An Analysis of Data at an Industrial Assessment Center for Improving Energy Efficiency

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ABSTRACT

One of the great challenges for improving energy efficiency in manufacturing facilities is convincing management to implement an idea. This study looks at not only the technical aspects of gaining credibility with the key players of a company but also the socio-economic factors that influence decision making. Two sources of data were used to conduct the analysis of these factors. First, a data base of the reasons why ideas were not implemented was collected over a five year period from 1999-2003 from clients of the Bradley University Industrial Assessment Center (IAC). Second, a survey tool was developed and sent to 26 of the clients.

Several practical low cost ways to increase the implementation of energy efficiency ideas were identified. The inference from these ideas was to 1) improve the communication with the client both during and after the site visit, 2) improve the presentation of technical data in an effort to overcome barriers to implementation and 3) concentrate on assessment recommendations that have a higher probability of implementation. This paper provides the details of these practical ways to implement these new ideas.

Introduction

Many environmental changes can be demonstrably attributed to energy consumption. The technological possibilities in many areas of energy saving, energy efficiency, use of renewable energy, and waste and productivity management have been identified to a great extent by several professional organizations, yet existing analysis of potential applications of these possibilities show a clear "implementation gap."

Despite the demonstrated potential for the practical reduction of energy waste in manufacturing, the implementation rate of these opportunities remains very small. Even the most successful programs, such as the Industrial Assessment Centers (IAC)[1], generate an implementation rate of only 46 percent.

Background

One of the key measures of the effectiveness of any IAC is its implementation rate. In other words, the energy or money saved by clients relative to the potential savings identified by the IAC is a measure of the Center's success. In addition to the implementation rate, the number and type of recommendations made by an IAC is an important parameter.

Recommendations made to manufacturers by the IACs can result in significantly improved performance through reduced energy costs, better working conditions, higher product quality, and improved productivity systems. However, special attention needs to be paid to the

[1] Industrial Assessment Centers are funded by the Department of Energy to serve small and medium sized manufacturers who do not have their own energy expertise.

process of selecting recommendations out of the wide variety of potential choices in order to accomplish their implementation by clients. There are practical ways to overcome the implementation obstacles. In order to develop these corrective actions a thorough analysis as to why the clients did not implement given recommendations was performed. This paper gives the findings of this analysis.

Objectives

The objectives of this analysis were to (1) understand how organizational interactions (based on a socio-economic model) impact a manufacturer's ability to implement energy efficiency recommendations (based on a techno-economic model); and (2) generate strategic guidance for clients to overcome both social and technical barriers to implementation.

Scope

The scope of the research was limited to an analysis of the Bradley University Industrial Assessment Center (BU IAC) database for the years 1999-2003. The methodology's main activity was a survey of past clients. From this survey a list of corrective actions were generated for improving implementation, and modified the assessment tool to record why clients failed to implement certain recommendations.

The next section of the reports describes the procedures used to accomplish the project objectives.

Procedures

Analysis of the Existing Database

The following steps were taken to analyze the existing data:

Step 1. The analysis began with a review of 125 reports, which included 1,631 different assessment recommendations (ARs). These reports were generated during the period 1999-2003 at the BU IAC. Some details from these reports are shown in Table 1.

In order to simplify the analysis, the 1,631 recommendations were categorized into three main categories as follows:

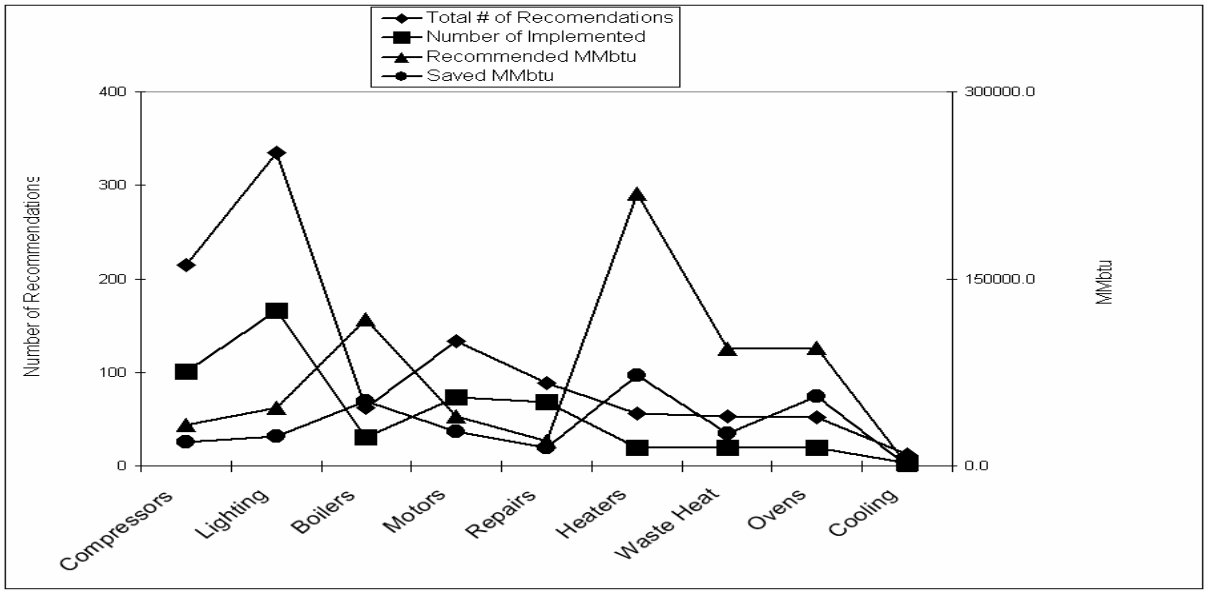
1. Energy assessment recommendations (EARs), which included nine sub-categories: air compressors, lighting, boilers, motors, Repair leaks, heaters, ovens, cooling, and waste heat.
2. Productivity assessment recommendations (PARs) and waste assessment recommendations (WARs), which included eight sub categories: automation, recycling, bills, selling, leasing, demand control, suppliers, resource waste.
3. Unique recommendations which are custom to the particular client.

