INDUSTRIAL PROGRAM DESIGN: THE IDEAL UTILITY APPROACH

Cynthia L. Blazina, Seattle City Light

INTRODUCTION

History

In 1992, a nationally and internationally acclaimed five-year Industrial Research and Demonstration (IRD) Project conducted by a major utility in the Pacific Northwest came to an important conclusion.[1] The conclusion was that the "ideal" design for a utility-based industrial energy conservation program was very different from the ways in which such programs were being currently designed across the United States. Since that 1992 report was published, calls for a drastic restructuring of industrial energy conservation programs have been echoed in various follow-up reports written for the utility. These have come from inside as well as outside; i.e. from utility staff as well as from highly esteemed energy consultants.

All of these reports focused on a point first made in the 1992 report, describing the three major components that an industrial conservation program must have in order to be considered "ideal".

- First, the program must take a "process-based" or "systems" approach to energy conservation.
- Second, the utility must try to attain energy efficiency in the industrial sector, rather than trying only to reduce the total industrial consumption of energy. In other words, the utility must emphasize ways its industrial customers can use energy more efficiently.
- Finally, the program has to look attractive from the customer's standpoint, and therefore needs to incorporate non-electric benefits.

Since 1992, these three components have become yardsticks against which industrial program design is increasingly being judged. At first, these components were discussed only by leading-edge utilities. Now, discussion has spread to regional and national forums. There is clearly a need to understand what these components mean, and definitions are in the next section.

Definitions

The Report on the Industrial Research and Demonstration (IRD) Project states that a process-based approach is "the key to major energy savings in industry." Since the terms "process-based approach" or "systems approach" will be used extensively in this report, it may help to define those terms in the beginning. A process-based approach (or systems approach) focuses on improving the efficiency of an industrial process as a whole, rather than making one specific piece of machinery (which is undoubtedly part of a whole process) more efficient.

Another phrase that should be defined is "Industrial Energy Conservation Opportunity", or "IECO". An IECO is a measure that promotes energy efficiency in manufacturing processes that are identified by industry and type of production activity. For example, a method of improving the efficiency of refrigeration to freeze ice-cream in a dairy plant would be an IECO for the Dairy Industry's cooling end-use. (Note that an IECO is different from a "conservation measure", such as " efficient refrigeration", which is defined only in terms of the equipment and not the industry in which it is used.) Extensive lists of IECOs have been developed by many national and regional agencies and corporations, including the University City Science Center (UCSC) which first developed the term. UCSC's list of IECOs is gathered in a document called the Dictionary of Industrial Energy Conservation Opportunities (DIECO)[2] which is used by agencies and organizations across the United States.

The Industrial Research and Demonstration (IRD) Project had also brought up the issue of non-electric benefits which had to be identified by conservation programs directed at electricity use in industry. They defined a list of three non-electric benefits that should be emphasized in an industrial conservation program: (1) the avoidance of capital costs, (2) the reduction of operation costs, and (3) enhanced end use performance.

Finally, The Industrial Research and Demonstration (IRD) Project also identified, in the research projects/audits, eight ways to represent electrical energy efficiency with respect to industrial processes. A brief list of the eight efficiency gains is shown in Table 1.

TABLE 1: Eight Efficiency Gains

EFFICIENCY GAIN	DESCRIPTION
DECREASE PROCESS TIME	Reduce the standard time for completing one cycle of an industrial process; increases output per week, month, or year.
INCREASE IN WATTAGE	Increase the power (in Watts) of equipment used in an industrial process;
INCREASE OUTPUT PER KWH	Increase the number of units of output produced per kWh used by an industrial process, OR reduce kWh used per unit of output.
PROCESS SHIFT	Change industrial process to make more efficient and/or use electrical energy more efficiently.
LOWER "PRICE" PER KWH	Reduce the "price" (i.e., cost per kWh) of electrical energy used in a specific industrial process.
LOWER EQUIPMENT COST PER KW	Reduce the cost per kilowatt of equipment used in an industrial process.
LOWER OPERATION COST PER HOUR	Reduce the cost per hour for operating the electrical equipment used in an industrial process.
LOWER COST OF PRODUCTION	Reduce the total cost (electric and non-electric) of production per unit of output for an industrial process.

