. SAMPLE MATHRISK INPUT STRUCTURE

- o Histograms of Measures of Project Worth - A line printer generated histogram of various output variables, such as NPV, is available.
- o Time Charts of Measures of Project Worth - These line printer plots display the distribution of variables such as cash flow over time.

The model's reporting options are flexible and the reports are easily understood and interpreted. Moreover, MATHRISK provides all requisite measures of a venture's financial attributes under uncertainty with the exception of governmental risk measures, such as the NPV of energy savings.

The MATHRISK model is available for purchase and could be readily installed on a DOE computer facility. In its current form, revisions would be required to include the NPV of energy savings. Further enhancements to reduce the rigid nature of the input data structure would be advisable in order to foster use of the model without the need of a trained computer specialist. Since the model has been effectively applied to venture analysis in the business community, it appeared as a viable candidate for adoption by BCS.

5.5 RISK MODEL - ECON

The ECON RISK model is very similar in structure to the MATHRISK model. The core cash flow computation procedure is iterated a number of times according to the Monte Carlo technique to produce a series of financial measures in the format of risk profiles. However, the ECON RISK model provides a number of features which enable the analyst to portray the venture in more detail.

The uncertainty variables employed by ECON RISK include:

- o The value of each capital expenditure item;
- o Development duration (the time elapsed before sales begin);
- o Fixed and variable portions of multiple expense items by year;
- o Total cost of sales by year; and
- o Total revenue by year.

Additionally, the revenue variables can be disaggregated and the following variables substituted for the last two items listed above:

- o Unit cost of sales;
- o Unit sales;
- o Selling price; and
- o Market share.

Each of these items is supplied for each product under evaluation for each of the analysis years.

Selection of a probability distribution for each uncertainty variable is simplified due to the existing library of twenty uncertainty profiles (including the most commonly applied distributions). In addition, the user can define any additional uncertainty profiles as necessary.

The extensive number of deterministic and execution variables in the ECON RISK model fosters a more thorough consideration of a venture's expected performance within a firm (Table 5-2). Furthermore, users are not required to collect all variables for every analysis. For example, an aggregate analysis at the early stages of a venture could be performed to obtain a gross assessment of a venture's risk employing default values wherever possible. This reduces the data collection burden and associated costs.

TABLE 5-2. INPUT VARIABLES - ECON RISK MODEL

● NUMBER OF YEARS	● BALANCE SHEET RELATED ITEMS
*● LIQUIDATION (Y/N)	- CASH (%)
*● GROWTH RATE	- RECEIVABLES (%)
*● BUSINESS SITUATION	- PAYABLES (%)
*● CORPORATE ASSESSMENT	- INVENTORY (%)
*● AGGREGATE/DISAGGREGATE ANALYSIS	
● NUMBER OF PRODUCTS	● EXISTING BALANCE SHEET ITEMS
*● UNCERTAINTY PROFILES	- CURRENT CASH
*● NAME OF UNCERTAINTY PROFILES TO BE USED FOR EACH UNCERTAINTY VARIABLE	- CURRENT RECEIVABLES
● PRICE/QUANTITY DATA	- CURRENT PAYABLES
● COST/QUANTITY DATA	- CURRENT INVENTORY
● PRODUCT INTERRELATIONSHIP	- BOOK VALUE OF ASSETS
● NUMBER OF EXPENSE ITEMS	- TYPE OF DEPRECIATION
	- REMAINING DEPRECIATION LIFE
● PRODUCTION LEVEL INDEPENDENT CAPITAL EXPENDITURE DATA	*● NUMBER OF DISCOUNT RATES
- NUMBER	*● DISCOUNT RATES
- TIME OF ACQUISITION	*● CORRELATION FACTOR FOR EACH VARIABLE
- TYPE OF DEPRECIATION	*● NUMBER OF SIMULATION RUNS
- DEPRECIATION LIFE	*● SURTAX RATE
	*● CORPORATE TAX RATE
*● PRODUCTION LEVEL RELATED CAPITAL EXPENDITURE DATA	*● "DIVIDENDS RECEIVED" TAX RATE
- INCREMENTAL PRODUCTION CAPABILITY	*● OUTPUT REQUEST DATA
- PRODUCTION LEVEL THRESHOLD	
- TYPE OF DEPRECIATION	
- DEPRECIATION LIFE	

*DEFAULT VALUES USED IF DATA OMITTED.

The ECON RISK model data input structure displays several advantageous characteristics. First, all related data items are grouped together. For example, all data items describing the characteristics of the venture within a firm are grouped under general data. Within each data category, a series of questions is posed to obtain the appropriate data item. Possible values for each variable are presented as well as the default value if the item is omitted. Therefore, the analyst can readily construct a data collection procedure which minimizes the amount of effort expended and reduces ambiguities. Data input is further simplified by the provision of pre-printed keypunch forms where each data item is directly associated with a question on the input form. Key words are employed to relate the input data to the questions; for example, MAXYRS = is the keyword for question 1 asking for the number of years the venture is to be simulated. Additionally, other than the starting column of the keyword, input values do not have to appear in specified columns.