Table 1: Previous Assessment Data for Years 1999-2003

Year	Number of Reports	Value of Recommendations		Value of Implementations	
		MMBtu	Dollars	MMBtu	Dollars
FY 2003	(#223 - #249)	223023	3,878,948	56666	1,250,315
FY 2002	(#198 - #222)	164902	2,721,052	29826	441,562
FY 2001	(#176 - #197)	150245	3,733,699	92136	1,476,134
FY 2000	(#151 - #175)	89329	6,971,758	62353	4,713,199
FY 1999	(#126 - #150)	102157	3,867,710	68498	2,575,184
Total	125	729657	21,173,167	309479	10,456,394

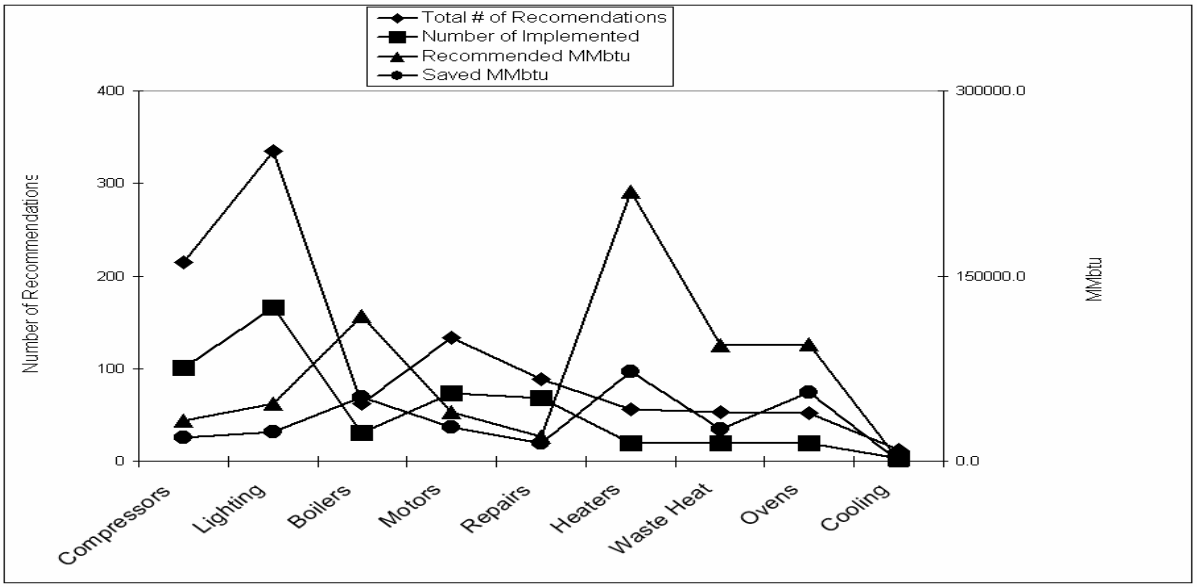
Step 2. A graphical presentation (Fig. 1) for each sub-category within category #1 shows the total number of recommendations made, the number of implemented recommendations, and the associated dollar savings.

Figure 1: EARs and Value of Savings for Main Category #1



A graphical presentation for each sub-category in the main category #1 was also developed to show the total number of recommendations made, the number of implemented recommendations, and the associated energy savings. This graphical presentation is shown in Figure 2.

