Quantifying the Hurdle Rates United States Industry Places On Energy Efficiency Opportunities

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ABSTRACT

Investment in energy efficiency by the United States' industry has long been recognized to lag most European and some Asian countries. Significant barriers have often been imposed so only the projects with the shortest, near-term gain and the least risk have been implemented. In an attempt to understand this phenomenon, we have undertaken a study of over 39,000 energy efficiency recommendations made by the Department of Energy's Energy Analysis and Diagnostic Centers (recently renamed Industrial Assessment Centers), located at universities throughout the United States to further understand this situation.

We present evidence that the industrial capital budgeting process holds energy efficiency investments to a stricter investment standard than other capital projects. It also appears energy efficiency investments are further differentiated among themselves by the extent it could affect the manufacturing process and whether the investment will result in the conservation of electricity or fossil fuel. We believe hurdle rates as high as 50% are used to evaluate energy saving recommendations, especially when they directly affect the manufacturing process. It also appears that fossil fuel energy saving recommendations have an additional 30% risk premium when compared to electricity saving recommendations. We suspect the link between the fuel used and the manufacturing process that suggests a causal relationship relating to this apparent fuel-dependent risk premium.

Introduction

The Energy Analysis and Diagnostic Center (EADC), was formed by the Department of Energy (DOE) to address the relative inefficiency of the United States industrial manufacturing base. Their mission was to provide free energy analysis to companies that may not have had staff dedicated to energy efficiency issues, and/or could not afford to hire consultants specializing in energy efficiency. The EADC's have recently been renamed the Industrial Assessment Centers (IACs) and now have the added responsibility of recommending production material waste minimization options.

Since 1976 over 39,000 recommendations have been made to small and medium sized manufacturers in SIC codes 20 through 39 by IACs located at universities throughout the United States. An examination of these recommendations shows approximately 50% have been implemented within the three years of being made. A database has been maintained that contains extensive information on the recommendations made and implemented, the customer, fuel-type conserved, economics and many other variables important to understanding the energy saving opportunities. Although we do not know what, if any quality control has been exercised to prevent bias from being introduced into the database, we believe the sample size is large enough for meaningful research.

We have undertaken a study of the recommendations made and implemented to determine if a causal relationship can be found between the recommendations, the fuel source conserved, and the end-use affected in order to quantify the hurdle rate premium United States' industry applies to energy efficiency investments.

Capital Budgeting Concepts

It may be helpful to first discuss the general concepts of capital budgeting before discussing our analysis. The capital budgeting process is usually an annual process in which companies decide how to allocate their financial resources to the various competing needs of the organization. Formally, capital budgeting is the allocation of corporate equity and/or obligation (usually via debt) for an asset that is expected to produce wealth for the shareholders.

While there are many ways in which the decision to allocate funds are made, it has been generally accepted that investments which provide the greatest positive Net Present Value over the life of an investment are those which should be implemented. However, it is well known that other assessment methods are used. Many surveys of small to large businesses show Simple Payback (SP), Return on Investment (ROI), Internal Rate of Return (IRR), and Net Present Value (NPV) are used to varying degrees. Simple Payback appears to be used by most businesses as the only analysis tool for financial decision-making, or at least as a screening tool used in combination with more sophisticated financial analysis tools [1]. A survey of companies participating in lighting upgrades found that thirty-eight percent relied solely upon SP to make investment decisions, while seventy-eight percent of the companies used SP as at least a component of their investment decision-making process. Forty-six percent of the survey respondents incorporated some form of discounted cash flow analysis including IRR, which was used by 25%, ROI, which was used by 26%, and NPV, which was used by 19%. [2]

Implicit in many capital budgeting processes is the prioritization of alternatives based upon the perception of risk versus reward. A risk factor is applied in some manner, usually in the form of an added premium to the company's standard investment hurdle rate. Often the value of this factor is not empirically derived as various agency factors enter into the evaluation process. Examples of agency factors include the proposal's potential effect on the manufacturing process, whether it has a high-level corporate champion, if those responsible for the analysis are also the decision makers, etc.