A total of nine risk profiles are produced by the ECON RISK model, all in tabular format. The profiles available are:

- o Revenues;
- o Expenses (one report for each expense item);
- o Capital expenditures;
- o Profit;
- o Cash Flow;
- o Cumulative Cash flow;
- o Return on assets;
- o Present worth; and
- o Payback period.

Due to the application of Monte Carlo techniques, a risk profile of the internal rate of return is not available, since cash flow could be positive or negative throughout the venture. However, the IRR profile can be obtained from the present worth data.

The ECON RISK model is available for purchase and could be readily installed on the DOE computer system. The model would require an enhancement to produce risk profiles of the present worth of energy savings.

5.6 EVALUATION

Both the ECON and MATHEMATICA models incorporate the major elements of uncertainty required to perform an effective risk analysis. Moreover, simulation of the venture according to Monte Carlo techniques represents the current state-of-the-art of risk analysis employed in business. Therefore, further consideration of a programming system based model was eliminated.

From a technical perspective the ECON RISK and MATHEMATICA models are approximately equivalent. Both models focus on the cash flow computation to simulate the venture. The ECON RISK model affords several advantages over the MATHRISK model. First, the ECON RISK model enables the analyst to portray the venture in greater detail. Demand-price relationships for a product can be used to control sales at differing product price levels, and the financial calculations are selected according to the type of business environment the venture will be implemented under (e.g., partnership, separate corporation, part of an existing corporation). The overriding technical advantage of the ECON RISK model is centered on its data collection and input procedures.

The ECON model offers the user a systematic process for collecting the venture's financial data. A series of structured questions, grouped by topic, facilitates the collection and verification of information. Therefore, the analysts' time expended and the sources of information required to develop the input data can be significantly reduced.

Moreover, the ability to construct an aggregate or disaggregate scenario, due to the presence of default values for many variables, affords greater flexibility in applying the model to a venture. This provision is especially important to BCS when considering a project in its early stages of development when data is not readily available. Finally, the use of free format input minimizes the complexity and level of error associated with preparing the data for use by the computer.

5.7 CONCLUSIONS

The ECON RISK model was recommended for use by BCS based on the evaluation criteria developed in this chapter. However, prior to initiating development work to incorporate the NPV of energy savings, it was recommended that the model be applied to two current BCS ventures, cogeneration and the gas-fired heat pump. These case studies, included as appendices to this report, proved the model to be a viable tool in analyzing conservation investments and policies. The following chapter illustrates the enhancements and proposes a framework for applying the model.

CHAPTER 6

RECOMMENDED METHODOLOGY

6.1 MODEL FEATURES

The analysis of available risk models resulted in the selection of the RISK model offered by ECON Incorporated. However, prior to formal acquisition of the model for installation on the DOE computer, a test case study employing the model was conducted. The Community Systems Division District Heating and Cooling (Cogeneration) project* was evaluated to measure the effectiveness of the model's features, given the characteristics of BCS projects. Additionally, the conduct of a case study was a valuable means of identifying enhancements to the model to improve its capabilities in the BCS setting.

The diversity of BCS projects mandates the selection of a risk model with a large number of features and capabilities since the economic attributes and business environment of the office's projects are diverse. Among the projects available for risk analysis, cogeneration is one of the more complex. In addition to the constraints imposed on the venture due to the actions of regulatory bodies (e.g. rate of return limitations, rate base impacts), the project is characterized by significant capital expenditures for power plant retrofitting and installation of a distribution network. Furthermore, the introduction of a thermal product as a result of cogeneration also impacts the sales of the utility's primary product, electricity. Finally, the retrofitting costs associated with modification of the end

*The results of the case study are presented in Appendix F.

user's HVAC plant (commercial and/or residential structures) directly impacts the demand for the cogeneration facility's products. Therefore, the cogeneration venture was viewed as an excellent test of the model's features. It should be noted that since the cogeneration venture would be implemented in a regulated environment, utility financial analysts would expand the risk analysis to evaluate the impact of cogeneration on the rate base. This was not viewed as a limiting factor in the analysis as utility investment representatives at a BCS investment seminar* indicated that most prospective ventures were evaluated on their individual merits employing common financial criteria, as well as on an analysis which is sensitive to regulatory constraints. As a result of the case study, the features presented below are viewed as the primary strengths of the model, which resulted in permanent acquisition of the RISK model by BCS.

Multiple Time Periods - The model allows for the simulation of a venture from one to ten years. Inputs can be specified to liquidate the venture at the end of the specified time period or continue at a given growth rate.

Trends In Future Time Periods - The RISK model can extrapolate trends beyond the specified time period limitation.

*For further details on the seminar refer to Utility Investment Practice Seminar Final Report prepared by DYNATREND, INC., April 5, 1978.

Multiple Products - The provision for evaluating the uncertainty of multiple products within a firm affords several advantages. For example, within the cogeneration project, an electric utility implementing cogeneration would be producing two products, electricity and thermal power. The expenses and revenues associated with the sale of these products are intertwined such that evaluation of thermal power alone could produce misleading results. Another example of a situation where this feature would be of value is the integrated appliance project. One firm producing two complementary units (e.g., air conditioners and heat pumps) may exhibit lower levels of uncertainty by virtue of having more control over production levels and realizing economies of scale in the marketing/distribution aspects of the venture. Given the complementary nature of many BCS initiatives, this model feature will be of value in applications other than cogeneration.