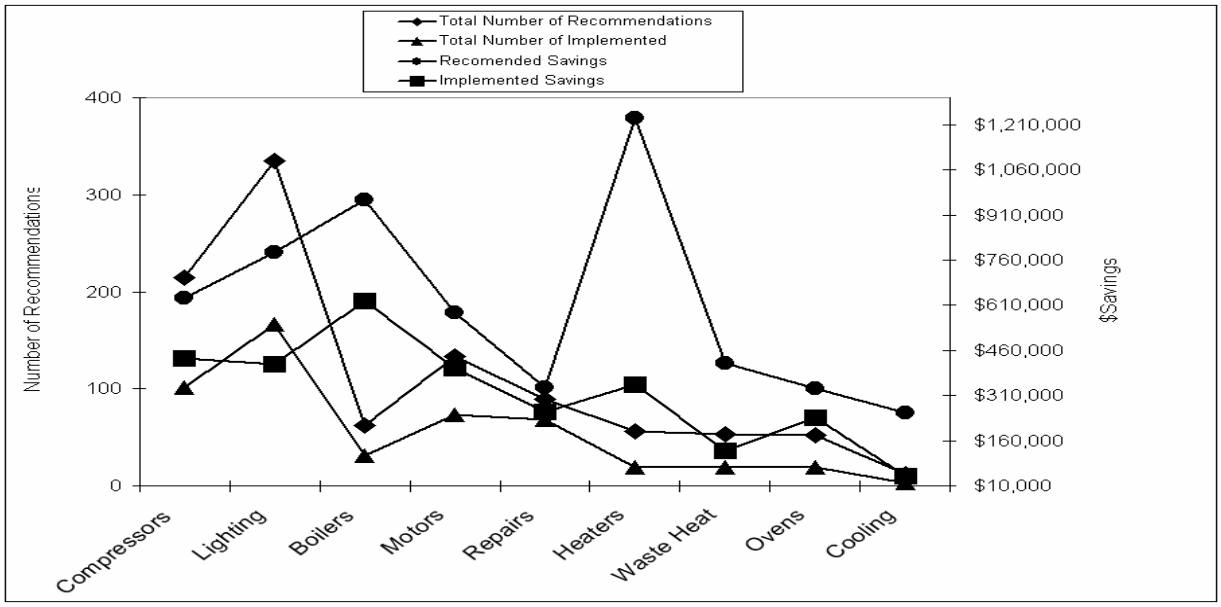
Figure 2. EARs and Energy for Main Category #1



These figures suggest that certain energy functions need increased focus during the assessments. Boilers, heaters, waste heat, ovens, and motors offer potential energy savings per recommendation that are significantly higher than the other sub-categories. This inference is based on the fact that even though the number of ARs made in areas like compressors and lighting were much higher, the number of implemented ARs and the associated energy and dollar savings for them are much lower compared to the sub-categories identified.

Similarly, a graphical presentation for each sub category in Main Category #2 was developed to show the total number of recommendations made, the number of implemented recommendations, and the associated dollar savings. This graphical presentation is shown in Figure 3.

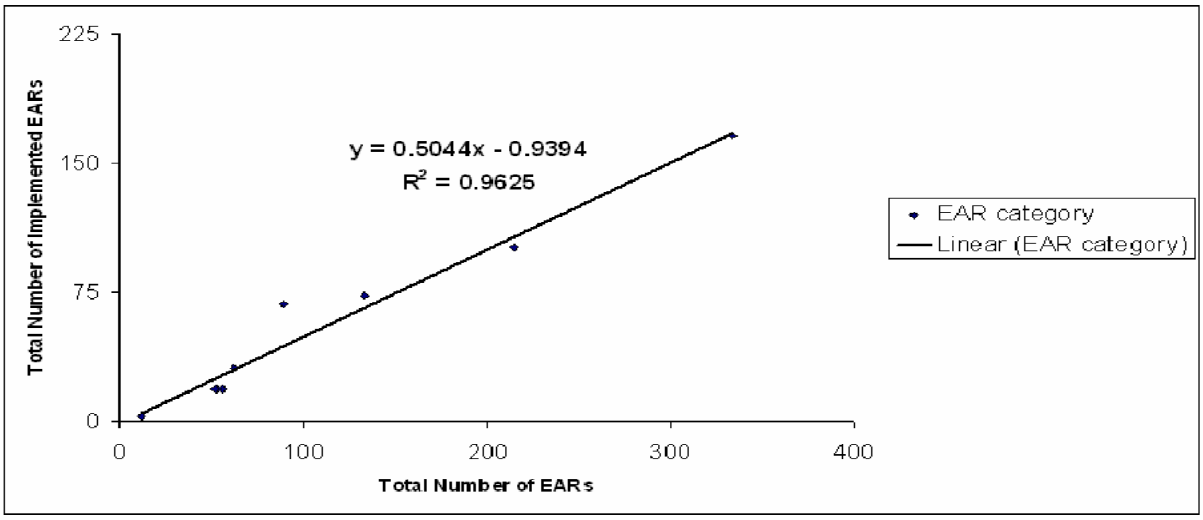
Figure 3. ARs and Dollar Savings for Main Category #2



It can also be inferred from Figure 3 that sub-categories like automation and painting need increased focus compared to the other sub-categories for the same reasons as described for the Main Category #1.

