Programs for Integrated Industrial Audits: The Audit Process and Case Studies for the NSTAR Eco-Efficiency Program and the NGRID ISOS Program

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ABSTRACT

Typical utility and other system benefit charge-funded efficiency programs for industrial facilities address electric energy saving measures only. Such programs avoid characterization and quantification of other potential savings streams that may be readily observed for an electric efficiency project, and do not address project opportunities at all if there are no electric energy savings. The NSTAR Electric Eco-Efficiency and the National Grid USA Industrial Systems Optimization Study (ISOS) Programs take a different and broader approach in providing industrial technical assistance and funding to their customers. These programs do continue to focus on electric energy efficiency, but also have an explicit goal to investigate other savings opportunities, including: non-electric energy; industrial productivity; water conservation; waste minimization; material usage reduction; and environmental emission reductions. This paper provides a comprehensive overview of a general integrated audit process and its objectives. We then discuss the Eco-Efficiency and ISOS program's alternative mechanisms for screening and qualifying measures (for incentives) that have both electrical efficiency benefits as well as other resource and productivity savings. Use of these alternative qualification approaches can facilitate offering incentives for projects that would otherwise not qualify for program funding. Case study examples of facilities that have participated in both of these programs will then be used to describe the typical types of projects that have been developed.

Broadening the Scope: Motivation for Integrated Industrial Audits

There are several motivating factors for broadening the scope of industrial audits to encompass more than electrical and fossil fuel energy savings potential. Effective incorporation of non-energy benefits in the overall industrial study process presents an opportunity to address the customer's needs more effectively, and to quantify savings that are often inherent, but commonly neglected, in basic energy studies.

Integrated industrial audits and studies (also referred to as Eco-Efficiency or E2-P2 projects, depending on the scope of the effort) have distinct advantages when compared to a traditional energy (or electrical energy) study project. An important set of considerations relates to motivating the customer (or end user) to implement sound projects and providing the customer with the necessary and complete information to facilitate this. There are numerous reasons why energy efficiency projects are never implemented. According to the work presented in the ACEEE study: "Designing Industrial DSM (Demand Side Management) Programs that Work", companies have not implemented all of the cost effective energy efficiency projects identified in their facilities for reasons including:

1. Energy costs are often small relative to other costs; energy efficiency projects are often considered non-strategic, taking low priority when firms allocate scarce capital.
2. Many firms have concerns about the long-term persistence of energy efficiency savings, the amount of production downtime that results from measure installation, maintenance, and the effect process changes have on productivity and on-going operations.
3. Payback periods may exceed customer investment criteria.
4. Companies have substantial technical expertise in their own fields, but often lack the human and capital resources to identify, evaluate or implement energy efficiency improvement projects, and may lack good information about future environmental control costs that may be deferred by efficiency investments.

Other reasons may be less rational, but just as impeding. The investment in energy efficiency may come out of one department's budget, while the savings benefit another's, and the greater corporate good gets lost in turf battles. Or as a manager observes, "we tried something like that once before, and it didn't work," without considering specifically what didn't work, or why, and how it could work better.

Energy efficiency programs have attempted to lower the financial barriers by providing companies with access to the long-term capital and technical resources needed to identify, evaluate and implement energy efficiency projects. Still, there are many projects that are justifiable, but not solely from an energy efficiency or load control basis. Through the integrated audit process, it is possible to identify and quantify additional savings streams that are possible in many industrial energy efficiency measures, thereby making projects more cost effective. Other measures can also be introduced to consideration that would have never received due consideration, however, such projects are worthy of consideration when energy is not the motivating factor. Integrated or eco-efficiency studies can be immensely valuable to customers, and they can readily help to positively effect the decision making process in regards to the key points listed above.

Integrated Industrial Audit Approach Background

Integrated industrial audits or eco-efficiency studies have a broader scope than the traditional facility energy study, which when funded through electric rate system benefit charges, only address electric energy savings projects. Improved economics can often be achieved when all potential savings streams are considered and quantified. These additional savings can represent all fuels energy efficiency, environmental impacts of energy efficiency, manufacturing productivity, water conservation, waste minimization, and the systematic integration of these benefits. The objective of most energy-focused studies is to only consider the energy savings benefits of a list of identified projects. Unfortunately, many of the measures considered do have other savings: these remain unquantified or not considered. There are also numerous opportunities for projects that would never be economic or worthy of consideration for their energy savings alone. Such measures, despite potential benefits to the facility or business, are only considered when a consultant focused on those types of savings or process improvement opportunities is hired. All too frequently businesses pass up these substantial integrated savings, and the important energy component of the integrated savings is never achieved.

