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An Expert-Based Assessment Software Program for Industrial Manufacturers

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Abstract

This paper discusses a software program that was developed at the University of Maine to assist manufacturers in minimizing waste and improving energy efficiency. The software combines the most common recommendations made in the U.S. Department of Energy's Industrial Assessment Center program in a user-friendly package that can be used by computer novices. It also includes "wizards" that serve as an expert system to lead the user through an assessment of their total facility. The program is interactive and based around the Windows 95 operating system. Once users enter the necessary data into the program, it will generate a report similar to those created by Industrial Assessment Centers. General code formation will be covered with a discussion of some of the recommendations that are included.

1. Introduction

Since 1978, the U.S. Department of Energy has sponsored the Industrial Assessment Center program. This program provides "no-cost" industrial assessments to small and medium-sized manufacturers around the United States. The program utilizes 30 Universities which each perform 30 assessments annually at firms within 150 miles of their respective campuses. It has been highly successful in training students in energy efficiency and waste minimization techniques. The program has also been very successful helping the manufacturers that are served by the program.

To have the greatest national effect on energy efficiency, the program is targeted toward those medium-sized manufacturers that have the highest energy consumption. It is assumed that large manufacturers have the necessary engineering expertise and savings generated for small manufacturers would have a minimal effect on national energy consumption.

For a manufacturer to qualify for an assessment, it must meet three of the four following criteria. Clients must have: less than 500 employees, less than 75 million dollars in gross sales, no in-house energy expertise and total energy bills between $100,000 and $1.75 million. They also must maintain a standard industrial classification (SIC) code of 20-39. This greatly focuses the type of client served by the program.

At the University of Maine Industrial Assessment Center, we came in contact with a large number of small manufacturers in the state of Maine that are too small to qualify for the program. Some of these clients did qualify for energy assistance through the Maine Department of Economic and Community Development's Energy Conservation Program (DECD). Through a partnership with DECD, we have provided technical assistance to some small clients being served by this state program. In this role, we found several of the common recommendations that are made for medium-sized manufacturers were equally applicable to small clients.

In our desire to provide further assistance to smaller manufacturers, we began investigating ways to share technical expertise with these small manufacturers. At the national level, the U.S. Department of Energy has developed publications in conjunction with Rutgers University that document typical energy conservation opportunities [1]. They also have developed a self-assessment workbook to assist manufacturers in improving energy efficiency [2]. Unfortunately, most facility managers of small manufacturing firms have little time to sort through large manuals educating themselves in energy efficiency.

This led us to the conclusion that we needed to develop a software package to assist these manufacturers. While a software program or publication can not provide the technical experience of a University Industrial Assessment Center team, it is our belief that a program can help manufacturers to implement some of the more common recommendations associated with the IAC program. In the most recent Annual Report of the IAC program, it was reported that the average IAC report recommends approximately $40,000 in annual savings for each client served [3]. We believe that a client using a software package should be able to develop average recommended savings of at least one-tenth of that amount. Though that number may be smaller than the savings generated by an IAC assessment, the cost per client served is much smaller and the client base is far larger.

The main requirements for our software were that it must be user friendly, contain the most common IAC recommendations, allow users to work on individual recommendations or use a “wizard” to guide them, and be able to print out report recommendations showing all formulas and numbers used in the calculations. Our prototype code meets all of these basic expectations and includes extra features that went beyond these specifications.

2. Generalized Software

Our goal was to develop a software application that would encapsulate a wide variety of recommendations that could apply to a wide variety of companies. The software had to be modular so that new recommendations, developed by students with different skill levels, could be seamlessly meshed into the existing software application. The following subsections discuss the salient features of the software framework.

2.1 The OLE Container

The software application is an OLE container much like Microsoft Word or Excel. The purpose of the OLE container is an application that consolidates all of the recommendations, which are separate applications known as an OLE servers, in one package making them easily accessible by the user. When the OLE container application is launched, it locates and embeds all of the recommendation servers installed on the PC.