For those who use SP as the sole decision-making tool, the risk factor may manifest itself through a policy where capital expenditures affecting the manufacturing process requires a two-year payback, while those affecting building and grounds may require a three-year payback. Implicit is management's decision that any recommendation affecting the manufacturing process must display an exceptionally high return to justify the potential risk of negatively affecting the currently acceptable process.

If a company uses a discounted cash flow decision-making tool such as NPV, the risk factor attributed to the analysis takes the form of changes to the discount rate. Mathematically, the NPV calculation is expressed as:

$$NPV = \left[\sum_{t=1}^{n} \left[E(CF_t)/(1+k_{DR})^t \right] \right] - I_0 \qquad (1)$$

where:

$E(CF_t)$ = expected cash flow at time t
k_{DR} = discount rate at time of investment, or required rate of return
I_0 = investment cost of project

The cash flows are summed over the n time periods, where n is the life of the investment, and are assumed to occur at the end of the time period.

Examination of this equation shows NPV of the project can readily be affected by varying the discount rate. In an ideal application of capital budgeting theory, the discount rate should be the company's cost of capital in a perfect market. However, this value is rarely used. Instead, the discount rate is changed either through rigorous analysis or other means to reflect the perceived or real risk of the project. The risk premium, k_{RP} is added to the discount rate, k_{DR} such that:

$$k_{DR}' = k_{RP} + k_{DR} \qquad (2)$$

If no risk is attributed to the project, $k_{RP} = 0$, and $k_{DR}' = k_{DR}$.

The NPV equation can be rewritten to incorporate these factors in the following manner:

$$NPV = [\sum_{t=1} [E(CF_t)/(1+k_{RP}+k_{DR})^t]] - I_0 \qquad (3)$$

Raising the risk premium will have the effect of decreasing NPV such that NPV may become negative, indicating the project should not be implemented. The most difficult part of estimating the economic viability of any project is determining the periodic cash flow that results from the investment. A large number of factors can affect the NPV calculation. As the number of factors increase, the complexity and chance for error will most likely increase, translating into expectations not being realized. Generally, one will find cash flows involving energy efficient investments are either increasing at a constant rate or are held positive at a constant value. Simple Payback and Internal Rate of Return can be useful for determining the economic viability of such investments, but they do not necessarily lead the organization to maximize wealth, as they would using NPV.

Net Present Value and SP can be related to each other if one is willing to assume personnel using SP are knowledgeable of the life of the investment. Figure One relates SP and NPV at two different investment lives: five and ten years.

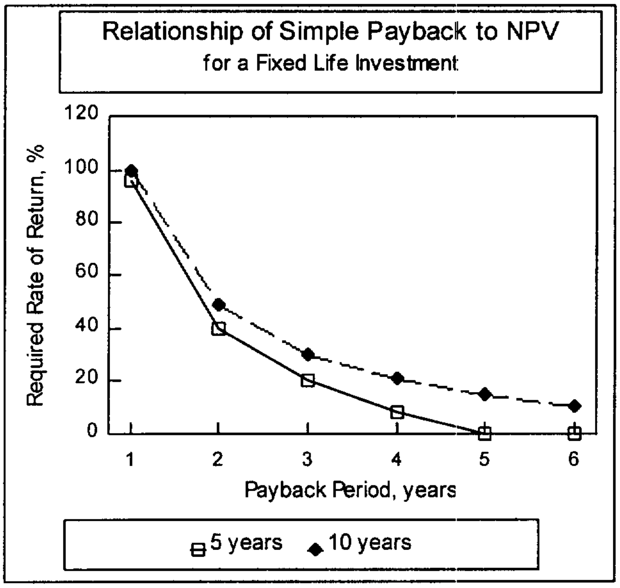

Figure 1. *Relationship of Simple Payback to NPV for a Fixed Life Investment*

This graphs shows that the longer an acceptable simple payback is, the lower the discount rate or required rate of return is in order to maintain positive NPV. This methodology can be used to estimate the required rate of return if the required SP is known. Note that a five year required simple payback for an investment with a five year life shows the required rate of return is essentially zero. This makes intuitive sense and further demonstrates that the simple payback perspective does not consider the time value of money.