Demand-Price Relationships - Fluctuations in demand for a product impact the unit price and vice versa. The RISK model allows the user to establish the relationship in the simulation for each product being considered. Therefore, policies affecting demand can be tested within the existing model structure.

Manufacturing Cost-Quantity Relationships - The costs of producing a product are highly dependent on the level of production.* Realization of manufacturing cost reductions due to higher production levels are common across most industries. Incorporation of this relationship in the model facilitates evaluation of a venture at varying production volumes. Therefore, the viability of building a plant with production capability above initial output

*Refer to the use of experience-learning curves in Appendix D.

requirements in anticipation of production increases at a later date can be evaluated.

Multiple Capital Expenditure Items - The capital requirements of any venture are typically composed of a number of items such as retrofit equipment and the distribution network in the cogeneration venture. Many times the uncertainty associated with each item is unique. Aggregation of all expenditures with only one uncertainty profile could mask major financial problems in a venture. Therefore, this feature can be employed to express capital expenditures individually, according to the level of uncertainty associated with each.

Depreciation Method - The choice of depreciation method varies across industries. Generally most firms select the depreciation method which will maximize their level of working capital. Four depreciation techniques are available: straight line; sum-of-the-years digits; double declining balance; or no depreciation. Each capital expenditure item can be linked with one of the available depreciation schemes.

Flexible Tax Structure - One of the more powerful roles BCS can assume in fostering commercialization of energy technology is encouraging tax policies favorable to the firm undertaking a conservation venture. Variations in corporate tax rates and investment tax credits provide the ability to assess the risk reduction impact of tax policies.

Business Situation - The business environment under which the venture will be conducted impacts the treatment of losses. The RISK model has three available business situations under which the venture can be simulated. They are:

- o Part of an existing corporation: Ventures conducted under the auspices of an existing corporation are assumed to have cash flows relatively small compared with the cash flow of the corporation as a whole. Ventures simulated in this environment have losses absorbed by the corporation. Therefore, losses are not carried forward but rather they are employed to offset profits produced from other ventures.
- o Partnership: Under the partnership environment the venture is simulated as a separate entity during the initial years when losses are incurred. The losses are absorbed by the investing partners to offset profits from other ventures. Once the venture under study becomes profitable, it reverts to a normal corporation.
- o Separate Corporation: The risk simulation is conducted as a normal corporation under this option, whereby all losses are carried forward and included in the determination of taxes.

The majority of all projects considered by BCS can be classified under one of the aforementioned business situations.

6.2 PROPOSED ENHANCEMENTS

Two immediate enhancements were proposed and subsequently implemented in the RISK model. First, the time horizon of the simulation was extended to twenty years. This facilitates not only the evaluation of ventures with long development and/or useful life time spans, but also permits evaluation of the energy savings over the same period.

Since one of the major reasons for BCS involvement in the development of technology is realization of energy savings, the

second modification provides risk profiles of the NPV of energy savings. Four energy types are included in the model: oil, natural gas, coal, and others (e.g., electricity), consistent with other BCS evaluation tools. Users specify the type(s) of energy to be saved by the technology and the minimum and maximum amounts of savings anticipated. Furthermore, energy savings are computed as a function of either annual or cumulative sales, at the user's discretion. A probability distribution is associated with the energy savings of each energy type for each year of the analysis. During the conduct of the simulation, energy savings are computed and stored in the same manner as other uncertainty variables in the model. A risk profile of energy savings is produced and can be plotted in a manner similar to the NPV of the venture. Table 6-1 illustrates the NPV of energy savings for the gas-fired heat pump venture at various discount rates. Since means and standard deviations of the energy savings NPV are also available, trade-offs between alternative BCS investment strategies can be performed as a function of risk.

As a result of the case study experience a number of enhancements are proposed:

Establish Default Values - The first is the development and implementation of default parameters for each generic industry category impacted by BCS. Currently, many variables have default values to facilitate the conduct of an aggregate level risk assessment. Although these default values were derived from the experiences of many firms, they could be further refined to reflect actual experiences of generic industry groups. Addition to default values for other industries such as the building materials industry, HVAC manufacturers, etc., would enable BCS to obtain aggregate risk analysis results with only a minimal amount of input data, yet simulated with parameters experienced by firms in the industry sector. The value of this proposed enhancement will be further discussed later in this chapter.

TABLE 6-1

BASE CASE
PRESENT WORTH OF ELECTRICITY ENERGY SAVINGS
(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

Low Speed Terminal Output - Development of an interactive version of the model with only summary reports would facilitate the evaluation of alternative investment strategies when employing the model for policy development/ analysis. Moreover, sensitivity studies could be performed more efficiently, and at a lower cost.

Graphic Risk Profile Output-- Currently, the user must transform the tabular risk profiles into graphical representations of the profiles. Graphic representations of the profiles are more readily interpreted and communicated to the decision maker. The reports available from the model should be expanded to include the option of graphic representations of the data. Programming and implementation costs of this enhancement are nominal and would significantly contribute to the effective communication of the risk analysis results.