2.2 The OLE Recommendation Servers

Each recommendation server provides a bitmap in the client area of the OLE container application. Double clicking on one of the bitmaps displays a dialog box that prompts the user for necessary data used in calculating the recommendation results. Once all the data has been entered, hitting the return key or clicking the Calculate button will calculate the results of the recommendation displaying them in the dark gray edit boxes. If the data is changed after calculating the results, the Data Has Changed box on the dialog will be checked telling the user that the results shown are not for the current data. The dialog box also provides printing capability as well as a help file explaining the significance of all questions and results within the recommendation dialog.

2.3 Printing Recommendations

The software prints a recommendation report that is identical to those the IAC would produce and present to a company. The report is generated from a Microsoft Word template file. Data and equations based on the user's input are inserted into the template to create a customized report. Using OLE, the application loads the template file in Microsoft Word and replaces the identifiers with the data and results in the dialog. The application then causes Microsoft Word to save the file under a new name and send it to a printer. Creating the recommendation reports in this manner allows for effortless modification to the recommendation report format. Changing the format of the report simply involves editing the Microsoft Word template file.

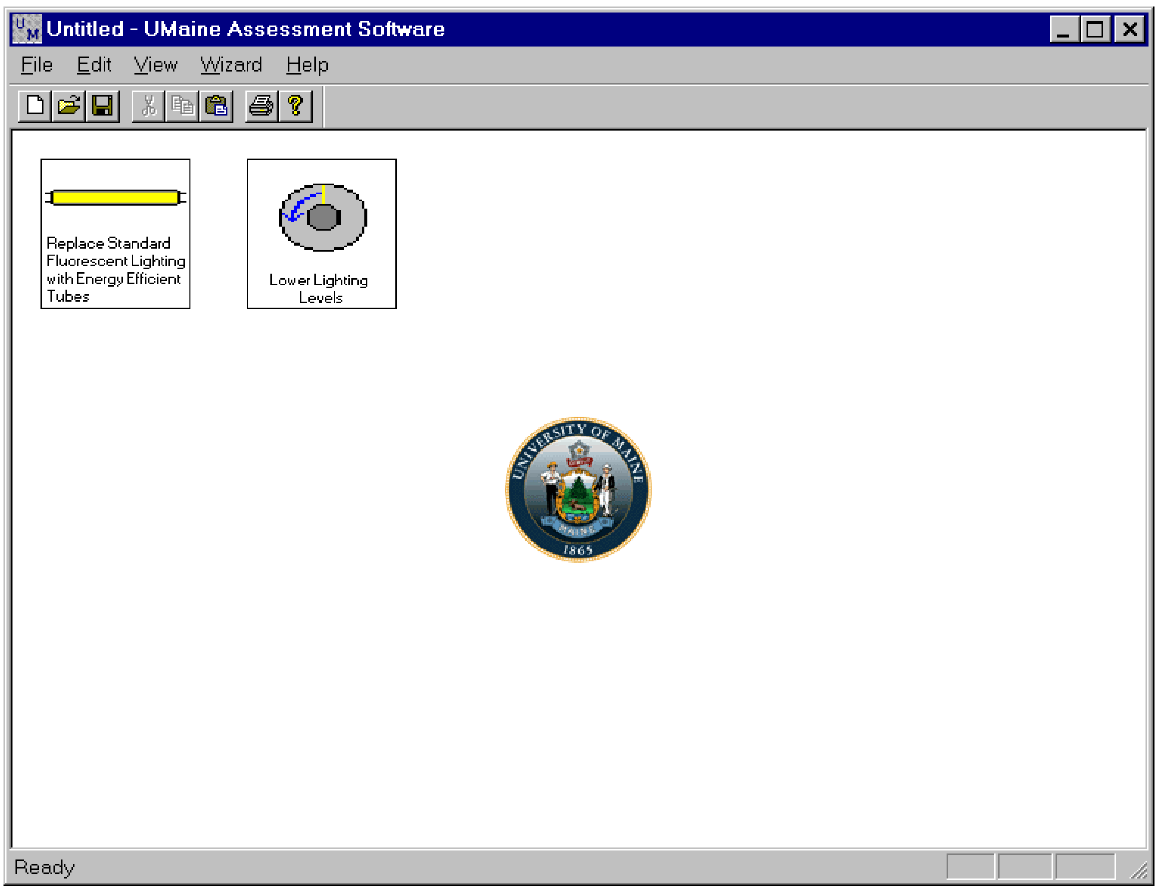


Figure 1: University of Maine Assessment Software application.