Possible Influence Factors Contributing to the Recommendation of Energy Saving Measures

Fuel-Type Influence

It has been our experience those energy conservation opportunities that save electricity are more likely to be implemented than those saving fossil fuel. This could be for at least two reasons: 1) more attractive economics, or 2) less possibility of failure to realize the calculated economic benefit (which transfers into less risk). We contend most engineers will confirm it is easier to calculate the savings from end-uses utilizing electricity than fossil fuel. The operating characteristics of an electrical device is more easily quantified, understood, and measured, thus making the energy saving calculations more precise and hopefully more accurate.

We initially ran extensive analysis on the database to determine characteristics that could provide valuable insight to the recommendations made and implemented. Germane to this research was the observation that 70% of the recommendations made were to conserve electricity. A low percentage of recommendations were made to conserve #2, #4, and #6 oil. Oil comprised only 2.1% of the total number of recommendations, while natural gas involved 25% of the recommendations. This may be the result of large-scale conversion from oil to natural gas throughout the United States where the gas supply is reliable and relatively inexpensive throughout the year, or may have regional characteristics that we did not explore. Table One shows the distribution of the recommendations made by the fuel type conserved.

Table 1. Percentage of Recommendations by Fuel Type Affected

Fuel Type	Percent of Total
Electricity	71.3%
Natural Gas	25.0%
Oil #2	1.2%
Oil #4	.4%
Oil #6	.5%
LP Gas	.6%
Other	1.0%

It is important to note that economics drives the selection of utilizing one energy source versus another in the manufacturing process. An example of this is the use of gas, oil or wood to produce steam, which in turn is used to dry newsprint paper. Traditionally, newsprint is a commodity product with a low profit margin. Therefore, the large amounts of thermal energy used in the drying process must provided at a low cost. Oil, gas or wood are typically lower-cost energy sources than electricity on a cost per energy unit value basis (such as $/MMBTU). Since accurate and precise temperature control is not required to produce acceptable quality newsprint, the solution has been for many years to employ steam drum dryers with gas, oil or wood as the energy source used to produce steam. Although they do not allow accurate and precise temperature control in the way that electric dryers would, the cost of using electric dryers can not be recovered in the selling price of the product.

Consider an alternative situation that necessitates utilizing a higher cost energy (electricity) for an industrial process such as precision injection molding. In order to produce superior molded products, close temperature and time control tolerances in the heating process are required. This can most reliably be obtained with molds that utilize electric heating bands (versus a fossil fuel derived heated mold). The selling price versus cost calculation shows the incremental income is greater for the higher quality product utilizing electric heating. Therefore in this example, the economic motivation is to utilize a higher cost energy source to produce the higher quality product.

For this reason, looking solely at the energy used in a given process and not linking it to the end use or the product can be misleading. Failure to account for this interrelationship would otherwise cause us to be concerned at the lack of gas or oil lighting energy saving recommendations in the IAC database.

End-Use Influence

We define the industrial process as an activity by which a commodity is made that can either be sold or used as a component in a subsequent process that can later be sold. Basically, it is the thing or things that allow the company to continue as a going concern. Recommendations in the IAC database are coded as to whether they affect process, non-process, or building and ground systems. These are defined as End-Use Application Codes.

We have observed that energy saving recommendations directly affecting processes are less likely to be implemented than those recommendations which affect other end-use applications.[3] We believe this is because process-related recommendations implicitly have a higher risk factor when compared to other end-use applications. The benefit of improving a process's energy efficiency is often valued less than the cost of negatively affecting a process in some manner via an effort to improve the process's energy efficiency. Because the individual and corporate ramifications of a failed (non-economic) process-related recommendation can be severe, the risk premium is high for these types of recommendations.

Table Two illustrates the frequency distribution of the End-uses as recommended and implemented. Process related measures in the database were implemented at a 2.3% lower rate than recommended. IAC recommendations that were Process-support, and Building and Grounds oriented were implemented at least as often as recommended. Certainly, the percentage difference between Recommended and Implemented recommendations is small. However, we think Table Two helps substantiate our contention that process-related recommendations are perceived by American industry as more risky, and are less likely to be recommended and installed.