Allowed Rate of Return Constraint (Discounted) - This improvement is also aimed at increasing the ability of the model to evaluate regulated ventures and to consider alternative regulatory constraints. The improvement would provide the capability of specifying allowed rate of return (i.e., the discounted return on investment or internal rate of return--that rate that makes the net present value equal to zero) on investment which would then be used to establish the appropriate price which could be charged and not exceed the allowable constraint. It should be noted that this constraint is not an annual constraint but measured over an extended period of time.

Competitive Pricing Constraint (Multiple Products) - This improvement is aimed at increasing the ability of the model to evaluate both regulated and unregulated district heating and cooling system (DHCS) business ventures. Multiple competitive products would be considered with

price forecasts input for each. The minimum price would result in a market constraint placed upon the pricing of thermal products from the DHCS. The market price constraint could be used in conjunction with the return on investment regulatory constraints to accurately model the regulated DHCS business environment.

Minimum Revenue Requirement Risk Model - This is a significant modification aimed at developing a risk model that simulates the utility minimum revenue requirements method computational procedures.

Segment Existing Model - The model consists of a large complex program. If additional modifications are to be made to this model it is highly desirable to segment the larger subroutines. This will significantly increase the efficiency with which modifications can be made to the model.

Energy Savings by Year - The model has been modified so that the risk profile of the present value of energy savings (by product and energy type) is established. The risk profiles, or at the minimum, the expected value and standard deviation of energy savings (by product and energy type) should be provided for each year of the time horizon. The energy savings computations need to be modified to accomplish this.

Sales Forecast Subroutines - Currently, the model requires input data to be provided in the form of a sales forecast (i.e., number of units sold as a function of time, including ranges of uncertainty). It is recommended that a sales forecast subroutine be developed that has two levels of capability. The first level of capability would allow the potential market to be specified (for example, number of residential units) in a disaggregated fashion together

with market penetration rate for the products in each market segment. These would be provided as uncertainty variables so that the resulting sales forecast would be in the form of a range of uncertainty together with the form of the uncertainty. The second level of capability would allow the sales forecast to be established in terms of user economics. The sales forecast, done at a disaggregate level, would take into account consumer economics in terms of annual savings and initial purchase price, and develop performance measures such as payback period. The sales forecast would then be related to the number of consumers having different payback periods where both the potential number of purchasers and the rate of purchase are related to payback period.

Allowed Rate of Return Constraint (Annual) - This improvement is aimed at increasing the ability of the model to evaluate regulated ventures. The improvement would provide the capability of specifying allowed annual return on investment, which would then be used to establish the appropriate price which could be charged and not exceed the allowable constraint.

6.3 APPLICATION OF THE METHODOLOGY

The risk analysis methodology can serve a variety of functions within BCS. In addition to its potential usefulness as a policy tool, the model can be a valuable resource in the conduct of the following BCS functions:

- o Project selection;
- o Funding strategy analysis;
- o Project in-process evaluation; and
- o Budget impact analysis.

For the most part, risk analysis also serves these functions in the private sector. Therefore, the suggested application of the methodology presented herein concentrates on integrating BCS risk analysis with the major decision points of the firm.

6.3.1 IDEA EVALUATION/PROJECT SELECTION

The formulation of new product ideas consistent with the firm's management objectives initiates the first stages of economic, institutional, and engineering evaluations. Discounted cash flow simulations based on preliminary engineering studies, market evaluations, and estimated sales volume are performed. The results of this simulation determine management's course of action. If the venture exhibits financial rewards consistent with the firm's objectives, including the range of uncertainty of key variables, the project will be supplied with the resources necessary to determine the production feasibility of the venture. At this juncture, the firm will also seek to identify the potential of obtaining support from the government if the effort is characterized by high risk and/or funding requirements beyond the resources available to the firm.

Any project proposed to BCS is currently evaluated according to a pre-defined project selection process. Components of this effort include the Threshold Evaluation System as well as the judgements of BCS technical and managerial support staffs. Projects successfully meeting the initial screening criteria are candidates for Federal funding. It would be appropriate to employ the RISK model once a project has passed the screening process, if one or more of the following conditions are true:

1. BCS and/or the firm's management perceive the risk associated with the project to be greater than the level commonly accepted within the industry.
2. The cumulative Federal investment requested for the project exceeds \$1,000,000.

3. The market place does not currently express a demand for the product, therefore sales levels are characterized by a high degree of uncertainty.
4. The firm lacks the internal resources to prepare a financial assessment of the venture.
5. The ratio of R&D costs to expected revenues is above current industry levels.

The RISK model can be used as the primary tool for formulating a final funding decision and specific funding strategies based on the major risk areas of the venture.

During the funding decision process, the model is most appropriately used in the aggregate mode. That is, default values should be employed whenever possible. This reduces the data collection burden and minimizes the level of effort expended. This will not reduce the accuracy of the analysis, especially if industry specific default values are employed (e.g., cost of sales, marketing expenditures, etc).

Evaluation of the model's output should focus on the following risk profiles:

- o Cash flow;
- o Indebtedness;
- o Payback period;
- o Present worth/rate of return; and
- o Energy savings.