2.4 The Wizard

The software offers a "wizard" for displaying the recommendations. The "wizard" will ask specific questions about the company. Depending on the answers, the "wizard" will embed only the recommendation servers pertaining to that company. If the "wizard" is not used the application will embed all servers installed on the PC. The user will then be able to choose from any of the recommendations.

2.5 Modularity

The architecture of the software is a completely modular. The container application, once developed, works with one recommendation or a number of recommendations. The development of the recommendation servers happens independently of other recommendation servers and does not affect the OLE container. If new recommendation servers are developed after a company has received the software, the new recommendation can simply be shipped to the company and installed on the PC. The new recommendation servers will be fully compatible with the container application. The software architecture also allows a custom application to be produced by sending only specific recommendation servers to a company.

3. Example Recommendation

Some of the more common recommendations are those for lighting. One of these is Replace Standard Fluorescent Lighting with Energy Efficient Tubes. This section will show an example of the application while investigating the recommendation mentioned above. Figure 1 shows the OLE container application with two recommendations embedded. Double clicking on the Replace Standard Fluorescent Lighting with Energy Efficient Tubes recommendation bitmap will launch the OLE server active in-place and display the dialog box shown in Figure 2.

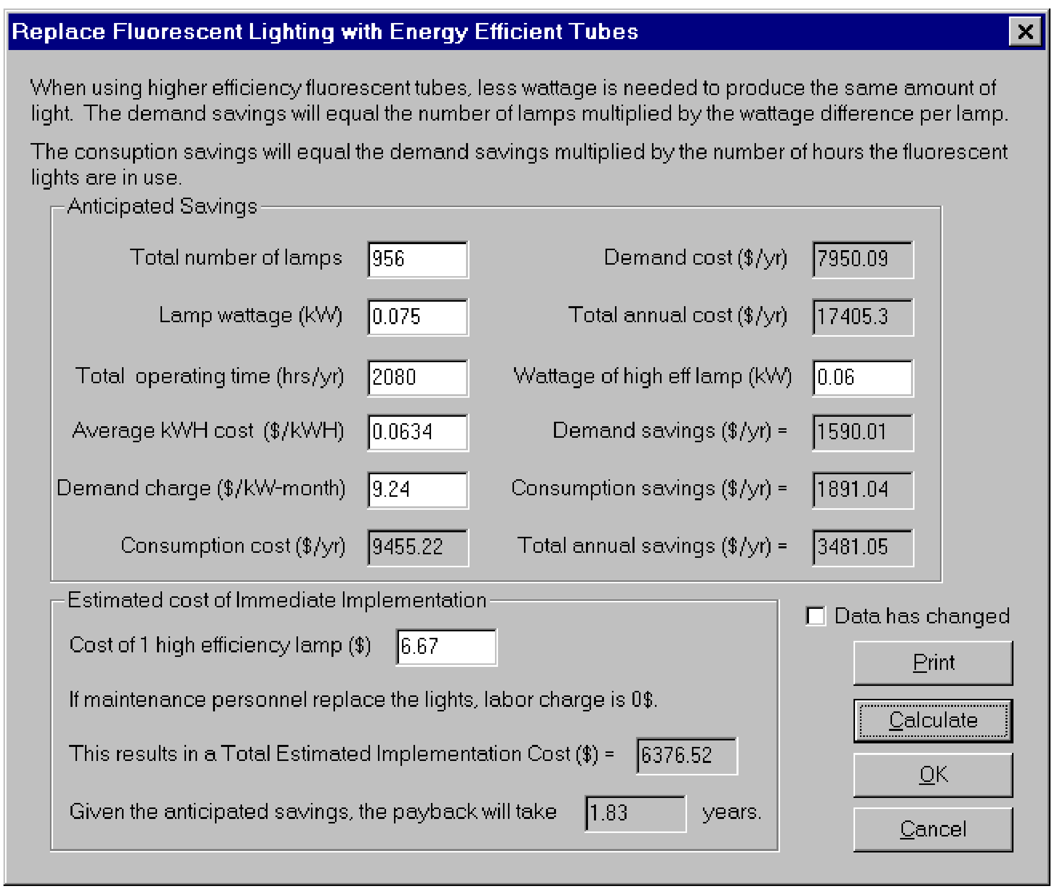


Figure 2: Dialog box for Energy Efficient Tubes recommendation.

Data is entered into the white edit boxes in the dialog . Hitting return or clicking the Calculate button after all data is entered, will update the dialog and display the savings and implementation costs in the gray edit boxes. Once this is done a recommendation report can be printed by clicking the Print button seen on the dialog in Figure 2. Appendix A-1 contains a print out of the report generated for this recommendation and the data given in Figure 2. Appendix A-2 shows the Microsoft Word template file that Word uses to generate the recommendation report. Notice the identifiers ~P1~ through ~P20~. These are the identifiers that get replaced by the data in the dialog. It is clear from looking at the template that it would be very easy to modify the format of the report.