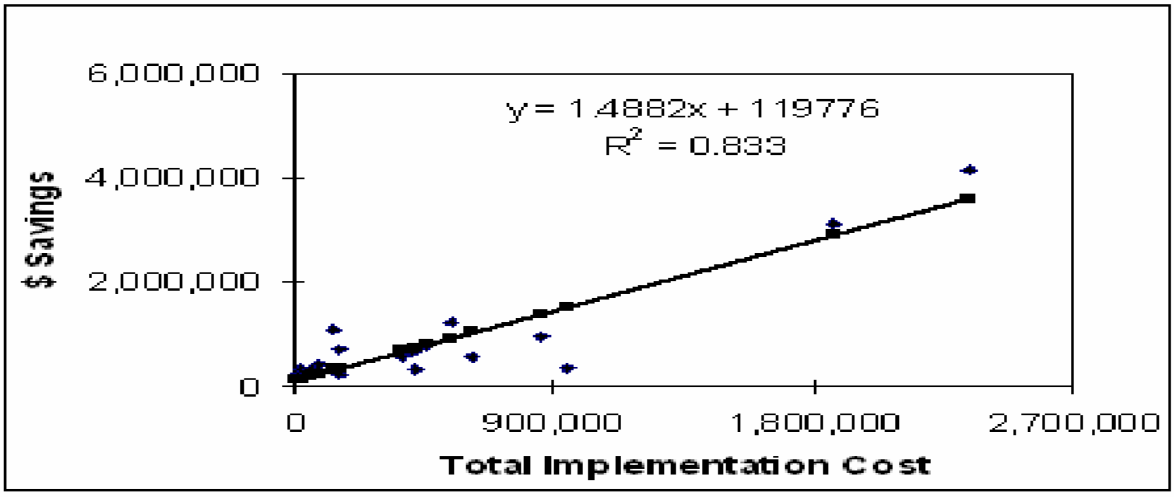
Will an increase in the number of assessment recommendations (AR's) made in the sub-categories identified for increased focus result in enhanced implementation? To answer this question, a regression analysis was carried out to check the correlation between the number of AR's made and implemented which is shown in Figure 4.

Figure 4. Regression Analysis for Total Recommended and Implemented ARs



From Figure 4 that a linear correlation does exist between the numbers of AR's identified and the number of AR's implemented. Furthermore, a regression analysis was carried out to check the correlation between the dollar savings of AR's and dollar cost of implementing AR's which is shown in Figure 5.

Figure 5. Regression Analysis for Total Dollar Savings and Dollar Cost of Implementation



In general from Figure 5 recommendations with higher dollar savings will have higher implementation costs. To assist the client with larger capital cost decisions a Life-Cycle Cost

Analysis could be included to provide the client with rate of return on the investment. Finally, an analysis was carried out of the data in main category #3 (Unique AR's). It was found that approximately 10 percent of the total 1,631 ARs belonged to this category. However, the dollar savings identified in the ARs of this category were approximately 36 percent of the total dollar savings identified in 1,631 ARs. In addition, the dollar savings accomplished from the ARs implemented in this category were 63 percent of the identified dollar savings in this category which is a significantly higher than the national average. So it is recognized that greater focus should be to generate unique ARs in order to enhance implementation.

Step 3. After determining the elements of successful implementation processes, an analysis of the unsuccessful determinants was undertaken. The analysis started with a review of the rejection codes. Currently, twenty-two rejection codes are used in the Implementation Reports. These reports are completed by the IAC clients in order to understand the cause for not implementing ARs. In order to simplify the analysis, these twenty-two rejection codes were grouped for the purpose of this analysis into six Rejection Groups as shown in Table 2.