These three things----IECOs, non-electric benefits and the eight types of efficiency gains---are cornerstones of the radical re-design of conservation programs that was first proposed in 1992 in the final Report of the Industrial Research and Demonstration (IRD) Project. At least two of the three---non-electric benefits, and the eight types of efficiency gains---had never been used in the design of industrial conservation programs as of 1992; in fact, most industrial conservation was based on excluding non-electric benefits, or ignoring energy-use efficiencies that did not directly reduce electricity consumption. Even as of 1995, the situation has hardly changed.

Proposal

This paper, therefore, proposes that an item of business arising from the 1992 Report of the Industrial Research and Demonstration (IRD) Project should be at last attended to. It attempts to demonstrate a new way of designing a utility sponsored industrial energy conservation program. The method that is proposed is one that, in terms of the IRD Report's original authors, might come closer to being called "ideal".

The method used in this report to demonstrate an "ideal" strategy for industrial conservation is to compare and contrast three industrial conservation program designs. Each program design is described and critiqued.
The first program that we describe is intended to exemplify how current methods of attempting to conserve energy in the industrial sector actually work. The second program embodies some changes from the approach taken by the first; it is an improvement, but still has some shortcomings. This sets the stage for the third program design method, which represents the approach proposed by this paper. In other words, the first and second programs serve as examples of what not to do in 1995 and beyond, if the knowledge gained by efforts such as IRD are ever to be put into use anywhere in the US. The third program approach shows why current program designs must be abandoned. It corrects the errors in the first two designs, and shows how more energy can be saved using the new approach.

It is important to bear in mind that both the second and third program design methods demonstrate conservation strategies that are better than the current approach towards industrial conservation taken by most utilities, as exemplified by the first program discussed. Both designs actively search for conservation opportunities. They do what most US industrial conservation programs in 1995 do not; that is, they do not simply sit around waiting for the customer to provide ideas. The differences between the second and third examples are of design, not intent. The third is simply more effective, and more efficient, than the second.

PROGRAM DESIGN METHOD 1: THE CURRENT APPROACH

The first example program design (referred to as PDM1 to preserve confidentiality) whole-heartedly embraces the current industrial energy conservation paradigm. According to this current paradigm, industrial energy conservation should be targeted in much the same way that commercial energy conservation is targeted. Under this paradigm, specific machinery retrofits are considered the major way of achieving energy conservation. Due to the presumed importance of retrofits in conserving energy, retrofits for specific machines are often partially or completely financially backed.

Program Design Method number one, or PDM1, represents a comprehensive equipment-retrofit program conducted by electric utilities in a four-state region in the Western half of the United States of America. Cumulative results of the first seven years of the program were compiled in early 1995.

PDM1 focuses on specific retrofits (or as the program itself calls them : "projects"). One customer may have one project or many projects done, or may have several "projects" occurring concurrently. Each "project" is a specific agreement to install a piece of equipment that the customer and the utility both agree would improve energy-use efficiency at the customer's plant. In many cases, a customer that is aware of the program and would like to avail itself of the incentives (usually financial) offered under it will present its electricity-service utility with information on some equipment that, if replaced, might improve the energy use for the purpose for which current equipment is being used. This inspires the utility to take action, and submit the proposed improvement as a "project" to a funding agency which will pay all or part of the costs of new equipment if it meets agency guidelines. In other cases, a utility representative may visit an industrial plant, and point out to its management some piece of equipment that could be replaced to improve use of energy, and which might also get paid for, in part or full. For example, if two of the refrigerators at a cold storage plant were becoming obsolete, the plant management could persuade the utility to write a contract to financially support the refrigerator replacements, and the utility would be interested if they could write a proposal to the program funding agency that met agency guidelines. This would be a specific contract, for an identified retrofit, and would not deal with other refrigerators, let alone other uses of energy in the facility as a whole. Without a whole series of contracts, or "projects", only a portion of total energy use at the cold storage plant would be likely to get addressed.