Conventional measure-based, energy efficiency assessments focus on increasing the efficiency of existing processes, while integrated assessments focus on restructuring processes to improve productivity, minimize waste, and more efficiently use raw materials. In many cases, the portion of the product that is wasted (scrap) has required significant energy to produce. This is particularly true if the waste occurs late in the production process. If waste is reduced, the energy and other resources required to produce the waste product can be redirected to produce salable product, and the energy and other costs associated with waste disposal can be avoided. Programs that take this approach can reduce production costs and improving product quality.

The integrated audit concept is not new. In fact, about a decade ago the 25 university-based Industrial Assessment Centers (IACs) expanded by adding a waste minimization audit component to their one-day energy audits. Assessment teams that work from these sites recommend specific actions to optimize energy efficiency, minimize waste, and improve the productivity of industrial operations. As an outgrowth of the more comprehensive IAC program and other similar efforts, a number of efficiency programs, consultants, and other organizations have been promoting the integrated industrial audit.

Integrated energy study projects vary considerably. The individual component benefits that may be considered in an integrated audit vary greatly based on the interest of the industrial facility, the funding program, the expertise of the consultant, and other factors. Many of the components are interrelated. For example, projects that improve manufacturing throughput may reduce energy use, water use, and minimize waste. The following sections of this paper discuss each of the savings opportunity components individually. We then describe the Nstar Eco-Efficiency and National Grid ISOS programs, and present case studies projects developed through these programs.

Savings Opportunity Components of Integrated Industrial Audits

As stated, there is no single strategy for all integrated industrial audits. Much of the focus of any study is driven by the needs of the customer, the expertise of the engineers and consultants handling the audit, the budget or scope of the audit, the relevance of certain savings opportunities at a given site, and the structure of any program sponsor for the study. The following paragraphs discuss the most typical categories for savings consideration.

Energy Efficiency and Demand Control: An All Fuels Approach

Typical energy studies supported through efficiency programs focus on electric energy since most programs are supported through system benefits charges on electric bills. For most efforts, electric energy efficiency, or energy efficiency in general, remains the fundamental theme. But moving beyond electric energy efficiency alone is the first major difference in integrated industrial audits. The scope of integrated industrial audits is typically expanded to include appropriate consideration for all fuels (natural gas, fuel oils, other fossil fuels, purchased steam, etc.). This broadening of the energy scope can be invaluable for the customer. Many processes that fall under consideration for electric efficiency studies also have savings potential for other energy sources that supply the same manufacturing operation. The multi-fuel consideration also facilitates objective consideration of properly selecting and optimizing the mix of fuels for specific processes or facility operations.

Environmental Impacts of Energy Efficiency Measures

The next area of consideration that is very common in integrated industrial audits involves inclusion of calculated energy savings-based environmental impacts. Such impacts can be from either direct on-site fossil fuel burning or indirect emissions associated with the power facilities that generate the electricity used at the site. These specific emission reductions under consideration can include carbon dioxide, nitrogen oxide, sulfur dioxide, particulates, and other trace emission gases. Calculations can be based on readily available data for electric energy generation in certain regions, or emissions per unit of fuel used directly on site.

Industrial Productivity

The savings opportunities in the category of industrial productivity is often of considerable interest to manufacturing facilities, since the emphasis moves to the fundamental rational for a business' existence. In this category the focus is on the product and how it is produced rather than on the utility services that are associated with the process. Using energy efficiently can be a benefit to a business, but energy use and control of it is never the fundamental reason why some firm is doing business. Manufacturing customers often view industrial productivity as one of the fundamental elements of their business (like marketing or sales), and recommendations developed in this category are associated with improving the overall bottom line of the companies. Specific areas for investigated include:

- **Increasing Overall Manufacturing Throughput.** Throughput is defined as the quantity of finished (or intermediate) product that can be produced through some process or facility-wide in a given time. Increasing throughput means there are either more products available for sale, or that less time and cost is required to make each unit.
- **Control or Elimination of Process Bottlenecks.** Bottlenecks are "slow" aspects in the sequence of events of some process that constrain the overall throughput of the process.
- **Improving Intermediate and Finished Product Quality Control.** Improving quality control will limit the amount of re-manufacturing that must be done. Techniques to identify quality issues early in the overall process can be of vital importance, since this will limit the cost put into later stages of the process for sub-standard materials.
- **Management of Raw Material and Finished Product Inventories.** This involves effective purchase, storage, and handling of both raw materials and finished products. Enhanced practices can lead to reduced storage space needs and reduced investment in items that do not have immediate use or market.