Table 2. Application Code Frequency Distribution

End-use Application Codes	Recommendation	Implemented
Process	24.6%	22.3%
Process Support	35.0%	37.4%
Building and Grounds/Infrastructure	39.4%	39.6%
Miscellaneous	1.0%	.7%

Assessment Recommendation Codes (ARCs)

The IAC database uses a four-digit field to identify the energy conservation recommendation. This four-digit field is known as Assessment Recommendation Codes (ARCs). ARCs are descriptive of the energy saving action recommended. Similar to Standard Industrial Classification (SIC) codes, ARCs become more precise with an increasing number of digits. ARCs by definition usually imply the fuel-type conserved, and can be used to further examine energy saving preferences. (The list of ARCs is quite long and we chose not to include it here.)

Table Three contains the top five recommended and implemented ARCs, which are all electrical energy saving recommendations. Boiler Maintenance, which in our opinion is a recommendation with a good track record of accurately predictable savings, failed to make the list of five frequent recommendations. It was the seventh most recommended energy conservation measure (3.9%), though the fifth most implemented (4.9%) measure. Even though boiler energy efficiency recommendations are fairly well understood, electrical energy conservation measures are still more frequently recommended and installed.

Table 3. Most Frequent ARC Recommendations by End Use at Three Digit ARC Level

Recommended			Implemented		
Code	Description	Percent of Total, %	Code	Description	Percent of Total, %
714	Lighting Hardware	16.0	714	Lighting Hardware	17.5
421	Air Compressor Operation	8.0	421	Air Compressor Operation	10.0
412	Motor Hardware	7.3	412	Motor Hardware	8.1
411	Motor Operation	5.4	411	Motor Operation	5.8
422	Air Compressors Hardware	5.2	422	Air Compressors Hardware	5.3

Determination of the Risk Placed Upon the Fuel-Type Conserved

We analyzed a number of possible links among the variables in the database to discover the preferences made by industry to save energy. We believe the data shows process-related recommendations are not made and implemented as often as non-process related recommendations. We also believe the data shows electricity recommendations are made more often and implemented more often than fossil fuel saving recommendations. This in of it self does show that there is necessarily an unexpected bias. We decided to seek out a variable that should theoretically show preference for a recommendation regardless of the fuel type saved or which part or the plant was affected. We found simple payback to be the most useful variable in the database for this purpose. One should expect measures with the same simple payback to have the same implementation rate unless more sophisticated financial analysis are used. (As discussed earlier, simple payback is still used by the large majority of American businesses.)

We contend the hypothesis that industry prefers to invest in electricity conserving opportunities is furthered strengthened when the implementation of recommendations is analyzed as a function of simple payback. We grouped the data into either fossil fuel saving or electricity saving recommendations, and then plotted their implementation as a function of simple payback. Once the SP was beyond one year, we found electricity saving recommendations to be implemented at a rate greater than fossil fuel saving recommendations for the same payback. Figure Two is the normalized graph of these phenomena from the data.

