Engineering Consultants, Utility Incentives and Utility Field Staff

Equals Industrial Efficiency

Tim Newcomb, Seattle City Light

Introduction

Seattle City Light (SCL) has promoted equipment retrofits which increase electrical efficiency in commercial and industrial establishments since 1980, and incentive payments to our customers continue to provide strong motivation for the replacement of inefficient equipment. Survey responses from commercial and industrial customers indicate clearly that incentives are important to the success of these projects. Promoting the retrofit of efficient equipment in the larger industrial plants has always posed special problems because of the complexity of industrial processes; yet the biggest opportunities often exist in these large plants.

Three common barriers to the development of industrial efficiency projects are (1) the tendency for plant engineering staff to be overcommitted and therefore without time to investigate opportunities for energy efficiency; (2) the lack of specialized industrial engineering knowledge among SCL's staff, and (3) the lack of plant capital budget to implement efficiency measures . Engineering experience with industries of a specified type is often required before an engineering firm can recommend realistic energy efficiency measures in a plant.

This paper cites three examples to show that a three-pronged approach can suffice to make industrial retrofit projects happen. The relative importance of incentives, specialized engineering help, and utility staff legwork varies from case to case, but all three make a difference.

Case 1 : Northstar Casteel Products Foundry

The Northstar Casteel Products foundry produces steel castings for heavy industries such as the railroad, trucking, logging and mining industries. Low alloy steel, manganese steel, and some stainless steel are the most common alloys used for these products. The induction melting furnaces use roughly sixty percent of the electric energy used in this plant and are a good target for opportunities to improve electric energy efficiency.

When the foundry manager asked us to consider providing them an incentive for a furnace upgrade we took the opportunity to use EPRI's Partnership Program for Industrial Competitiveness (EPIC) which provided a foundry expert, Dr. John Svoboda. Dr. Svoboda visited the plant for a day and a half in late 1994 and produced a report listing eight changes in equipment or practice that would bring significant benefits. Figure 1 displays these changes.

Figure1
Summary of EPIC's recommended changes at the
Northstar Casteel Products steel foundry by Process Metallurgy, Inc[3]

Recommended change	Anticipated Benefits	Estimated Payback
Install new, efficient induction melting equipment	Electricity savings Reduced indoor air pollution	4 years
Install efficient ladle preheater	Electricity savings Natural gas savings	1.5 years
Scrap reduction program	Electricity savings Lower Unit costs	1 year
Waste heat recovery on natural gas oven	Natural gas savings	Requires engineering analysis
Ladle pouring practice improvements	Reduced scrap	1 year
Computerized rigging analysis	Reduced scrap Greater customer satisfaction	Requires more detailed analysis
Compressed air system maintenance	Electricity savings	Immediate

3. Based on "Plant Survey Report for North Star Casteel Products, Inc., A final report prepared for Seattle City Light, EPRI Partnership for Industrial Competitiveness", 1995, Process Metallurgy International, Inc, of Arlington Heights, Illinois.

In 1996 Northstar completed the installation of a new induction furnace melting system that included a new power supply capable of supplying both active furnaces at once, a new closed-loop water cooling system, new furnaces, furnace fume rings, furnace covers, and an automatic program to power the furnaces during the sintering of new furnace linings. This cost the company approximately $ 400,000. Whereas the two old power supplies had a combined total of 625 kW, the single new power supply could deliver 1,000 kW.

SCL's incentive program calculates its grant amounts for industry based on the estimated improvement in electrical efficiency per unit of product, or energy intensity. For the foundry, the grant was computed as the product of the estimated reduction in kWh per ton of steel melted times the anticipated production rate of the new furnaces in tons per year. The logic behind this computation is that it is important to compute the reduction in electricity use of new efficient equipment , given the plant is determined to increase its production rate. SCL computed the baseline consumption per ton using the metered electrical data and production data from the foundry for one year, arriving at an average number of 857 kWh/Ton of melted steel. By today's standards this is an inefficient induction melting system, and the bulk of the inefficiency in this case can be attributed to the power supply itself which was old and subject to occasional breakdowns.

The metered electrical data and production data for May and June of 1996 support an average consumption of the new power supply and furnaces of 661 kWh per ton of steel. This is a reduction of 196 kWh/Ton , or 22.8 %. The increase in production amounted to 45 % ! The explanation for this lies principally in the greater power of the new melting power supply, and partly in the better power density of the power supply.