Effective consideration of industrial productivity opportunities requires a different perspective than that often associated with the skill-set of energy efficiency experts. However, it is certainly possible to leverage those energy efficiency engineering skills in the development of sound associated expertise in assessing productivity opportunities.

The end result of an industrial productivity assessment is a list of recommendations that will result in a combination of reduced cost per unit of production, a higher production rate, improved product quality, optimized use of utilities and other operating costs, and better management of raw materials, intermediate materials of production, and the final product. Many energy efficiency enhancements and industrial productivity enhancements are interrelated. For example, some state-of-the-art all-electric injection molding systems reduce energy use (by elimination of large hydraulic drives) and have concurrent increased throughput. The net result is a reduced energy input per unit of production and an increase in the quantity of units produced.

Water Efficiency and Conservation

Water efficiency means using improved technologies and practices that deliver equal or better service with less water. In contrast, water conservation attempts to curtail water use by doing less with less water. Water conservation may also include day-to-day demand management of how and when water is used. It is common to hear the words water conservation used synonymously with water efficiency, but there are definitive differences.

In industrial processes, water is used for a multitude of applications, including process cooling and heating, space cooling, stock water, compressed air system cooling, and for cooling tower systems. There are many opportunities to reduce water use through improved process heating or cooling containment and management, improved water treatment, and water system demand management. Numerous process and industrial energy efficiency measures have associated opportunities to concurrently reduce water use.

Waste Minimization and Material Conservation

Waste minimization includes: source reduction practices that reduce or eliminate waste generation at the source; and environmentally sound recycling practices, where source reduction is not economically practical.

Source reduction includes any practice that reduces the quantity of waste or pollutants entering a waste stream prior to recycling, treatment, or disposal. Examples include: equipment or technology modifications, reformulation or redesign of products, substitution of less toxic raw materials, improvements in work practices, maintenance, worker training, and better inventory control.

Recycling includes the use, reuse and/or reclamation of waste residuals. A material is "used or reused" if it is used as an ingredient in an industrial process to make a product or, or if it is used as an effective substitute for a commercial product. A material is "reclaimed" if it is processed to recover a usable product, or if it is regenerated.

The recommendations that are defined in this savings category can indicate that the product can be produced using less input material, or alternative materials, and that some of the waste stream can be reused in the process. Cost savings in this category can be considerable.

Value of Integrated Audits

In order for management to make the best decisions regarding energy and other resource conservation projects, they must understand all of the costs and benefits associated with an investment in *general* efficiency (process, energy, water, etc.), and make decisions based on whether the company's total net benefits are greater than total net costs. As stated, the various efficiencies are interrelated. In an integrated industrial audit it is critical that all savings related to such projects — energy and non-energy — be included in the financial analysis so that management understands the complete financial ramifications of a project. Net benefits should reflect all applicable savings possibilities, including:

- Energy and other utility savings
- Reduced costs of environmental compliance
- Improved worker safety (resulting in reduced lost work and insurance costs)
- Reduced production costs (including labor, raw materials, and energy)
- Reduced waste disposal costs
- Improved product quality (reducing scrap and rework costs and improving customer satisfaction)
- Improved capacity utilization
- Improved reliability

The importance of quantifying all benefits is exemplified below in the case study presentations, in which energy efficiency projects' non-energy benefits can exceed energy savings. Since each project is unique and uniquely interacts with other aspects of the manufacturing operation, it is difficult to accurately estimate average total benefits that result from energy efficiency projects. However, it is a critical step in the corporate capital-investment decision-making process to estimate all costs and benefits related to a proposed investment before the investment is made. Enhanced corporate image is one benefit that a company will probably not attempt to quantify, but it should still be taken into account qualitatively when making decisions with environmental benefits.

Overview of the Programs

This paper presents the results of two studies that were sponsored through the programs of Nstar Electric and National Grid. Both programs have great similarities, and have objectives to 1) provide enhanced service to customers, 2) expand the perspectives of customers and the efficiency industry, and 3) address customer projects that would not qualify on the basis of electric savings alone.