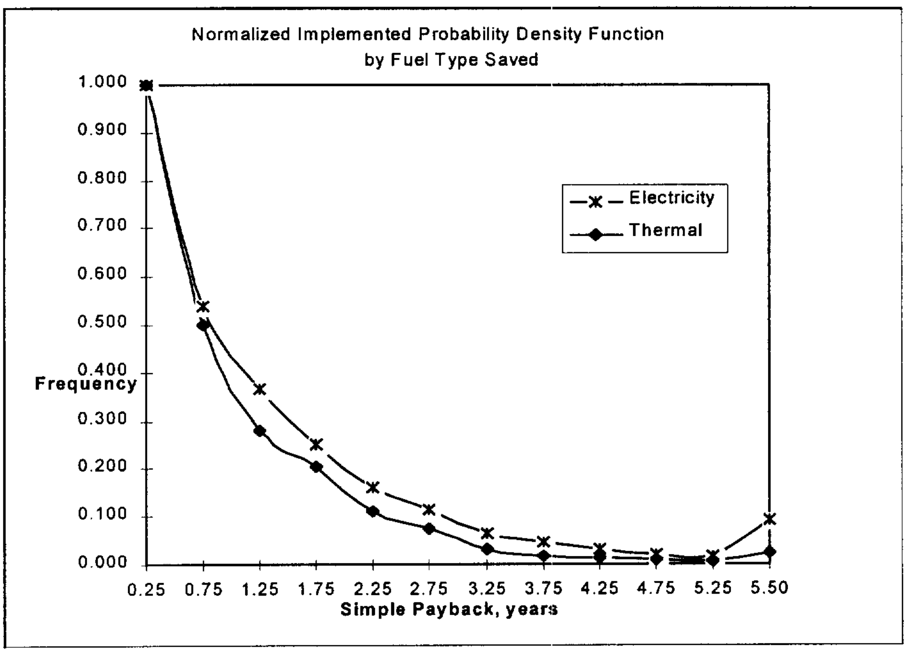

Figure 2. *Normalized Implemented Probability Density Function by Fuel Type Saved*

Adding the data point percentage difference between electric and fossil fuel normalized implementation rates to Figure Two leads us to conclude that in order for electricity saving recommendations to be implemented at the same rate as fossil fuel energy saving recommendations, electricity saving recommendations require approximately a 25% to 33% greater return. Figure Three contains the data point percentage difference line and its linear regression.

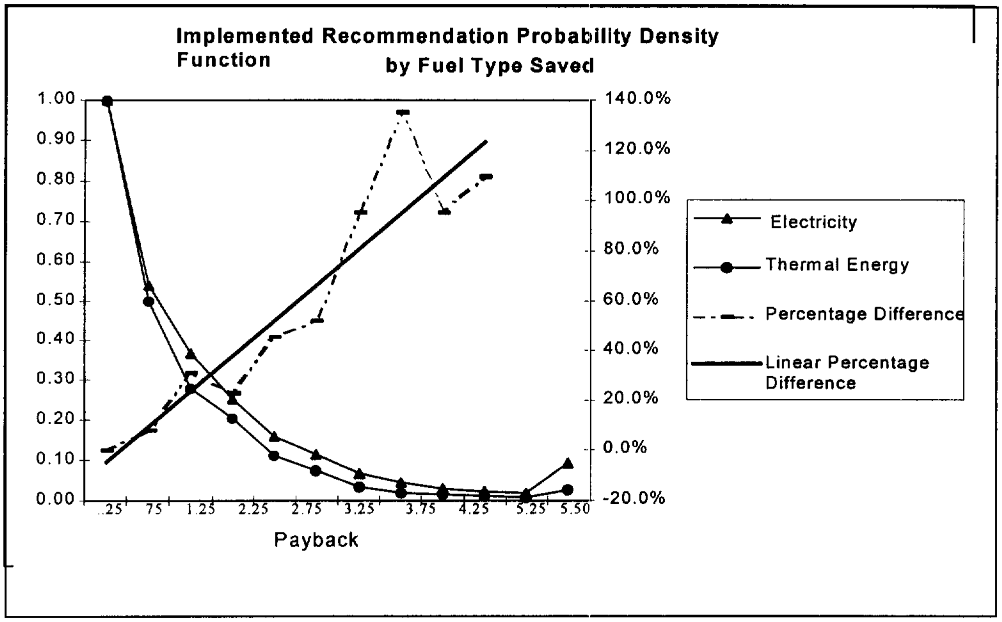

Figure 3. *Implemented Recommendation Probability Density Function by Fuel Type Saved*

The need for fossil fuel energy to have a greater return is most pronounced for paybacks beyond .75 years. There appears to be little difference in the implementation frequency of recommendations with paybacks shorter than .75 years as a function of fuel saved. This is mostly likely due to these recommendations being expensed from the operating budget rather than being implemented as the result of a capital expenditure.

We developed mathematical expressions for the implementation rate of each of the fuel dependent curves as a function of simple payback. Figure Four shows the curve fit for electricity saving recommendations, while Figure Five is for fossil fuel saving recommendations.