Table 2. Rejection Groups

Company inflexibility	**Problems with the cash flow**	**Technical Disagreement**
Process and/or equipment changes (6) Facility changes (7) Personnel changes (8) Production schedule changes (9) Material restrictions (10) Bureaucratic restrictions (11) Risk or inconvenience to personnel (17) Lack of staff (14)	Too expensive initially (2) Cash flow prevents implementation (3)	Suspected risk or problem with equipment or product (18) Not worthwhile (15) Impractical (5) Rejected after implementation (19)
Lack of Feasibility Unsuitable return on investment (1) Unacceptable operating charges (4)	**Absence of Communications** Disagree (16) Unknown (20)	**Unforeseeable factors** Could not contact plant (21) Other (22)

Next, the reasons for all rejected ARs were distributed among the above Rejection Groups. The data shown in Figures 6-8 is based upon a detailed analysis of individual ARs. The influence of each rejection group on EARs is shown in Figure 6.

Figure 6. Influence of Each Rejection Group on EARs

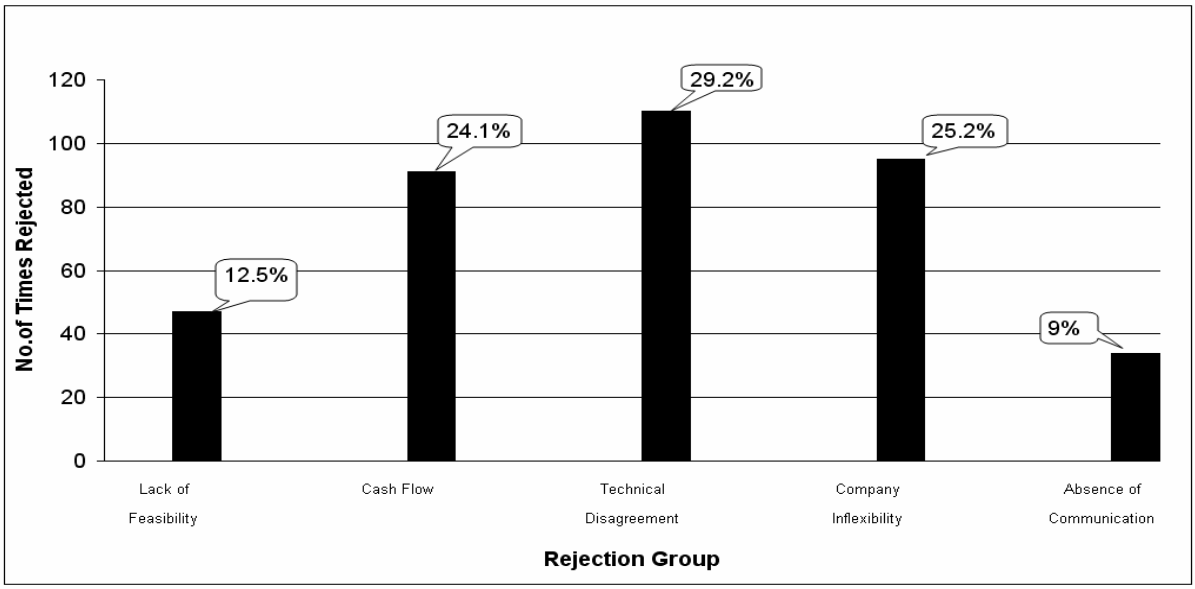


Figure 6 shows the major determinants for rejection are technical disagreement (29.2%), cash flow (24.1%), and company inflexibility (25.2%). Next, the influence of each rejection group on productivity assessment recommendations (PARs) is shown in Figure 7.