The first two objectives are achieved through the integrated study process and report. Effective integrated studies serve as valuable tools for assessing facility and process enhancements. As stated earlier, costly projects may never be implemented if assessed on the basis of electrical energy savings alone. Understanding the interplay between energy and other savings streams can serve to enlighten the customer and motivate them to investigate projects that would have otherwise received little consideration.

Both of these programs continue to focus on measures that save electrical energy. However, projects that are too costly to qualify for incentives (on the basis of electric savings alone) can now qualify if there are additional (non-electric or non-energy) savings benefits that can be quantified. These additional savings can include any of the aforementioned categories discussed in this paper: non-electric energy; environmental benefits; productivity enhancements; reductions in raw materials; waste minimization; and water savings. Now, in order to qualify for savings, all energy and non-energy savings are quantified. Non-electrical energy savings are differentiated from electrical energy savings. Then, the project implementation cost is developed. This project cost, which may have traditionally been too high to result in a cost-effective project (one that qualifies for incentives), is proportionally decreased or prorated consistent with the percentage of overall savings that is energy electrical energy based. This component of the project implementation cost is now used in the program's project screening tools. While overall incentives may be lower since only a prorated fraction of the project cost is considered, the opportunity exists for sound and economically advantageous projects to receive incentives.

Case Study One: Nstar Eco-Efficiency Study for Rodney Metals

The Eco-Efficiency Program study sponsored by NSTAR Electric at Allegheny Rodney Metals primarily focused on electric energy savings, but included other source stream savings in accordance with the general program requirements. In addition, the study report presented emissions savings associated with each measure. This study was completed in December of 2002, and facility management are developing plans to act on project implementation.

This Allegheny Rodney Metals facility was established in 1945 as a manufacturer of custom, thin film stainless steel, titanium, copper, brass, and other alloy metal products. The finished product is in the form of a roll of thin metal sheet. These rolls of metal sheets are used by Allegheny Rodney Metal's customers to produce an array of products.

The manufacturing process at Allegheny Rodney Metals involves roll milling, annealing, and slitting of raw metal sheets. These raw metal sheets are transformed into metal sheets of customer-desired thickness and properties. Several milling machines and furnaces are involved in the manufacturing process.

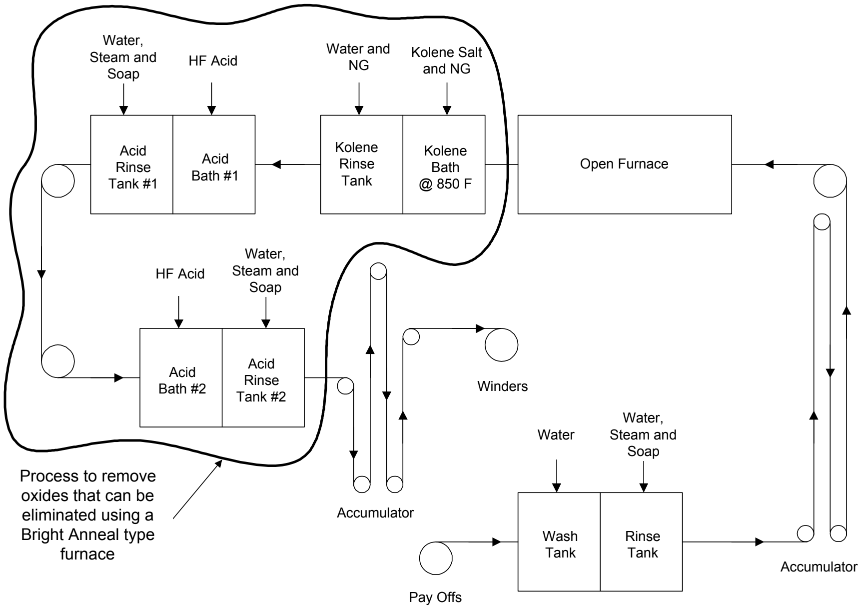
Energy Efficiency Measures Recommended

The Eco-Efficiency study at the Rodney Metals facility resulted in eight distinct energy saving measures, the first three of which had multiple savings streams. The eco-efficiency energy measures recommended at Allegheny Rodney Metals are 1) to convert open gas furnaces to bright anneal furnaces, 2) to replace R22 refrigerant on rooftop units with R417A refrigerant, and 3) to replace hydraulic pumps on mill center guides with electro-mechanical equivalents.