As might be expected, energy savings as percent of the load varied widely from site to site under PDM1, and the overall averages were modest. Over a seven-year period, the total savings for PDM1 averaged around 8%; a small number of sites (especially with multiple projects) recorded savings of 30% or even 40%, but most were "single-project" sites which were able to save only 2 - 5%. Summary results of PDM1 are shown in Table 2 below.

TABLE 2: Technical Conservation Potential By Industry Suggested By PDM1

Industry	Approx. Savings %
Food	14.0%
Lumber	7.5%
Pulp & Paper	10.0%
Chemicals	6.5%
Primary Metals	6.5%
Other	6.5%

PROGRAM DESIGN METHOD 2: A GOOD ATTEMPT

A major state energy office in the Western United States took a different approach. Its program, called PDM2 in this report, went after a specific technology that was assumed to be in use in many industries in the state. The technology of choice was the Adjustable (or Variable) Speed Drive (VSD). The conservation program "delivery" method, however, was still retrofit as was the case in PDM1.

To proceed with the program, it was necessary to make some initial assumptions about which pieces of machinery were candidates for a VSD retrofit. This way the auditors could go into plants and search for places to install VSDs. The auditors, however, found that only a few motors (just 5% of the motor load) were determined to be acceptable candidates for VSD retrofits. This was partly due to two facts, which appear not to have been foreseen when the program was being put together:

- Pieces of equipment with a chance of savings from any competing technology (e.g. steam turbine drives) were usually not considered for candidacy, because energy savings could not be calculated in the standard manner used for industrial retrofits;
- Large motors were assumed to be "not candidates for VSDs." This was because (it was admitted) the resources available to the auditors were simply not equal to the task of comprehensively analyzing "large motors". So, by default, a huge portion of the motor load simply could not be addressed by program auditors.

At least in intent, PDM2 had a better program approach than PDM1. Because it focused on studying the savings potential due to one specific technology, it was able to actively search for more conservation opportunities than the "passive" PDM1 approach would have revealed. PDM2 also required that people conducting the study do some background research on VSDs and other ("competing") technologies , which is seldom the case in PDM1-type programs. Above all, the blind financial backing of specific machine retrofits was no longer in vogue; more technical justification was needed. Yet PDM2 ultimately fell short because its convictions did not (in the end) match its courage. Its choice of a new strategy seemed to be undercut by reliance on "old tools of the trade". As a result, its findings on savings potential were only marginally better than PDM1 (see table below), leading many to question the effectiveness of the new approach---and perhaps, of industrial conservation strategy itself. Some of the shortcomings of PDM2 are discussed below.

There are three main problems with PDM2. First, it lacks a specific taxonomy of enduses (or ways electricity is used) among which each industrial firm's load could be distributed. Second, the program takes an incremental or "non-systems" approach to achieve industrial energy efficiency. And third, PDM2 totally ignores non-electric benefits, and with that, the customer's perspective.

An "enduse taxonomy" is a list of enduses or industrial processes into which any industrial energy consumption can be classified. In other words, it is a list of all the possible ways energy could be (and is being) used in an industrial plant. Only with a taxonomy of this kind is it possible to link a proposed industrial conservation program with a list of possible industrial energy conservation opportunities (IECOs). This is because IECOs are specific to enduses AND to industries (see definition in the Definitions section), so they cannot be placed in a program which mentions specific industries or firms unless their enduse taxonomies are known. On the other hand, if even a working description of the enduse taxonomy of a firm is available, an auditor can go into the plant with ideas of where to look for IECOs pertaining to specific industrial processes or end uses.

This is where PDM2 came up short. It could only search industrial plants for specific types of machinery, with no regard for the industrial process or end use with which the machine was associated. So the PDM2 auditors could have had no clear idea of which IECOs associated with the selected machinery could be applicable to its corresponding process or end use. With only rule-of-thumb knowledge as their guide, they would have had to miss a lot of opportunities for industrial conservation that were in fact available. This leads to the second problem with PDM2: it had a non-systems approach.