Analysis of these profiles will identify the level of risk and target areas for Federal funding. Each can be interpreted in the following manner:

Cash Flow - The probability of the cash flow exceeding specified probability levels during each year of the venture is a measure of the financial requirements a

venture will place on a firm. Cash outflows are expected during the initial years of most ventures. However, their magnitude will determine the viability of the venture within the firm. Evaluation of the cash flow against measures of the firm's liquidity ratios will identify the magnitude of importance of the cash flow. Ventures with high cash requirements in a firm accustomed to low cash outflows represent one opportunity for BCS to reduce the venture's risk.

Indebtedness - The level of indebtedness at various probability levels measured against the firm's current level of debt will identify the need for financial assistance in the years before the venture begins realizing profits. Specific attention should be focused on the peak levels of indebtedness at various probability levels to determine the firm's ability to meet the debt requirements.

Payback Period - Many industries establish threshold payback periods. If the probability of meeting a firm's threshold value is low, risk reduction measures should be developed to offset the impact of long payback ventures. The nature of these measures must reflect the two aforementioned risk areas of cash flow and indebtedness. Expense items or capital expenditures having the greatest impact on elongating the payback period are ideal targets for BCS assistance.

Present Worth/Rate Of Return - The probability of a venture having an NPV equal to or greater than zero is the most important measure of risk and therefore of the venture's likelihood of being successful. Ventures with positive NPV's at 80-100% probability levels are more likely to succeed without Federal assistance. However, should the venture only meet NPV investment criteria at or below the 50% level, sensitivity studies should be performed to

determine the variable(s) having the greatest impact. Funding strategies aimed at reducing the risk of having an unfavorable NPV should focus on the key expenditure and/or market variable contributing to the variance in NPV.

Energy Savings - The BCS decision-maker must evaluate the probability of meeting or exceeding the project's energy savings goals. Changes in the position of the venture on the mean/standard deviation plane as a result of potential funding strategies will portray the impact of Federal funding. Measures which result in lower standard deviations and higher means reduce the government's risk of not attaining conservation goals.

The results of this evaluation provide BCS with the data required to develop risk reduction funding strategies. Knowledge of the key variables contributing to the project's risk premium and the points in time where they are most critical enable BCS to jointly prepare a capital budgeting plan with the firm.

6.3.2 FUNDING STRATEGY ANALYSIS

The formulation of specific BCS funding strategies is in many ways analogous to the capital budgeting process within a firm. Criteria are established to measure the worthiness of the venture, such as maximizing both the NPV of the venture and NPV of energy savings.

The outcome of a financial analysis, including risk, produces the level and timing of BCS funding. BCS at this point can introduce funding strategies aimed at the major areas of risk.

During the R&D stage, financial assistance to support that function provides the firm with two major benefits. First, removal of the R&D cost factor should improve the risk profiles for cash flow, indebtedness, and NPV. Second, the firm when

performing R&D under government contract can capitalize and defer their costs associated with the R&D effort (Reference 24). This is a significant advantage since all R&D costs of the firm must otherwise be charged to expense when incurred (Reference 24).

Funding strategies beyond the R&D stage should be linked with the technical development milestone schedule. Therefore, when the financial parameters are defined in greater detail as a result of R&D efforts, the financial simulation can be reiterated to determine their impact on risk. As the costs of production and market share are refined, for example, the range of costs and the probability distribution of each will be refined. This enables BCS to target funds and related project efforts on an incremental basis to the venture.

6.3.3 IN-PROCESS EVALUATION

The range of uncertainty associated with a venture should narrow as experience is gained in the effort. Systematic application of the RISK model to BCS projects in-process will measure the effectiveness of risk reduction strategies. This type of procedure has been routinely employed with the threshold system. Risk profile comparisons over the course of BCS involvement in a project enable quantitative assessments of a project's progress, and strengthen the justification for Federal funding.

6.3.4 BUDGET IMPACT ANALYSIS

The annual Federal budget cycle generates a wide variety of questions on the impact of additional funding within each project. Once an initial risk analysis has been performed, the introduction of potential additional funding into a project is relatively straightforward. Ventures can be simulated with BCS bearing part of the financial risk burden and risk profiles of each alternative can be evaluated for program impacts.

6.4 DATA REQUIREMENTS

In spite of the large number of variables with default values in the RISK model, the acquisition and validation of input data remains a major concern. For the most part, the data required for any risk analysis is viewed as being proprietary to the firm. This perspective is understandable since under normal circumstances (e.g. no Federal assistance) the information, if available to a competitor, could impact the firm's market share and ultimately the profitability of the entire venture. Clearcut solutions to this issue are not always available; however, several actions by BCS could serve to improve the availability and quality of financial data needed by the RISK model.

Among the measures to encourage the availability and exchange of data, the most efficient would be a contract data requirements clause. This mechanism, mentioned earlier in the report, would require the firm to disclose certain data items throughout the course of Federal involvement in the venture. Another measure would be the specification of a data coordinator within the firm to act as the primary contact point with the Planning, Analysis and Evaluation Branch. This would significantly reduce the level of effort expended on data collection by both the firm and BCS. Provision of assurance to the firm that the information would not be improperly used is very important. Establishing a contractual arrangement regarding the handling of data will ensure that both the firm and BCS are aware of the procedures to be followed in the protection of data made available by the firm.