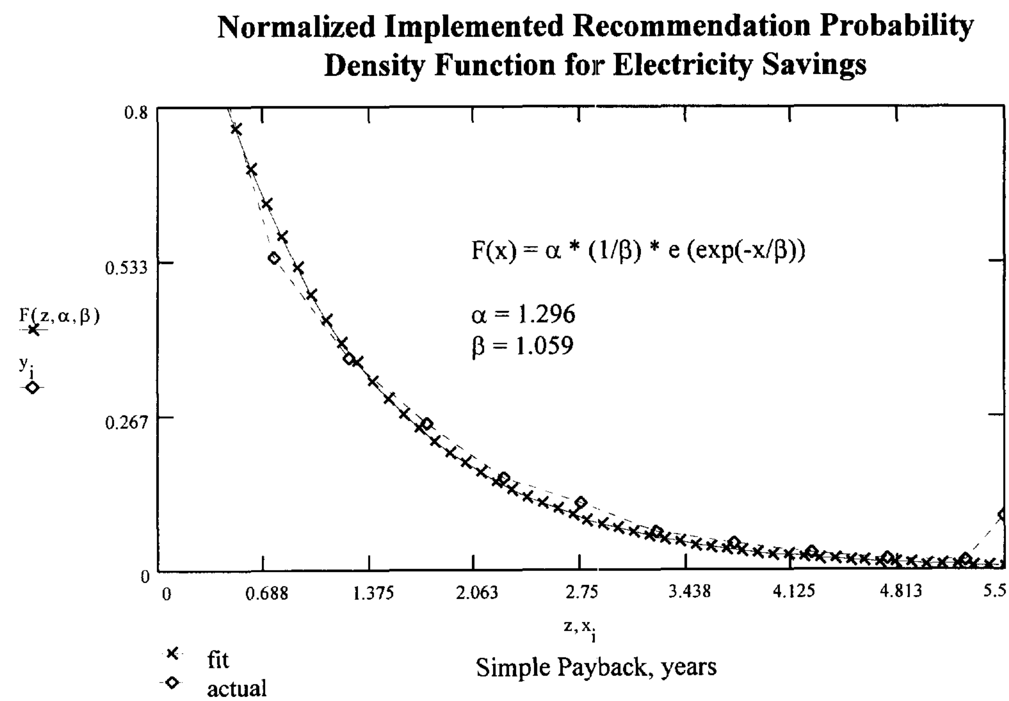

Figure 4. *Normalized Implemented Recommendation Probability Density Function for Electricity Savings*