4. Conclusion

The end result of the project was a software application that provides the following features: user-friendly interface, modularity, and customizability. With this free software package, companies that do not qualify for the IAC evaluations will now be able to benefit from an IAC-like energy assessment. Future development of the servers will also provide an educational aspect for students. In developing more servers, the students will learn about energy savings in all areas of the industrial and business communities.

5. References

[1] Muller, M.R., Simek, M., Mak, J., “Modern Industrial Assessments: A Training Manual”, Rutgers University Press, 1996

[2] Muller, M.R., “A Self-Assessment Workbook for Small Manufacturers”, Rutgers University Press, 1996

[3] Kirsch, W., Muller, M.R.,” Annual Report for the Industrial Assessment Center Program”, Rutgers University Press, 1996

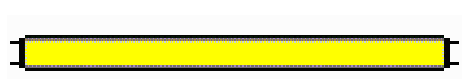
[4] Brockschmidt, K., “Inside OLE”, Microsoft Press, 1995

[5] Kruglinski, D., “Inside Visual C++”, Microsoft Press, 1995

[6] Matteson, B., ed., “Microsoft Word Developer’s Kit”, Microsoft Press, 1995

Appendix A-1

REPLACE STANDARD FLOURESCENT LIGHTING WITH ENERGY EFFICIENT TUBES



Recommended Action

Replace all standard fluorescent tubes with high efficiency tubes.

Anticipated Savings

The present lighting in the office and the plant consists of 956 of the 0.075 kWatt-8 ft. standard lamps. Assuming a ballast factor of 1.1 and noting that the lighting is on an average of 2080 hrs/yr, the power consumption (PC) and energy consumption (EC) by the 8 ft. tubes is:

PC = (956 lamps x 0.075 kW/lamp) x 1.1 = 78.9 kW

EC = 78.9 kW x 2080 hrs/yr = 164112 kWH/yr

With an average kWH cost of $0.0634/kWH and a demand charge of $9.24/kW-month. This amounts to a yearly cost of:

Consumption Cost = ($0.0634/kWH) x (164,112 kWH/yr) = $10405/yr

Demand Cost = 78.9 kW x ($9.24/kW-month) x 12 months/yr = $8748/yr

Total Annual Cost = $19153/yr

Using a higher efficiency tube, less wattage is needed to provide essentially the same amount of light. If a 0.060 kWatt high efficiency lamp is used there will be a savings of 15 watts per lamp.