The process of melting scrap steel, and the addition of chemical additives needed to make the desired alloys, release significant amounts of fumes including oxides into the air. Through this project the plant achieved a significant reduction in indoor air pollution because the covers and fume rings on the furnaces prevent a significant fraction of the fumes from escaping into the plant. The Puget Sound Air Pollution Control Agency indicated their satisfaction with the corresponding reduction in fugitive emissions from the plant in a letter to SCL in late 1996[5] &.

---

[5] Letter from Melissa McAfee, Field Inspector at Puget Sound Air Pollution Control Agency, 1996.

This project probably would have proceeded without the intervention of SCL, although the SCL incentive represented 30 % of the project cost. Even when the incentive is subtracted from the project cost, the simple payback to the plant based on energy savings alone was nearly ten years. SCL field staff contributed many hours of statistical analysis of electrical meter data to help the plant pinpoint the sources of electrical inefficiency. Plant engineers would not have undertaken this work themselves, although they made approximate computations and used vendor estimates of the electrical efficiency of the new equipment. The SCL pre-project estimate of electrical savings from this project was 7.8 % above the actual measured improvement in electrical intensity following the installation of the new equipment.

The intervention of SCL and of Dr. Svoboda helped to persuade the company to use furnace covers and fume rings which bring both additional energy savings and greater pollution control. Engineering calculations suggest that furnace covers are responsible for perhaps fifteen percent of the achieved electricity savings, assuming that the covers are used once the scrap steel is loaded into the furnaces.

If the foundry adopts other recommendations for electrical efficiency made by Dr. Svoboda in the future, this project will reap additional benefits for SCL and for the foundry.

Summary

The most important stimulus provided by SCL for this project was the incentive of $ 121,600. This money undoubtedly made it possible for the plant to purchase additional features that it would not have purchased otherwise, perhaps including the furnace covers.

The information supplied by Process Metallurgy was very detailed and covered areas that the plant should revisit in the future. SCL will remind the foundry of the other recommendations in the EPIC report in the future. In addition, Dr. Svoboda made it clear to the plant engineer that furnace covers would be a benefit to them in several ways.

SCL provided a very significant amount of analysis concerning the inefficiency of the old electric power supply and the electrical benefits of the proposed new equipment. It is likely that this information provided comfort to the foundry staff as they considered the pros and cons of purchasing the new equipment.

For all of these reasons the project was improved through the utility's intervention.

Case 2 :   Ball-Foster Glass Company

Ball-Foster (BFG) makes glass bottles and jars, principally for beverages. It is Seattle City Light's third largest industrial customer, and a natural target for electric efficiency projects. The air compressors in the 50 pound, or low pressure, system provide most of the compressed air used to form the bottles from hot glass. The total horsepower for the 50 pound system is approximately 3,100 HP , depending upon which compressors are out for maintenance. The compressed air company in Seattle that services the reciprocating air compressors, R & R Compressor Services, demonstrated for us that a large number of valves and pipes are left open during production to drain moisture from the 50 pound air system. Vented compressed air is a tremendous waste of electrical energy, and air compressors waste 80 % or more of the input energy in any case.

The reason why pipes and valves are left open to remove moisture is that water which gets to the hot glass which is formed into bottles causes defects in appearance, which make the bottles unacceptable to the customers. We were interested in investigating ways to dry the compressed air so that these pipes and valves could be closed, reducing the electricity needed for the compressed air.

The Ball-Foster plant is a very large plant, extending perhaps 0.4 miles from north to south. The manufacturing of the glass containers takes place at ten IS machines which receive precisely measured gobs of molten glass, and blow them out to the desired shape in a two-step process. Bottle blanks are made in the first step, then transferred to another mold where the final shape is achieved. Most of the air compressors are located in one of five locations along the north-south axis of the plant, so that long runs of piping are required.

Since SCL had recently signed a contract with Scales Compressor Services of Carle Place, New York for audits of compressed air systems, we asked Mr. Bill Scales to inspect this low pressure system at BFG. Mr. Scales had the great insight to see that the root of the problem was fouled cooling water resulting from contamination of open cooling towers. The fouled water reduced the effectiveness of aftercoolers and towers, diminishing the ability of this equipment to remove moisture. This plant is surrounded by one limestone and two cement plants, and in addition uses raw materials including sand and lime. These materials make their way into the open loop cooling towers and contaminate the cooling water. Mr. Scales advised that it would be unwise to install refrigerated air dryers or new aftercoolers to dehumidify the compressed air without removing contaminants from the cooling water, since the new equipment would eventually be fouled and become useless. A summary of Mr. Scales' recommendations is presented in Figure 2.