PDM2 used what is known in the trade as an "incremental approach" to energy conservation. In general, this means looking at the status quo and examining only those things that could marginally improve this state of affairs. The aspect of PDM2 which exemplifies an incremental approach to conservation is that the auditors of

PDM2 looked at specific motors, and if it did not fit their particular guidelines for a 'candidate' for an adjustable speed drive, it was ignored rather than recommended for a different type of IECO.

The truth is that, according to a nationally recognized industrial consultant, "a systems approach to implementing energy efficiency programs captures more savings compared to an incremental approach."[3] For example, higher efficiency gains can be realized from targeting improvements in motor systems as opposed to stand-alone high efficiency motor and/or adjustable speed drive programs. PDM2 auditors were either unable or unwilling to take such a global view. While they were aware of other "competing" technologies, they simply did not apply their knowledge in a useful (that is, energy efficiency oriented) manner.

The third problem with PDM2 is that it ignored non-electric benefits, and thus the customer's standpoint, altogether. The importance of incorporating non-electric benefits into program design and analysis has been demonstrated by respected industrial energy use authorities. For example, the IRD states: "A cost-benefit analysis which only considers electric savings as a benefit ignores an important fact. In many cases, industrial customers achieve other benefits unrelated to electric savings. An all-payer cost-benefit analysis must include these if it is to have a balanced representation of benefits versus cost associated with promoting efficiency in the use of electrical energy in the industrial sector." Another report supports the IRD conclusions, as follows: "For customers, electrotechnology applications will be attractive because non-energy benefits often equal or exceed reductions in energy costs... In order to assist such customers, the planning framework will have to emphasize non-electric benefits. A comprehensive approach that expands the evaluation of energy cost reduction opportunities to include non-energy benefits will have to be developed."[3]

PDM2 had no methodology for even defining non-electric benefits for the electrotechnology (i.e. adjustable speed drives) they were proposing to introduce. Like most conservation programs, they focused narrowly on electricity benefits, and electrical costs. In this, they were not unusual. Most energy-related agencies and utilities avoid the topic, and the few who even mention it will usually hedge their discussion with all kinds of "ifs", "buts" and other caveats. PDM2 may have decided it was enough to innovate in one direction; to do more might have been politically as well as programmatically risky.

A summary table (Table 3) showing PDM2's results is provided below (savings numbers have been rounded). It can be seen from the data that the energy savings anticipated by PDM2's program design are not much of an improvement over PDM1.

TABLE 3: Savings Potential Claimed by PDM2

Retrofit Description (i.e. size of motor)	Incremental Savings (in aMW)	Applicability Factor (minus. Penetration)	Potential Indicated by PDM2 Audits	Modified Energy Savings (in aMW)
VSD > 125 HP	308	30	1.5%	15
VSD 51 - 125 HP	111	20	7.0%	39
VSD 21 - 50 HP	44	20	8.1%	18
VSD 5 - 20 HP	31	20	28.2%	44

PDM2's final conclusion appears to be that variable speed drives, or VSDs, had little conservation potential in their targeted region. PDM2's extrapolations say that only minimal savings could be achieved with variable speed drives because they got hardly any savings. Yet, as has been shown, their conclusion may have been flawed because they used the wrong methods. If they changed their methodology to a process-based approach, it is likely they would have found a great deal more savings. The savings would be in the energy used by motors to produce the customer's product, and part of those savings could be attributable to VSDs. In other words, it is conceivable that VSDs may produce significant savings if the correct methods were used in designing and executing Program Design Method Two, or PDM2.

PROGRAM DESIGN METHOD 3: The Best Approach to Date

The third program design (PDM3) is a pilot program sponsored by a major Northwest electric utility based, like PDM2, on a major technology. PDM3's technology/enduse of choice is Industrial Air Compressors. Its stated aim is to target the substantial Industrial Air Compressor load that was estimated to exist in its service area, and achieve the maximum possible conservation out of this specific load. At this point, PDM3 makes a radical departure. It attempts to break out of the constraints associated with the current industrial paradigm (described in the PDM1 section of the paper). PDM3 assumes that "industrial customers need innovative and customized energy services which includes:

- information on leading industrial energy-efficient technologies
- technical and financial assistance
- plant energy audits by specialized experts
- plant mapping/design for maximum plant efficiency
- operation and maintenance schedules
- training to make informed economic and technical decisions on energy efficiency improvement projects."