Demand Saving = 956 x .015 kW/lamp = 14.3 kW

Consumption Saving = 14.3 kW x 2080 hrs/yr = 29744 kWH/yr

Implementation of the efficient tubes would then provide a cost savings of:

Consumption Cost Savings = 29744 kWH/yr x $0.0634/kWH = $1886/yr

Demand Cost Savings = 14.3 kW x ($9.24/kW-month) x 12 months/yr = $1586/yr

Total Annual Savings = $3472/yr

Immediate Implementation

The estimated cost of implementation of this recommendation is:

Materials:

New Tubes: (956 x $6.67) = $6377

Labor:

Can be replaced by maintenance personnel = $0

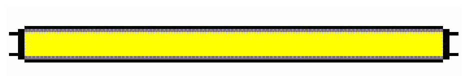
Total Estimated Implementation Cost = $6377

Based on the above implementation cost and energy cost savings, the simple payback period for this recommendation is:

($6377 implementation cost)/($3472/yr) = 1.8 year payback

Appendix A-2

REPLACE STANDARD FLOURESCENT LIGHTING WITH ENERGY EFFICIENT TUBES



Recommended Action

Replace all standard fluorescent tubes with high efficiency tubes.

Anticipated Savings

The present lighting in the office and the plant consists of ~P1~ of the ~P2~ kWatt-8 ft. standard lamps. Assuming a ballast factor of 1.1 and noting that the lighting is on an average of ~P3~ hrs/yr, the power consumption (PC) and energy consumption (EC) by the 8 ft. tubes is:

PC = (~P1~ lamps x ~P2~ kW/lamp) x 1.1 = ~P4~ kW

EC = ~P4~ kW x ~P3~ hrs/yr = ~P5~ kWH/yr

With an average kWH cost of $~P6~/kWH and a demand charge of $~P7~/kW-month. This amounts to a yearly cost of:

Consumption Cost = ($~P6~/kWH) x (~P5~ kWH/yr) = $~P8~/yr

Demand Cost = ~P4~ kW x ($~P7~/kW-month) x 12 months/yr = $~P9~/yr

Total Annual Cost = $~P10~/yr

Using a higher efficiency tube, less wattage is needed to provide essentially the same amount of light. If a ~P11~ kWatt high efficiency lamp is `used there will be a savings of ~P12~ watts per lamp.

Demand Saving = ~P1~ x ~P12~ kW/lamp = ~P13~ kW

Consumption Saving = ~P13~ kW x ~P3~ hrs/yr = ~P14~ kWH/yr

Implementation of the efficient tubes would then provide a cost savings of:

Consumption Cost Savings = ~P14~ kWH/yr x $~P6~/kWH = $~P15~/yr

Demand Cost Savings = ~P13~ kW x ($~P7~/kW-month) x 12 months/yr = $~P16~/yr

Total Annual Savings = $~P17~/yr

Immediate Implementation

The estimated cost of implementation of this recommendation is:

Materials:

New Tubes: (~P1~ x $~P18~) = $~P19~

Labor:

Can be replaced by maintenance personnel = $0

Total Estimated Implementation Cost = $~P19~

Based on the above implementation cost and energy cost savings, the simple payback period for this recommendation is:

($~P19~ implementation cost) / ($~P17~/yr) = ~P20~ year payback

Biography

SCOTT C. DUNNING in an Assistant Professor of Electrical Engineering Technology at the University of Maine, Orono, Maine. He teaches undergraduate courses in electrical machinery and power systems. He received the BSEE and MSEE from the University of Maine. He is a licensed professional engineer in the state of Maine. He is currently Chairman for the Executive Committee of the Institute of Electrical and Electronics Engineers in Maine (IEEE) and a Member of the Amercan Society for Engineering Education(ASEE).

Dr. BRUCE SEGEE received a PhD in Engineering from the University of New Hampshire in 1992. He has been an assistant professor of electrical and computer engineering at the University of Maine since that time. At the University of Maine he heads the Instrumentation Research Laboratory, an organization dedicated to research and teaching involving instrumentation and automation. Work in the lab includes the use of PC's, PLC's, and embedded controllers for instrumentation, automation, and networking. Work also includes the use of fuzzy logic and artificial neural networks.

VINCENT M. ALLEN has recently received a Bachelor of Science degree in Electrical Engineering at the University of Maine. Currently he is working in the Instrumentation Lab at the University of Maine toward a Master of Science degree in Computer Engineering.