Figure 7. Influence of Each Rejection Group on PARs

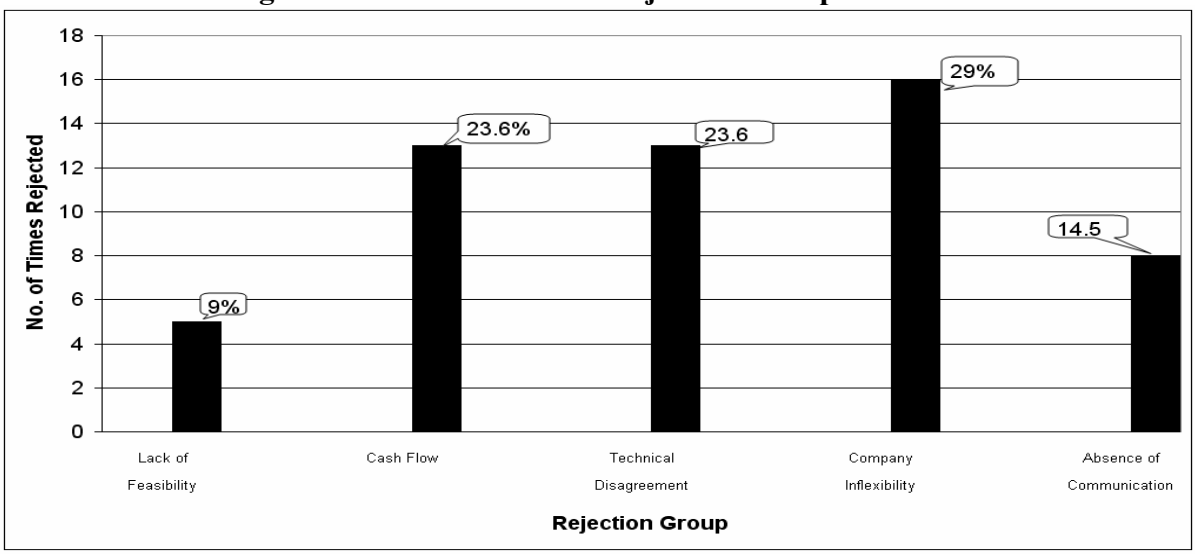
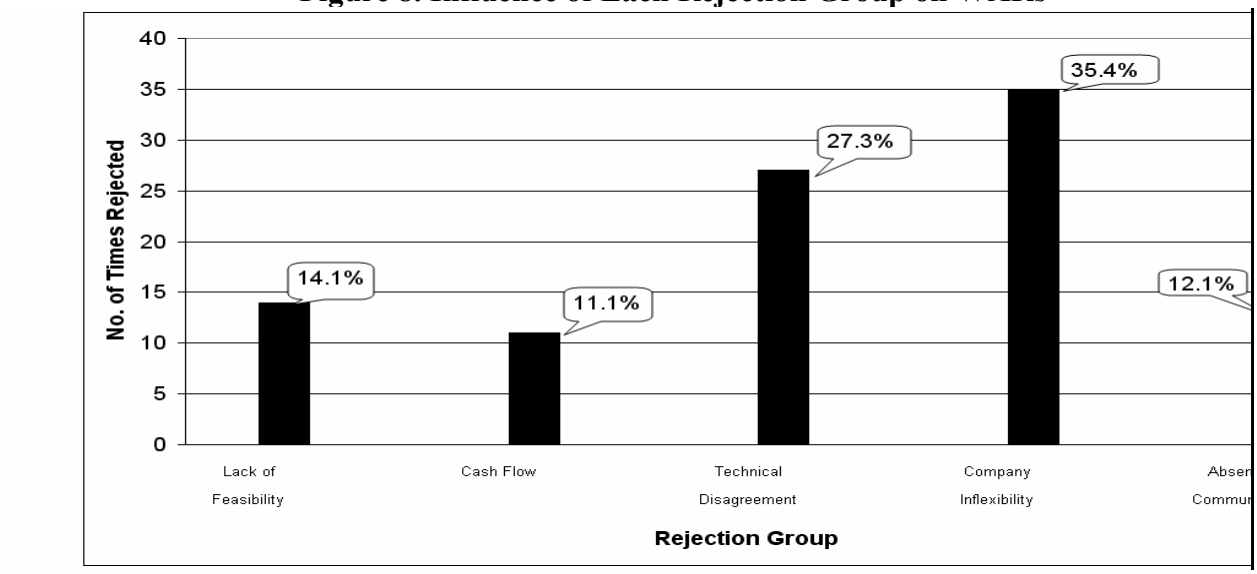


Figure 7 shows that the major determinants for rejecting PARs are Company inflexibility (29%), Technical disagreement (23.6%), and Cash flow (23.6 %).The influence of each rejection group on waste assessment recommendations (WARs) is shown in Figure 8.

Figure 8 on the next page shows the major determinants of WARs that are not implemented are company inflexibility (35.4%), and technical disagreement (27.3%)

Figure 8. Influence of Each Rejection Group on WARs



The potential energy and $ savings which were not captured (loss) due to non-implementation of the recommended ARs in these groups are shown in Table 3.

Table 3. Losses Due to Non-Implementation

		EAR	PAR	WAR
Rejection Group	Loss of possible MMBtu Savings	Loss of possible $savings		
Lack of Feasibility	30682	264,350	195,999	247,325
Cash Flow	59405	511,826	509,597	194,327
Technical Disagreement	71808	618,691	509,597	476,984
Company Inflexibility	62018	534,324	827,197	618,313
Absence of Communication	22195	191,232	313,598	211,993
Unforeseeable factors	104448	899,914	862,396	936,302

In addition to unforeseeable factors, two rejections groups, technical disagreement and company inflexibility, were found to be the major determinants of AR rejections. Further, Table 3 demonstrates the fact that cash flow is a lesser determinant, which is contrary to the commonly held belief by the IACs. The significant role of "unforeseeable factors" complicates this analysis because it gives the client an opportunity to reject a particular AR without disclosing the real reasons.

Based upon the analysis in steps 1-3 and the brain storming sessions, it was felt that: a) there was a scope for improving the rejection codes and this topic should be explored further when final corrective actions are developed, b) the following possible corrective actions which were noticeable should be kept in mind while designing the survey instrument in order to validate concerns related to the techno-economic model.