The following paragraphs describe those measures that would save other resources in addition to electrical energy.

Measure 1. The facility has eight furnaces that heat-treat the metal rolls processed in the five milling machines. According to the facility personnel, the furnace operation is a process bottleneck and hence, any improvements to the furnace would lead to increased productivity. Currently, a few of the existing furnaces are bright anneal-type furnaces. Such furnaces heat treat using electric heat in a hydrogen-nitrogen atmosphere. Since the metal is isolated from the atmosphere (oxygen), the metal being annealed is free from oxides and does not require subsequent chemical treatment. In contrast, in the open gas fired furnaces, oxides are formed and the annealed metal requires chemical treatment for cleaning the oxides. Chemical treatment involves purchase and disposal of large volumes of hydrofluoric acid, nitric acid, soaps, salts, and water. In addition, the chemical treatment also requires electrical energy. Converting the open gas-fired furnace to bright anneal furnace will eliminate the need of chemical treatment, thereby saving chemical materials and mitigating associated disposal costs, water costs, and natural gas and electrical energy. In addition, according to the plant personnel, bright anneal furnaces have greater production speeds than open gas-fired furnaces. Thus, this conversion has associated productivity gains. After the open gas-fired furnaces are converted to the bright-anneal type, the use of hydrogen and nitrogen will increase. The existing and proposed furnace operations are schematically shown in Figures 1 and 2, demonstrating the elimination of many process steps. This results in energy, productivity, waste reduction, and environmental benefits.

Figure 1. Existing Furnace Operation



Eco-Efficiency measure 2. The offices and few production areas are cooled using fifteen (15) rooftop HVAC units. These units use R22 refrigerant in the compression cycle. Our investigations demonstrated that a new refrigerant, R417A, has been used as a replacement for R22 refrigerant in Europe for more than four years. R22 refrigerant, although popular, has been subjected to regional restrictions due to its ozone depleting potential (ODP). R417A refrigerant is a non-ozone depleting substance and hence, preferable. R417A refrigerant can be used with the same equipment as that for R22 without any additional equipment modifications. The comparison charts for both refrigerants are provided below, indicating that replacing R22 with R417A would result in 0.05 ODP savings.

Eco-Efficiency measure 3. The Rodney Metals milling machines have center guides, which are used to center the raw metal roll prior to milling operation. The centering process requires a few minutes during which the hydraulic pumps circulate hydraulic oil for actuation. Once centered, the hydraulic motors run idle until the next cycle. Electro-mechanical alternative such as electric motors to achieve this actuation can be used instead of hydraulic motors. This will eliminate the use of hydraulic oil and will operate the motor only when needed. The rest of the time the motors will shut off, savings a significant amount of energy. This measure would save approximately 400 gallons of hydraulic oil in addition to electrical savings.

Figure 2. Proposed Furnace Operation

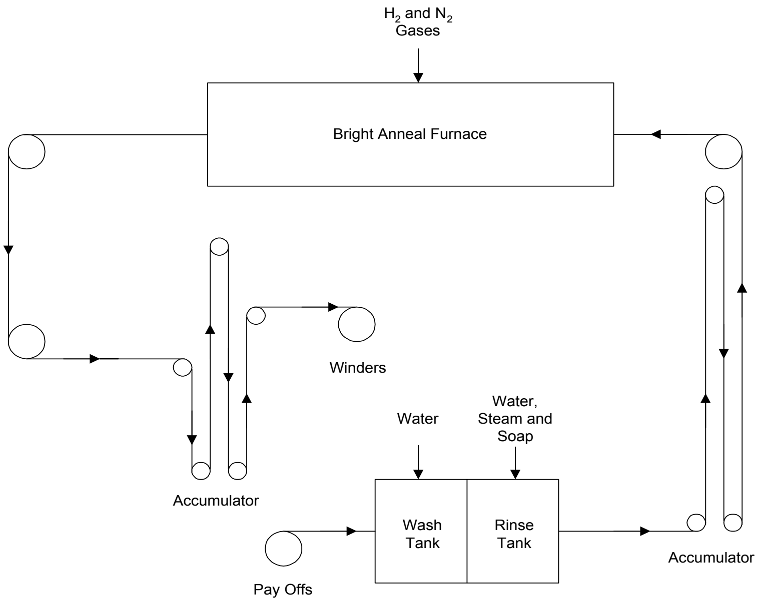
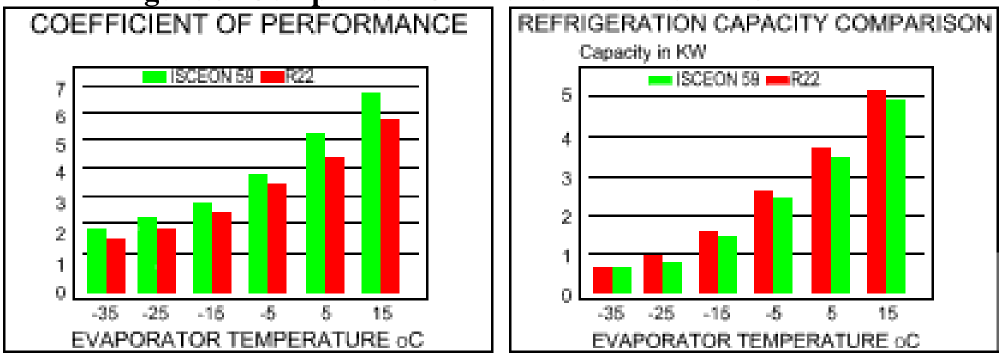