Figure 2
Recommended Measures to Improve Electrical Energy Efficiency of the 50 Pound Compressed Air System at Ball-Foster Glass' Seattle Plant[5,6]

Electrical Efficiency Measure		Estimated Benefits	Estimated Costs
1.	Reduce Air Leaks	1,080,000 kWh/Yr $ 35,363 annually	$ 4,000
2.	Clean Water System	2,520,000 kWh/Yr $ 82,500	$ 150,000 - 280,000
3.	Reheat Compressed Air	1,633,740 kWh/Yr $ 53,500	$ 60,000
4.	Reduce Air Pressure	1,724,288 kWh/Yr $ 56,460	$ 0

[5] Based on "Air Compressor Analysis Report Prepared for Ball-Foster Glass Company", January 1996, William E. Scales, Scales Compressor Corporation, Carle Place, New York.

[6] NOTE : Subsequent text indicates significant changes in equipment and approach from the recommendations in this report.

The report by the Scales Compressor Corporation depended heavily on data collected by SCL staff that quantifies both the number and size of the leaks from open valves and the electrical power used to generate the 50 pound air. The cost of having this consultant visit the plant repeatedly to collect such data would have been prohibitive. These measurements have been repeated several times and provide a good picture of the operation of the system before the retrofit. Figure 3 summarizes data from visits to the plant in 1995 and 1996.

Figure 3

Estimates of Total Electrical Power Use and Total Leaking Air Volume in The 50 Pound Compressed Air System During Production

---

Estimated total power used by air compressors[7]:

August, 1995	2,113 kW from 2,725 HP of compressors operating at partial or full load. Plant in production.
November, 1996	2,165 kW from 2,775 HP of compressors operating at partial or full load. Plant in production.
December, 1996	1,970 kW from 2,500 HP of compressors operating at partial or full load. Plant in production.
December, 1996	950 HP of compressors operating with production idle.

Estimated total venting of compressed air at pipes and valves[8]:

August, 1995	7,119 CFM

---

[7] This estimate based on 40 readings at each compressor, using amperage and voltage data from air compressor meters.

[8] This estimate based on precise measurement of valve and pipe opening sizes, and an estimate of 50 pounds of gauge pressure.

SCL's approach to achieve the electrical energy efficiency improvement was to provide an incentive to the company for the purchase of new closed-loop water cooling equipment, new or refurbished aftercoolers, and new air dryers. Therefore, we requested a meeting with the corporate engineering-staff to present our case and to determine their commitment to improving the 50 pound air system's electrical efficiency. Corporate engineering staff responded that the improvements recommended in the report could become a model for other plants in their company and that they were ready to undertake the work.

SCL compiled the data about present system operation that was needed to support an incentive proposal to replace most towers with closed loop cooling systems. Replacement or cleaning of many of the existing aftercoolers and the addition of refrigerated dryers would complete the project to dehumidify the compressed air and permit the closing of all valves and pipes currently kept open. A very conservative estimate of 5,000 CFM of wasted compressed air was used in the incentive calculations despite the data presented in Figure 3 above which suggest a figure closer to 700 CFM. The estimate was purposely conservative because plant personnel indicated that some leakage occurs inside the bottle-forming machines when they are idle.

The SCL field representative wrote an evaluation plan for the company recommending the use of dewpoint sensors in the compressed air lines. It is SCL's conviction that data about the changes in humidity levels and about the absolute humidity levels following successful implementation of the new equipment would be useful in two ways. The drop in humidity will serve to convince the plant staff that it is indeed no longer necessary to keep valves and pipes open to keep water out of the compressed air. And the data may assist in troubleshooting in case there are points in the system where the compressed air is not sufficiently dried by the new equipment.

The final proposal for this project included the efficiency improvements listed in Figure 4.