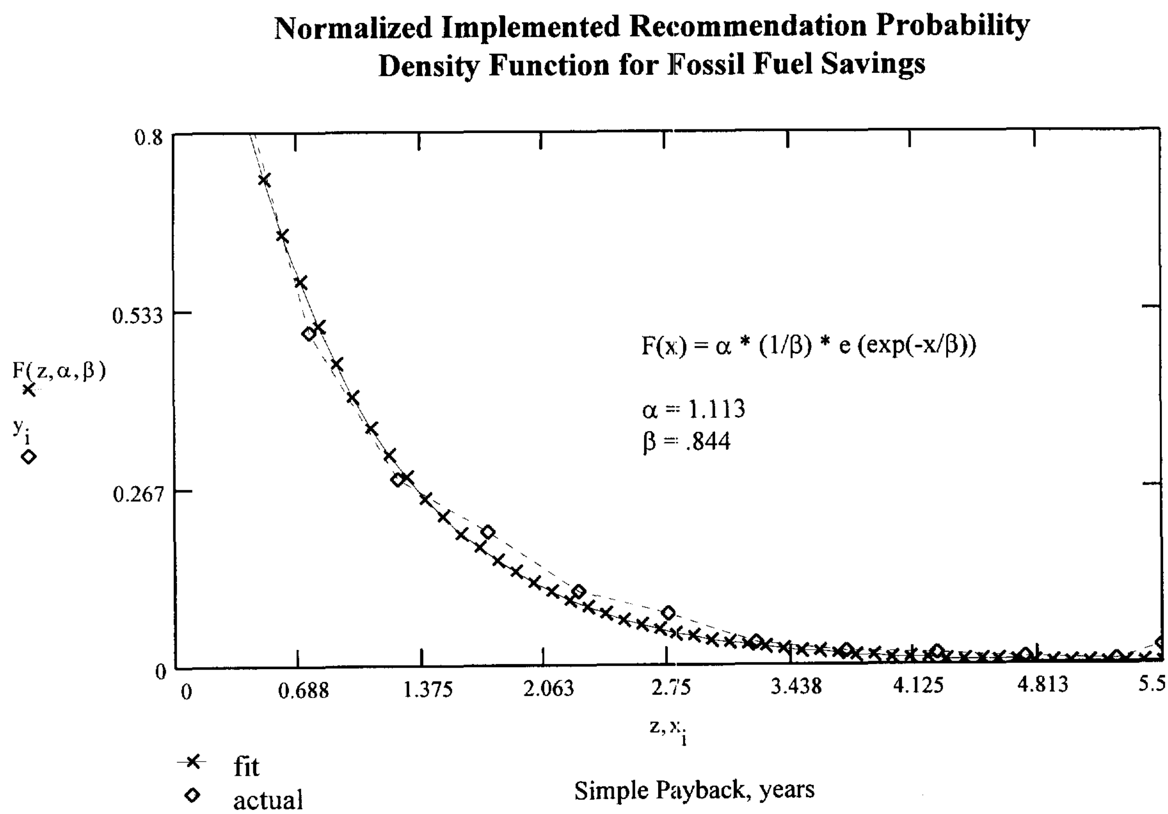

Figure 5. *Normalized Implemented Recommendation Probability Density Function for Thermal Savings*

The curves take the form of:

$$F(x) = \alpha * 1/\beta * e\,(\exp(-x/\beta)) \tag{4}$$

Table Four contains the constants for each fuel type saved.

Table 4. Constants of the Equations Describing the Recommendation Implementation

Probability Density Functions

$F(x) = \alpha * 1/\beta * e\,(\exp(-x/\beta))$	α	β
Electricity	1.296	1.059
Fossil Fuel	1.113	0.844

Characteristic Curve Risk Assessment

We would like to introduce the hypothesis that Figures Four and Five also relate the concept of risk in a form different from, but in concept similar to, Standard Deviation. A steeply sloped curve in Figures Four and Five would indicate high risk associated with the probability density function as longer simple payback recommendations would be instituted with relatively small frequency. Conversely, flat curves would show less difference in the implementation of recommendations based upon simple payback. We argue that if simple paybacks do not significantly alter the rate of implementation of recommendations, then industry does not discriminate between paybacks of differing length.

To illustrate this concept, let's assume we have investors A, B, and C who are presented with exactly the same range of investment choices and are financially identical with the same capital structure, balance sheet, income statement and cash flow statement. This being the case, one would assume the function representing implemented recommendations requiring a capital budgeted item as a function of simple payback will be the same for all three. However, because there will be a difference in the perception of risk among A, B, and C, there will be three different curves as risk will cause differing rates of implementation of the recommendations. Figure Six illustrates this concept.