Figure 3. Comparison Charts for R22 and R417A



(Courtesy – Rhodia Ltd. ISCEON Products)

Resource Savings Estimates

The Eco-Efficiency study at Allegheny Rodney Metals demonstrated the potential for excellent energy saving opportunities coupled with other resource stream savings. The estimated non-electric cost savings are approximately 1.2 million dollars. The total annual cost savings are estimated to be around 1.4 million dollars with estimated implementation cost of 2.4 million dollars. The study resulted in emissions savings of approximately 3.6 million pounds in CO_2, 15,000 pounds in SO_2, 4,500 pounds in NO_x and 600 pounds in CO.

The tables below summarize the resource savings and emissions savings from all the eco-efficiency measures described above.

Table 1. Summary of Resource Savings for Eco-Efficiency Measures

Resource	Annual Savings	
	Quantity	Dollars
Electric Demand (kW)	146	$8,273
Electric Energy (kWh)	1,405,398	$117,071
Natural Gas (MMBtu)	47,290	$290,312
Salt (lbs)	1,600,000	$700,000
Water (gallons)	22,425,600	$2,731
Hydrofluoric Acid (lbs)	260,000	$163,800
Nitric Acid (lbs)	500,000	$72,900
Soap (lbs)	13,641	$10,777
Chrome Sludge Disposal ($)	-	$45,000
Ozone Depletion Potential (ODP)	0.05	-
Hydraulic Oil (gallons)	420	$1,554
Total		**$1,410,864**

Table 2. Summary of Emissions Savings for Eco-Efficiency Measures

Emissons	Quantity (lbs/yr)
CO_2	2,487,877
CO	359
SO_2	9,415
NO_x	2,825

Case Study Two: National Grid ISOS Study for Riverdale Mills

The overall objective of this ISOS process study was to evaluate the resource use characteristics and differences between a traditional strand galvanizing line system (using convective heating and pickling for removal of scale) and a “first-of-its kind” strand galvanizing line (using induction heating in a nitrogen-hydrogen atmosphere). The main objective of the process is to zinc-coat low carbon steel (C1006 – C1010) that range in size from 8 to 22 gauge. This project has been successfully installed and the customer is very happy with the results achieved, both from and energy and productivity perspective.

The baseline process involves annealing of steel wire material at about 1,350°F using electric resistance heating in an ordinary air environment. Heat treatment in an air environment results in the development of oxidation scale on the surface of the wire, which would be detrimental to the subsequent galvanizing tasks. The annealed steel wire is quenched, by spraying 55°F well water, to about 200°F. The wastewater from spray cooling can be discharged directly to the river at no cost. The next step involves pickling where the wire stock is run through hydrochloric bath and then thoroughly cleaned by spraying pre-heated water. The wire stock is dried using a small fan system. The water from spray cleaning requires treatment. To make the wire material receptive to zinc surface galvanizing, zinc ammonium chloride flux is applied to the wire stock. The final step involves zinc galvanizing where the wire material is constantly run through zinc in galvanizing tank, achieving temperature about 825 °F, called the galvanizing temperature. Natural gas-fired heaters are used for heating the wire. This galvanized wire is spray cooled. The wastewater from spray cooling requires treatment.