Another approach to data collection and validation would involve the establishment of industry/government task forces in each generic industry impacted by BCS. Financial representatives of firms within, for example, the household appliance sector, would be brought together to define the financial parameters of key BCS projects. In addition to the collection and validation

of important financial data, these individuals could offer unique insights on the levels of risk acceptable to the industry. This would enable the establishment of risk behavior utility functions in each impacted industry.

The data acquisition issue is not insurmountable; however, it must be consistently reassessed to insure that BCS risk reduction funding decisions are based on the most accurate information available.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The importance of explicitly defining and quantifying the uncertainty surrounding the financial attributes of a venture must be acknowledged. Decision-makers in the private, utility, and public sectors have recognized the relative importance of such an analysis in venture decisions by their increasing interest in, and application of, risk analysis, especially in major investment decisions. The nature of uncertainty in potential and current conservation technology ventures gives further credence to the need for risk analysis when defining Federal policies and investment strategies. If conservation goals in the buildings and community systems sector are to be achieved, risk analysis must assume an important role in addition to other analytical tools employed by BCS.

The private sector has typically been hesitant to accept governmental assistance beyond research-oriented efforts for the development of new technologies. For the most part, this is due to the fact that private sector decision-makers have not viewed government actions as being sensitive to the firm's value model and the market forces which impact commercialization. The results of this study serve to minimize or alleviate government actions which are incongruent with the firm's value model. Representation of the BCS role within the firm's value model is one of the most important facets of the use of the risk model described in this report. It enables the government decision-makers to formulate, test, and implement policies within the value model. Through this approach the firm can be provided with the incentive to meet commercialization goals.

The available roles BCS can assume in risk reduction can be classified as technology push and technology pull actions (Reference 1). Abernathy and Chakravarthy define technology push actions as those policies and programs in which the government directly supports the development and/or modification of technology. Technology push actions can range from supporting the education of scientists/technicians in the particular technology to grants, subsidies, cost-sharing, and research, development, or demonstration contracts.

Technology pull actions focus on creating market conditions which will make adoption of the technology more feasible (in financial terms) given the characteristics of the firm's value model. Examples of such actions are tax incentives for or selected taxes on the consumer, regulations, and Federal procurement.

Abernathy and Chakravarthy found that in projects where the government felt that strong technology push activities were required to overcome major technological barriers, the presence or absence of corresponding technology pull actions determined whether or not the technology would be successfully transferred into general use. In projects where radical technological innovation was not required, the government has more freedom to select its desired approach (Reference 1).

Application of the risk model enables the decision-maker to test intense and weak technology push and technology pull actions, as well as combinations of these actions, to determine their impact on the venture's success and therefore to determine the optimum policy to follow.

The adoption and future application of risk analysis by BCS is viewed as beneficial for many other reasons. The conduct of a risk analysis encourages a more thorough analysis and appreciation of the financial parameters of current and future projects.

Most economic analysis tools available to BCS employ highly aggregated data which could inadvertently miss one or more major obstacles to success. Through the definition of individual expense and revenue items, within the structure of the firm's value model, major uncertainties in the timing and magnitude of resource requirements can be identified for BCS policy action.

Risk analysis also serves as a means of evaluating program progress. The impact of BCS policy on risk can be quantitatively assessed by constantly refining the input parameters to reflect the experience gained over time. Therefore, as the range of possible values for a venture's uncertainty variables is narrowed as a result of BCS policy, progress can be measured in terms of improvements to NPV, rate of return, and energy savings goals, which will serve to optimize Federal expenditures.

As a result of this study, it was concluded that the collection of data for the analysis will prove to be the major obstacle to effective and timely application of the procedure. The basic attributes of the firm's value model are usually available; however, acquisition of specific expenditure and revenue patterns proved difficult. Although enough information can be collected to construct a valid base case, greater cooperation from the firm and personnel charged with other technical/engineering tasks would significantly improve the entire risk analysis process.

7.2 RECOMMENDATIONS

Seven specific recommendations are offered as a result of this study. The recommendations are geared toward improving and streamlining the risk analysis procedures:

1. Perform a risk analysis on the largest project within each BCS branch. Establishment of a base case and associated risk analysis for the major investment in each branch will

enable BCS management to readily test alternative funding strategies and new policies. Once the base case has been verified and evaluated, policy studies are straightforward and easy to implement.

2. Task the firm sponsoring the major project within each branch with a review of the base case data and assumptions. Through such a review, BCS can obtain more detailed input from the firm. Moreover, this action will encourage the firm to initiate a continuing dialogue with BCS on the project's financial parameters with respect to its value model.
3. Evaluate the trade-offs of alternative data collection procedures and implement a standard procedure for obtaining the financial and technical data necessary to perform a risk analysis, as well as other economic evaluation procedures employed by BCS. This effort should include a survey of methods employed by other DOE entities such as the Assistant Secretary's Office of Planning, Analysis and Evaluation. Selection and implementation of data acquisition policy would enhance the knowledge base of BCS management.
4. Establish industry task forces in each of the generic industry categories impacted by BCS. Each task force, composed of financial and technical representatives of firms engaged in BCS projects, would be charged with two tasks:
 - o Development of risk model default values which represent the general characteristics of the value models of firms in the industry.