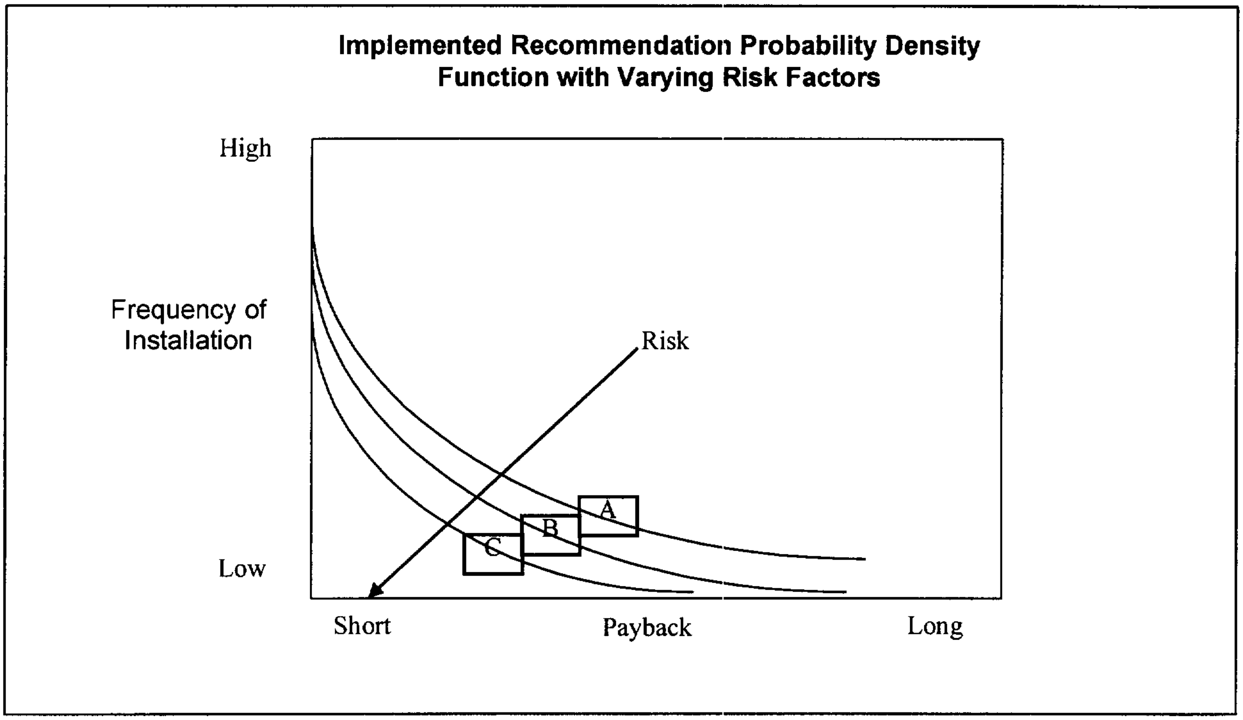

Figure 6. *Implemented Recommendation Probability Density Function with Varying Risk Factors*

Curve A is indicative of a relatively high frequency of recommendations with long paybacks being implemented. The curve is the least sloped and continues furthest to the right on the Payback axis. Acceptance of longer paybacks indicates an investor with the perception that the investment has low risk. Curve B shows less willingness to accept longer paybacks, as the frequency of implementation drops off more rapidly with the increase in the length of payback. Curve C displays characteristics of the most risk, as the curve is most steeply sloped, showing the smallest number of investors implementing recommendations for a given payback. This indicates Curve C decision-makers are most risk adverse.

A review of corporate capital structure and investments indicates the discount rate for most businesses receiving IAC services is somewhere between 22%-28%. Please note though, every company and industry will have its own investment criteria characteristics. Fast-growth industries have a much higher requirement, while most established industries have lower requirements. As we can see by Figures One, Four and Five, investment tails off at a 2 year SP, or approximately a 40% discount rate for investments with a five year life, and 50% discount rate for investments with 10 year life.

Conclusions

We believe our work provides strong evidence that supports the theory that risk factors affect the selection and implementation of energy efficiency projects, and that these risk factors are fuel type, end-use and process specific. Recommendations which affect manufacturing processes have a risk factor attributed to it that is linked to the fuel type utilized by the process. Examination of the data shows that fossil fuel saving and process-related recommendations are less likely to be implemented than any other type of recommendation which has the same simple payback. We attribute this in part to the more difficult calculations associated with fossil fuel saving recommendations and the high risk associated with altering a manufacturing process which is already producing an acceptable product at an acceptable cost. We contend fossil fuel conserving projects have an additional 25%-33% risk premium placed upon them which is mostly likely linked to the degree by which the manufacturing process is affected.

The current relative low cost of energy compared to ten or twenty years ago has diverted financial resources away from controlling this particular cost of business for most manufacturers. We believe corporate financial resources are being used to focus more on expanding business by increasing or improving product(s) rather than invest in improving the energy efficiency of manufacturing the product(s). Businesses are more willing to invest in projects with higher risk and corresponding reward that are directed toward this purpose.

In the event of a change in the stability of energy prices leading to higher energy costs, we would expect attention to be refocused. In the meantime, the United States will continue to utilize energy at higher rates than its competitors in most of the industrialized world.

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