Development of the Survey Instrument

In order to develop the survey instrument an analysis of the existing database, which was based on the techno-economic model, a study was undertaken of a socio-economic model to understand the organizational behavior (Ancona , 1999).

Figure 9. Possible Reactions

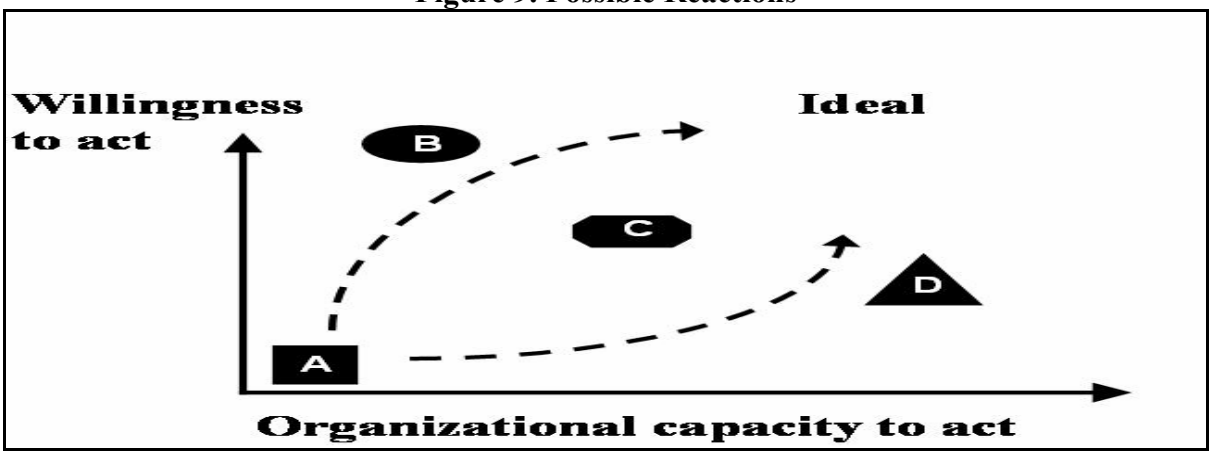
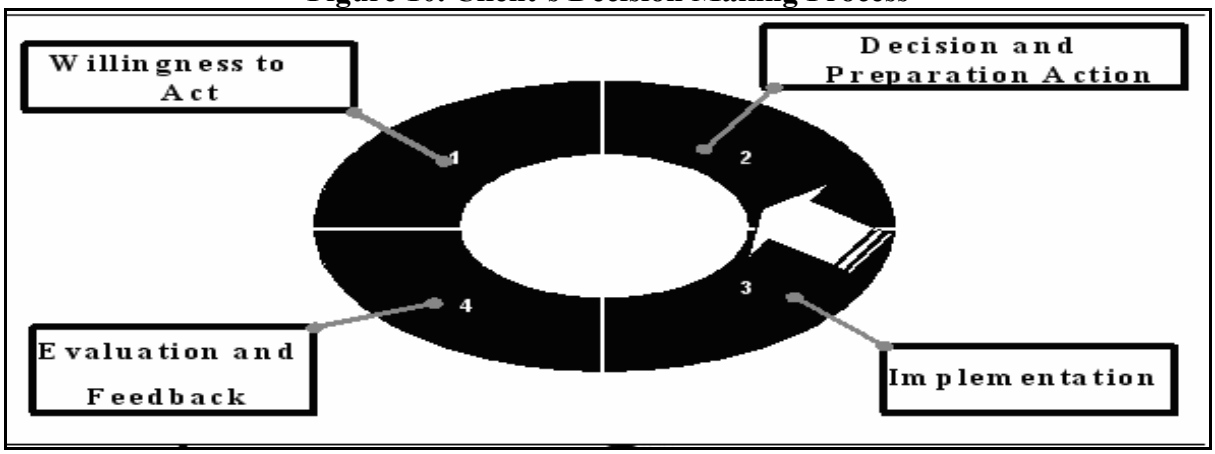


Figure 9 illustrates the possible reactions of IAC clients

Figure 10. Client's Decision Making Process



Furthermore, Figure 10 (Ancona , 1999) represents a client's decision making process. Using this organizational model and the results of our analysis, a survey instrument was prepared and sent to 26 clients.

Corrective Actions with Survey Results

The following general and specific corrective actions are based upon both the data base and the responses received from the clients during the survey. Only responses with a support of 65 percent or higher were included in the development of corrective actions which are listed below.