Figure 4
Seattle City Light Project to Improve Electrical Efficiency of The 50 Pound Compressed Air System at Ball-Foster Glass Company

Equipment	Purpose	Cost
Cooling fans	Replace vented compressed air used for cooling workers	$ 650
Aftercoolers (New or refurbished)	Improve dehumidification of compressed air	$ 30,753
Leak surveys for all systems	Identify and quantify the venting of compressed air before and after installation of equipment	$ 8,000
Closed-loop industrial coolers including installation and piping	To cool cooling water without contamination	$ 169,080
Automatic drains and receivers or traps	To remove moisture from the compressed air	$ 20,900
Dew-point probes	To quantify humidity in the 50 pound compressed air and document reductions in humidity following installation of equipment	$ 5,300
Refrigerated air dryers including installation and piping	Bring the dewpoint down to 38 Degrees F	$ 257,333

The total SCL grant was $ 393,933, contingent upon a reduction in compressed air output in the system of 4.53 gWh of electricity annually. Anecdotal evidence confirms what seems obvious, namely that the company was convinced to undertake this project by an incentive amounting to 80 % of the total cost including installation.

The equipment is currently being installed, and the target date for switch over to the refrigerated dryers and cooling loops is August, 1997. Both SCL and the plant engineers recognize that bottle machine operators will need to be brought into discussions about the need to close off valves and pipes. The use of data from the dewpoint sensors should be instrumental at this stage of the project.

There are a number of anticipated "non-energy " benefits from this project, which are listed in Figure 5 .

Figure 5
Expected "Non-energy" Benefits from Ball-Foster Glass 50 pound Compressed Air Energy Efficiency Project

---

1. At the present time the oil used to lubricate the bottle-forming machines is hydrophilic due to the water content of the compressed air. When this oil is accumulated in the plant water recycling system it becomes a sludge that is difficult to dispose of. Non-hydrophilic oil can be used after the air is dried.

2. Cooling water jackets of the air compressors which now are fouled will remain relatively contaminant-free . Water compartments of aftercoolers will also remain relatively contaminant-free. This will reduce air compressor energy requirements, reduce operations and maintenance costs and equipment downtime, and lengthen the lifetimes of the air compressors and aftercoolers.

3. Some reduction in the rate of production of defective bottles may be anticipated. This will be measured by comparing rates of defective product before and after the installation.

4. Water cooling system operations and maintenance costs will be reduced due to the removal of airborne contaminants.

Summary

The advice of the consultant, Scales Compressor Services, was a key to the successful development of this project. Mr. Scales' logical approach to the existing problem of cooling water contamination in the 50 pound compressed air system at Ball-Foster Glass provided convincing arguments both to SCL staff and to the glass plant staff. He facilitated communication with all the plant personnel from the front office managers to the equipment maintenance staff.

Some of the consultant's recommendations were not followed, either because they turned out to be impractical when applied to this plant, or because the corporate engineering staff were more familiar with other solutions to the same problem. This company makes glass containers at many plants around the world. The company is used to solving certain problems in established ways that have worked in the past.

The SCL Commercial and Industrial planning staff in charge of developing an air compressor efficiency program had the wisdom to select an experienced and effective consultant and to make him available on short notice for this project.

The SCL incentive made the project so attractive financially to the corporate engineers that they could not turn it down. However, their acceptance of this project was the result of almost two years of project development by SCL which included data collection, redrafting of project proposals, communication and consultation with consultant, with plant maintenance staff and air compressor vendors.

For all these reasons, the three- pronged approach was necessary get the project under way and the liklihood that this project was a free-rider is nil.

Case 3 : The West Point wastewater treatment plant

The West Point wastewater facility underwent a complete overhaul between 1990 and 1995 to add secondary wastewater treatment equipment and increase the capacity to 300 million gallons per day (MGD). The plant serves the City of Seattle and other nearby communities and receives combined sewer overflow as well as wastewater. The electrical load of the new facility is about 6.8 average megawatts, though the consumption varies seasonally, rising spectacularly during periods of winter rain and declining during the summer.

SCL joined The Electric Power Research Institute's (EPRI's) Municipal Water and Wastewater Project in order to bring an experienced consultant in wastewater treatment energy efficiency to the new plant in 1995 for an electric efficiency audit. Plant management recognized that once the plant operations became stable and predictable it would be advantageous to reduce electricity costs as much as possible. However, the management had not yet made any arrangements to examine opportunities for saving electric energy systematically. EPRI provided the services of HDR Engineering, Inc to work with the plant staff for two days and develop a list of recommendations for electric efficiency. This engineering firm has made recommendations to improve electrical efficiency at many wastewater plants around the U.S. The plant management requested that special attention be given to plantwide electrical demand, to the intermediate and effluent pumping stations, and to the new vacuum swing adsorption (VSA) oxygen generation plant which was one of the first of its kind to be built in the United States. The audit was provided by SCL without charge to the County.