Incorporation of such default value models in the risk program would facilitate the conduct of a risk analysis without extensive data collection effort.

- o Establish a catalog of industry hurdle rates for the evaluation of risk profiles.
- 5. Given the comprehensive scope of BCS actions to encourage conservation (technical/engineering, consumer motivation, standards), develop decision tree techniques to evaluate the potential outcome of interrelated decisions. This effort would be directed toward optimizing the mix of technology push and technology pull actions.
- 6. Initiate a study of capital market behavior toward conservation investments. In addition to an evaluation of the criteria employed by capital markets, and the costs of capital, the impact of various Federal roles on capital market behavior should be explored. Therefore, BCS policies can encourage private sector participation in risk reduction/sharing programs.
- 7. Incorporate the remaining recommended model enhancements to further improve the viability of the model in the BCS setting.

Implementation of the recommendations coupled with efforts to familiarize branch personnel with the importance and potential uses of risk analysis will result in more informed decisions and a higher probability of meeting conservation goals.

APPENDIX A
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APPENDIX B

GLOSSARY

AFTER-TAX PROFIT

The level of monetary rewards received from the sales of a product (revenue less expenses) adjusted to reflect corporate income taxes, investment tax credits, and any losses carried forward from previous time periods.

ASSETS

Resources of the firm, including capital, such as plant and equipment, which have some future benefit in use and whose value can be expressed in monetary terms.

BALANCE SHEET

A report on the financial position of a firm at one particular point in time which identifies the adjusted historical costs of the firm's resources which are available for future use. For example, if an existing manufacturing plant is to be employed in a new venture, the venture must consider any costs incurred for the use of that facility, such as depreciation expenses.

BEFORE-TAX PROFIT

The remainder of revenues less expenses reflecting the level of rewards received from the production and sales of a product.

CAPITAL

In economic terms, capital is the stock of machines, plant, equipment, etc. employed in the production of goods. Accountants, however, refer to capital as the amount of equity the stockholders or owners have in the firm. Within the context of risk analysis, the later definition is most often employed since the focus is on the level of investment required to support the plant and equipment needs of a venture.

CAPITAL BARRIERS

Obstacles to the acquisition of capital in support of a venture. Most often, these barriers are related to high risk levels. An example would be abnormally high interest rates.

CAPITAL BUDGETING

The process of planning for investment decisions which defines the level of resources required and the financing required for a project.

CAPITAL MARKETS

Sources of finance to support planned investments.

CASH FLOW

Revenue less total expenses adjusted by taxes, capital expenditures, and changes in balance sheet items yields annual cash flow. Negative values denote a cash outflow where the firm expends funds and a positive cash flow indicates funds are flowing into the firm.

COMMERCIALIZATION

The process of producing and introducing a new product for sale in the marketplace.

COST OF CAPITAL

The rate of return required of an investment to justify the expenditure of funds in anticipation of future rewards.

DECISION ANALYSIS

The systematic process of defining all future events and actions which can affect the investment decision.

DEFAULT VALUE

The value which will be assigned to a variable if a specific value is not specified.

DELPHI TECHNIQUE

A forecasting procedure which collects data from a group of individuals unaware of each other's response; presents statistical summaries of the group's responses; and resolicits data from each individual until the group reaches a consensus. The procedure attempts to remove the impact of dominant personalities

and/or biased opinions to arrive at a more objective conclusion.

DEPRECIATION

The allocation of the cost of an item with a long-term life over its economic life. Common depreciation techniques are:

Straight-line: Costs are allocated equally over the economic life of the asset.

Sum-of-the-years-digits: A larger amount of an asset's costs are allocated during the first half of its economic life than the second half.

Double-declining balance: The majority of the costs are allocated during the first few years of the asset life without consideration of the asset's salvage value.

DISCOUNT RATE

The average weighted cost of capital committed to the venture under consideration.

DISCOUNTING

The process which determines the present value of money in the future. For example, a bank account with a balance of \$10 five years from now with 5% interest has a present value of \$7.84.

ECONOMIES OF SCALE

Efficiencies which result from the producer having the proper proportions of land, labor, and machinery to meet a given market.

EXPENSES

Any charges or costs incurred in the conduct of business.

FIXED COSTS

A cost which does not vary with changes in a firm's output over the short run. Fixed costs would remain even if there were no output, since they are associated with the existence and maintenance of the firm's facilities. Rent, interest payments, depreciation, plant and equipment are commonly classed as fixed costs.

GENERAL & ADMINISTRATIVE
(G&A) EXPENSES

Expenses such as general office, accounting, personnel, and credit and collection expenses which are not incurred in the production of a product.

INDEBTEDNESS

The total amount of outstanding debt incurred by the firm.

INNOVATION

A new or different method of doing something or obtaining a result. Usually a means of increasing productivity or providing a superior product.