The optimized system involves annealing of the wire stock at 1,350°F in a controlled environment using induction heating. Before passing the wire stock through the induction furnace, the following operations have to take place, thorough rinsing by pre-heated water, ultrasonic cleaning and fan blow-off. The controlled environment contains 95% nitrogen and 5% hydrogen and requires 5 gas changes per hour. The next step is zinc galvanizing, which is a unique process. The hot wire from the furnace directly enters the galvanizing zinc kettle. The zinc kettle is supplied with supplemental heat by an induction heater to melt the zinc in tank. The wire stands run continuously through the tank and are spray cooled as it leaves the system. The wastewater from spray cooling requires treatment. The wastewater treatment plant consists of a settling tank / filter press system. The final wastewater product is a sludge retrieved by a waste disposal firm.

Resource Savings Results

Electricity is used in baseline process for resistance heating of steel wires, for pumping quenching water, for pumping acid pickling chemicals, for pumping rinse water after galvanizing. Electricity is used in the optimized process for electric induction heating of the wires, pumping water for initial and final rinse, and finally to heat zinc for galvanizing. While the resistance heating in baseline process is 100% efficient, most of the thermal energy is lost to the environment. The induction furnace directly heats the wires and the wires in turn heat the gas environment. The estimated overall efficiency of the resistance-heating furnace is about 40% as compared to 63% for induction heating furnace. Preliminary estimates indicate a demand savings of 405 kW and energy savings of about 1,200,000 kWh per year.

The water used in the baseline process is mainly for quenching wire strands, for rinsing pickling chemicals and for rinsing zinc after galvanizing. In optimized process, water is used for initial and final rinse only. Since well water is used for all the processes, there is no associated actual cost differential. The wastewater from each rinse after treatment is converted into sludge, which is required to be disposed appropriately. An estimated 19.8 million gallons of water per year is required for baseline process as compared to an estimated 2.7 million gallons per year for optimized process. This reduces the wastewater sludge disposal cost approximately by $11,000 annually.

In the baseline process, natural gas is used to reheat the wire stock after pickling process. Natural gas use is eliminated in the optimized process and based on our calculations there will be a natural gas savings of about 30,000 therms.

The chemicals used in baseline process are hydrochloric acid for the pickling process and zinc ammonium chloride as a flux. These chemicals are not required in the optimized process; instead nitrogen and hydrogen are utilized to maintain an inert atmosphere in the induction furnace. Based on the results presented, we conclude that the optimized system is the most favorable system to adopt. The overall savings from all the resources is about $115,000 per year. The incremental implementation cost is approximately $380,000. Table 3 summarizes the resource savings for the process efficiency measure discussed above.

Table 3. Summary of Resource Savings for Process Efficiency Measure

Resource	Annual Savings	
	Quantity	Dollars
Electric Energy (kWh)	1,216,760	$91,257
Natural Gas (Therms)	29,970	$12,767
Water (gallons)	17,000,000	-
Wastewater Treatment (gallons)	3,000,000	$11,250
Total		**$115,274**

Conclusions and Recommendations

In this paper we have described the general process of the integrated industrial audit. This process provides an opportunity to consider far more than just energy when one is developing measure opportunities and quantifying potential savings. We have also described representative projects from two programs that focus on such integrated industrial audits. The case studies presented demonstrate that there is considerable savings inherent in certain projects for which only energy savings has been traditionally quantified.

Efficiency programs of the type discussed here can demonstrate enhanced benefits, both from their customer's and from a societal perspective. Such programs allow the sponsoring organizations to quantify and receive credit for those benefits. Since businesses make most decisions based on bottom-line impact, it makes sense to look at energy efficiency as part of overall 'efficiency' (e.g., pollution prevention, process efficiency, enhanced productivity, water efficiency, waste and material management) in order to account for all the savings that a business will realize from projects. In order to make a more compelling case for energy efficiency, it is critical to understand the decision-making process of business management. This means understanding the interrelationships of various forms of efficiency, and measuring costs and benefits so that the financial ramifications of project proposals are fully understood and can be communicated to management in terms with which they can identify. Combining the benefits of energy efficiency with other interrelated savings opportunities, and viewing them simply as efficiency is an opportunity for businesses to more effectively achieve their goals.

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