General Corrective Actions

Increase the number of recommendations in boilers, heaters, and cooling, waste heat, ovens, automation and paint areas. The corrective actions suggested are:

1. To include a graph in the assessment reports showing trends in natural gas and electricity prices. Seventy-nine percent of the clients were very interested in looking at trends and 70 percent of the clients would most likely implement the natural gas related recommendation if the acceptable trends were provided to them. Eighty-nine percent of clients showed strong sensitivity towards energy price fluctuations, which indicates their greater interest in energy cost-saving opportunities due to significant price level instability.
2. To provide schematics of the proposed system change, if any, in a recommendation (mostly related to heat recovery). Seventy-seven percent of clients indicated they would most likely implement if such schematics were provided to them.
3. To provide life-cycle cost analysis to prove the feasibility of the recommendation. Seventy-four percent of clients will most likely implement the recommendation if such analysis is available to them
4. To conduct more two-day audits. Sixty-nine percent of clients agree that one-day audits are too short.

Specific Corrective Actions

Specific corrective actions in different rejection groups are shown in Table 2 are as follows:

I. Lack of feasibility

   1. Perform a cost-benefit analysis. Seventy-nine percent of clients were strongly interested in this idea.
   2. Communicate with clients to know their acceptable payback period and rate of return for certain investments. Seventy-four percent of the clients indicated that the pay back period has an important role in implementing a particular recommendation.

II. Cash flow

   1. Familiarize manufacturers with sources of financial assistance. However, 65 percent of clients strongly object to capital investments.

2. Avoid recommendations which require high capital investment without consulting the client during the exit visit.

III. Technical disagreement

1. Include a "roadmap" in the report. Eighty-nine percent of clients showed strong interest in having a road map for the implementation of complicated recommendations (e.g. automation).
2. Provide the source of technical information for recommendations. Seventy percent of the clients showed a strong interest in such information.
3. Provide a case study for commonly recommended recommendations. Seventy-two percent of the clients showed strong interest in having such information available to them.
4. Provide incremental analysis for recommendations (e.g. reducing compressor air pressure for different increments of pressure reduction). Seventy-nine percent of the clients will most likely implement the recommendation if such analysis is made available to them.

IV. Company inflexibility

1. Conduct a detailed interview to understand the client's organizational issues (e.g. corporation restrictions).
2. Identify and engage the client's main decision-makers in a brainstorming session.
1. Clients showed resistance to external financial assistance. The feedback indicates that efforts to increase energy-efficiency awareness will not have a significant impact on decision-making.

V. Absence of communication

1. Include the clients in brainstorming sessions. Seventy-two percent of clients are strongly interested in this.
2. Make follow-up phone calls to clients after the client receives the report. One hundred percent of clients are strongly interested in receiving follow-up calls from IAC staff.
3. Send an electronic copy of the report and utility bills analysis along with the hard copy. Ninety-five percent of the clients are interested in receiving it. They have also indicated that this will help their process of internal communications within the company.

Unexpected Result: Clients showed the least interest in communication during preparation of the energy report because they are too busy and short of time.

VI. Unforeseeable factors

Make awards available to clients that implement the recommendations. Eighty-four percent of clients show great interest in having such an award or recognition of some kind.

VII. Additional Findings

Clients interviewed for this analysis were not motivated by appeals to "advance energy efficiency." However, they were much more responsive to solutions for "increased energy costs." The clients felt that the government's role is to promote energy efficiency. Clients do not feel that they would have a significant role in promoting energy efficiency.

Conclusions

- Assessment recommendations (AR's) related to heat transfer processes, motors, painting and automation along with unique AR's, produce higher implementation rates than lighting and compressor related ARs.
- Based on an analysis of the current rejection codes, most clients do not implement recommendations because of company inflexibility and technical disagreements.
- Based on the survey results, the clients are receptive to several practical, low cost ideas that can be incorporated into the audit process. These ideas ranging from calling the client after submitting the report to adding case studies to the report may help to improve implementation rates.
- Place a greater emphasis on heat transfer related and unique AR's. Since these AR's are more data intensive, it is recommended that IAC's be allowed to conduct more two-day client audits.
- Implement corrective actions which have been identified as a result of the analysis of the rejection codes and the survey. In general, the actions which we believe to be most effective are summarized below:
    - Call the client after the report has been delivered
    - Send an electronic copy of the report to the client
    - Reformat the report
        - Move equations to an appendix
        - Add rate of return analysis
        - Add a roadmap for implementation
        - Add schematics of the system
        - Add relevant case studies
        - Show energy price trends
    - Conduct brainstorming sessions with clients to discuss considerations that don't come up during the standard assessment procedure.
- Revise the current list of 22 rejection codes. These have been reorganized by category and condensed into the form that is shown in Table 2.

Reference

Ancona, D.G., *Managing for the future: organizational behavior & processes*. Cincinnati, Ohio: South Western College Pub., c1999.