INTEREST

The price paid for the use of money over a period of time.

INTERNAL RATE OF RETURN

The rate of interest that produces a net present value of zero such that the present value of the cash flow is equal to the initial outlay.

LIQUIDATION

The process of selling assets such as inventories or securities in order to achieve a better cash position. The term also refers to the termination of a business by converting its assets to cash, paying its liabilities, and distributing the residue among the stockholders or partners.

MARKET

The demand or potential demand for a given product or commodity.

MARKET SHARE

The ratio of a company's sales, in units or dollars, to total industry sales, on either an actual or potential basis for a specific time period.

MEAN

The statistical representation of central tendency or average. It is the sum of individual values divided by the number of observations.

MEDIAN

The median is the value of the middle item when the items are arranged according to size. If there is an even number of items, the median is taken as the arithmetic mean of the values of the two central items.

MONTE CARLO TECHNIQUE

A simulation technique which models uncertain (stochastic) quantities. A large number of potential (probabilistic) outcomes are simulated within constraints established by the investigator to identify the most likely set of results expressed in statistical terms.

NET PRESENT VALUE

The current value of a future stream of cash inflows and outflows at a specified rate of interest (discount rate).

NET PRESENT WORTH

(See Net Present Value.)

OPPORTUNITY COSTS

The value of the productive resources used in producing one good instead of another good.

OVERHEAD

All production costs other than for direct materials and direct labor.

PAYBACK PERIOD

The amount of time required for the cash inflows of an investment to pay back the initial outlay.

PORTFOLIO

A group of investments often selected to complement each other and maximize the objectives of the investor.

PRESENT VALUE

The amount of funds in current dollars which will produce a future value at a given level of interest.

PRIVATE SECTOR

Organizations engaged in business with one of their primary objectives being the realization of a profit on the product or service produced by the organization.

PROBABILITY

The existence of a regular pattern underlying the results of a random selection of events of a particular universe.

PROFIT

The amount left over after a business enterprise has paid all its bills.

PROGRAMMING SYSTEM

A set of computer instructions which enables users to concentrate on only the core mathematical routine. Therefore, data input, data handling and report generation functions are preprogrammed.

PUBLIC SECTOR

Organizations with goals aimed at improving public welfare. Thus, they do not have profit as a primary goal.

R&D

According to the NSF, the basic and applied research and engineering, as well as the design and development of prototypes and processes undertaken by business, governmental and non-profit organizations.

RETURN ON ASSETS

A measure of the monetary productivity of the capital components of a venture.

RETURN ON EQUITY

The level of monetary rewards in a venture from the owners and/or stockholders investment (equity) in the venture.

RETURN ON INVESTMENT

The profit earned in relation to the value of the capital required to produce the profit.

REVENUES

The total income of an operation.

RISK

The determination of the probability that key measures of performance of a venture, such as profit, cash flow, and present value, will exceed specified values.

RISK ANALYSIS

A systematic quantitative or qualitative procedure for determining the potential outcomes of a business venture.

RISK PROFILE

A probability distribution of a financial figure of merit produced from a Monte Carlo risk analysis which identifies the chance of the figure of merit exceeding various values.

RISK REDUCTION

Any action which narrows the values of potential risk elements in a venture. Within a Monte Carlo risk analysis the decrease of the standard deviation of a financial figure of merit represents a reduction of risk.

RISK SHARING

The process of allocating the level of risk inherent in a venture to more than one participant.

SALVAGE VALUE

The residual value in an asset which is no longer useful for its intended purpose, but which has more than scrap value.

SENSITIVITY ANALYSIS

A systematic process of determining the changes in the results of a model to changes in input parameters.

SIMPLE RATE OF RETURN

The rate of monetary returns on an investment ignoring the time value of money.

SIMULATION

The symbolic representation of a series of events in mathematical terms to replicate reality.

STANDARD DEVIATION

A statistical measure of the dispersion of values about the mean of a variable. It is the square root of the variance.

SUBJECTIVE PROBABILITY

The definition of an underlying regular pattern of events based on an individual's or group of individuals' judgements.

TANGIBLE NET WORTH

The equity in a business, figured only on the basis of tangible assets.

UNCERTAINTY

The indeterminate nature of input values for risk analysis which is represented by a probability distribution fitted to the range of possible values associated with a given input parameter.

UNIT SALES

The total number of units sold in the marketplace.

USEFUL LIFE

The period of time in which a product performs its designed function.

UTILITY SECTOR

Organizations operating as private businesses providing a public good under the control of a public regulatory body.

UTILITY THEORY

The quantitative procedure of defining an investor's propensity to accept risk.

VALUE MODEL

The financial, economic, and philosophical parameters within which a firm makes investment decisions.

VARIABLE COSTS

Costs incurred by the firm which vary according to production level.

VARIANCE

A statistical measure of how closely individual values cluster around the mean. It is the average of the squares of the deviations of each of those values from the mean.

VENTURE

A business situation which requires an outlay of funds in order to receive benefit at a future point in time.

VENTURE ANALYSIS

The systematic process of determining the potential benefits of a business venture given the level of investment required of the firm.

WORKING CAPITAL

Funds generated internally within a firm available for capital investments.