In order to provide these services to customers, PDM3 incorporates many of the necessary elements of an "ideal" industrial conservation program approach into its design. A description of the manner in which each of the elements are integrated into the program design and their importance is the bulk of this section.

PDM3 takes a systems (process-based) approach. It focuses on the efficiency of the production of the plant as a whole. The energy service staff will go into plants and audit them to see if there are any places where an industrial energy conservation opportunity (IECOs) would be beneficial to the customer and/or the utility. The auditors would then inform the customer of the IECO or IECOs and of the best way to carry it out. If the implementation of the IECO is cost effective for the utility (that is, the utility can "afford" to give the customer a financial incentive to implement the IECO), then a contract is drawn up to solidify the financial agreement between the customer and the utility. By approaching energy conservation in this fashion, the customer and the utility get what they want. More specifically, the customer has a heightened "awareness of leading industrial energy-efficient technologies program benefits," and the possibility for reducing their electricity bill; while the utility has the opportunity to achieve energy conservation, yet can reserve the option to back out if they decide the IECO is not cost effective by their standards.

The key difference between PDM3 and PDMs 1 & 2 is that the auditors enter the plant with extensive knowledge of IECOs and the latest efficient technologies and their relationship to various processes conducted in an industrial plant. This goes back to the issue of the necessity of a process (or enduse) taxonomy.

The auditors cannot store that kind of information in their heads, so an interactive database (or multiple databases linked together) had to be developed. The first important bank of data is a baseline energy consumption database with the customer's energy consumption broken down by the process/enduse taxonomy. That same taxonomy is linked to IECOs and their savings potential. The IECO's payback and financial investment levels are linked to savings potential. This way the research that has to be done to determine the initial investments and payback periods for various conservation measures (IECOs) is relatively simple and fast.

The PDM3 concept report sums up the major goals of the program as trying to "achieve maximum industrial energy efficiency improvements, industrial customers' satisfaction, and earn industrial customers' trust and confidence." The first goal is addressed by the process-based audits by knowledgeable staff. The second and third goals require incorporation of non-electric benefits. The program purports to "foster and promote common strategic vision of [the utility], its industrial customers, interested local and federal government agencies, and public institutions/organizations to attain clean environment, low cost electrical energy, sustainable industrial growth and competitive edge." The preceding statement is directly related to the three non-electric benefits defined by the IRD: avoidance of capital costs, enhanced enduse performance, and operation costs reduction. PDM3 takes into account the fact that many customers are more interested in how they can cut their labor costs or their environmental fines than how to use energy more efficiently. In many cases, the electric bill is dwarfed by capital and/or operation costs. The auditors enter a plant with these assumptions, and aggressively "sell" the potential IECOs.

PDM3 does require background research and the potential retraining of some staff members, while the first two program designs do not. However, it is designed to defray the cost of education and training in a short period of time, by achieving more savings *per audit*, or *per auditor*, than PDM1 and PDM2. This is because, once they are properly retrained, auditors can expect to be more informed and have stronger backgrounds in efficiency.

PDM3 ensures its own cost-effectiveness by requiring that measures with a low initial investment which have short payback periods are candidates for customer self-implementation (i.e., the utility provides no financial incentive). By the same token, only IECOs with implementation procedures that are cost-effective are financially supported by the utility.

PDM3's program design also uses the eight efficiency gains (defined in the IRD) as one of the types of measures of potential comprehensive savings. It recognizes, as did the IRD, that efficiency gains are responsible for a substantial chunk of industrial conservation potential. In fact, when efficiency gains are incorporated into industrial conservation programs, the potential for energy savings can nearly double. This has been factored into PDM3, and its conservation potential is given in table 5 below.

TABLE 5: Savings Potential Suggested by PDM3

Industry Name (Description)	Approx. Savings Potential
Food	21 %
Stone, Clay, & Glass	20 %
Primary Metals	37 %
Aerospace	16 %
Shipbuilding	20 %
Other (Miscellaneous)	36 %

CONCLUSIONS

At the program design level, there would appear to be no contest. PDM3 is designed to achieve much higher energy savings than either PDM1 or PDM2, as shown by comparing tables 2, 3, and 5. The average savings percent for PDM1 is 8.5 %, and 11.2 % for PDM2. Compare those savings potentials to the average savings percent for PDM3 of 25 %, which is over twice the average potential savings of either PDM1 or PDM2. This confirms that program designs one and two are inadequate methods.

The fact that PDM2 did not anticipate larger levels of energy savings than PDM1 in spite of taking an innovative approach suggests that good intentions are not enough. The strategy of energy conservation itself has to change if there is to be a substantial gain in anticipated energy savings. This was anticipated several years ago by the IRD, which laid out the conditions under which major improvements in achieving energy conservation could be accomplished. PDM3 takes those recommendations, and shows how much more can be achieved if the underlying logistics of program delivery are also improved to match program intentions.

Some people who have worked for many years on the implementation of industrial conservation programs will argue that programs like PDM3 may be designed well but the savings potential they have claimed cannot be achieved. These people justify this belief by the fact that savings of that level have never before been achieved, and therefore the potentials suggested by programs like PDM3 are impossible to attain. They urge the utilities to continue to use program designs like PDM1 and PDM2 because those designs have more "reasonable" savings potentials.

This argument, however, does not withstand "reasonable" scrutiny.

If programs are designed to achieve the same amount of savings as has been proven to be achievable, then the "achievable potential" will always be pegged to historical experience. This would mean that no energy savings arising from new technologies, or new conservation opportunities, can ever be counted in "achievable potential", and industrial conservation programs will merely recycle obsolete program designs because they are the only ones that have been "proved"!

Besides, the percentage savings claimed in PDM3 are not the only ones of that caliber. There now exists sufficient proof that opportunities for energy savings of the order of 20-50% can exist, the only problem being that program designs are not imaginative enough to figure out how to try to go after them. For example, in April 1994, the American Council for an Energy Efficient Economy (ACEEE) put out a paper entitled "Potential for Electric Energy Savings in the Manufacturing Sector" which gave a high value estimate of industrial potential of 38 percent.

Program designs must continually challenge the notion of achievable savings. One can never hit a home run if one does not step up to the plate.

It remains to be seen whether programs such as PDM3 will really succeed in raising the levels of actual energy conservation. This will only be known after several years of field trials. Meanwhile, PDM3 does offer hope to those who would like to see utilities take a more active role in promoting industrial conservation. New, high-yield program approaches to industrial conservation like PDM3 may at last be becoming available as more and more utilities expand their mental horizons. The results should be interesting.

REFERENCES

1 Das, D.K., Healy, J., Battis, J., and Blazina, C.; I.R.D.-- The Industrial Research and Demonstration Project 1987 to 1992 , February 1993

2 University City Science Center, Dictionary of Industrial Energy Conservation Opportunities

3 Strategic Energy Technologies Technical and Market Potential in Food Industry, October 6, 1995

(Additional references provided on request, to preserve confidentiality.)

ACKNOWLEDGMENTS

This paper could not possibly have been written without the generous support and information provided by many people. Bahiru Egziabiher of Seattle City Light provided innovative ideas, concepts and program designs which were far ahead of any of his contemporaries, and (by example) set many of the standards which we are exemplifying in the best program designs like PDM3. Nikhil Gandhi, of Strategic Energy Technologies, provided profound insights, rigorous vision and a willingness to answer my stupidest questions. Margaret Gardner of the Northwest Power Planning Council gave encouragement, advice and information on many related topics. Stacey Hobart of the American Public Power Association supported my research in its earliest stages, was helpful in my obtaining funds to continue it, and has been a source of inspiration for the past two years. And there are others, too numerous to mention, who also helped in putting the paper together.

A special acknowledgment and personal thank you goes to the man who truly made this paper a reality:
Deb K. Das.