SCL field staff prepared for HDR's visit by discussing the visit with engineering staff beforehand and collecting material for the audit report. This material included pump and system curves for the effluent pumping station, and pump curves for the intermediate pumps. Effluent pumping energy can be reduced to zero during periods of the day when the tides are low enough to permit gravity flow, and pumping is accomplished by three 2,200 HP pumps with adjustable speed drives. SCL also collected lists of electrical equipment in the new plant including the expected annual operating hours and the expected average power draw of each piece of large electrical equipment. SCL staff identified the site engineers who could contribute to the meetings with HDR Engineering, and helped arrange for the meetings. This was important given the preoccupation of plant staff with operations testing and other preparations needed to meet the deadline for EPA certification.

In addition, SCL initiated another project to incorporate electric power data into the supervisory control system (SCS) that operates plant equipment. The design of the SCS did not include electric power data of any kind, making the real time analysis of impacts of operational changes on electric energy and demand costs impossible. The power data from existing recording meters in eight plant substations were connected to the SCS and incorporated in the system software in the corresponding screens . With this addition to the SCS, the recommendations made by HDR Engineering, as well as other energy saving adjustments to be made in the future, can be reviewed for their impact on electricity consumption within the archived data of the SCS. Operators can observe the changes in electricity use as they change operating procedures in the treatment plant. This project involved an incentive of $ 22,000 from SCL to the County, and was completed during the winter of 1996-1997.

HDR Engineering recommended four changes at the plant, *of which three do not involve any equipment costs.* These are summarized in Figure 6.

Figure 6

Recommended Measures to Improve Electrical Energy Efficiency at The West Point Wastewater Treatment Plant, Seattle, Washington[1,2]

	Electrical Efficiency Measure	Estimated Benefits	Estimated Costs
1.	Raise the Intermediate Pump Wetwell level by 1.5 feet during dry weather	145,000 kWh/Yr $ 5,076 electricity savings annually	Programming costs only
2.	Raise the Effluent Pump Wetwell level by 4.0 feet. during dry weather	Up to 417,600 kWh/Yr Up to $ 14,600 electricity savings annually	Programming costs only
3.	Fine-tune the Oxygen Generation Plant system controls	289,100 kWh/Yr $ 10,200 electricity savings annually	Programming costs only
4.	Retrofit six adjustable speed drives to mixers in the High Purity Oxygen Aeration Basins and reduce the level of dissolved Oxygen slightly	1,764,440 kWh/Yr $ 62,100 electricity savings annually	$ 115,000 for adjustable speed drives

[1] Based on "Final Report : Electrotechnology Assessment, Seattle Metro West Point Wastewater Facility", April 1996, HDR Engineering, Lake Oswego, Oregon, and upon subsequent discussions with plant engineers and upon testing at the plant

[2] The analysis of the potential for electrical savings in the VSA plant was conducted by DWG Associates, a subcontractor in this EPRI project.

To date the plant management has committed to following recommendations 1,2 & 3. The fourth measure is in doubt because of the requirement that the level of dissolved Oxygen in some of the aeration basins be reduced as part of the measure.

The energy benefits of measure 1 have been verified by analysis and comparison of flow and electrical energy consumption data from the intermediate pumps at 111.5 feet and 113.0 feet. The change in energy use with change in wetwell levels agrees with the HDR estimate per foot of rise in the wetwell to within 1.7 %. Although the consultant predicted this operational change could be instituted year round, plant staff will only institute it during periods of normal flow because of the need for excess wetwell capacity during rainy weather. Analysis of plant flow and weather data show this measure can be operational for about 5,000 hours per year. Software changes allow the wetwell level to gradually ramp up as flow volume drops, and gradually ramp down the level as the flow increases. The annual bill savings of $ 5,100 comes at no cost to the County. The final test of Measure 1 will utilize the newly available real time power data from the intermediate pump substation in the SCS, in combination with real time flow data through the pump station.

Testing of the feasibility of Measure 2 has been underway for about a year, due to concern that decreased mixing in the effluent wetwell would make the breakdown of chlorine less effective. Tests do indicate that the chlorine levels will remain acceptably low even with a higher wetwell level, and that this measure is viable. However, the measure cannot be fully implemented until an additional chlorine sensor is installed in the effluent stream below the plant and the level of chlorine can be monitored fully. This measure may not be implemented during periods of rain either, due to the need for backup storage space in the effluent wetwell. The plan is to program the effluent wetwell level for one of two levels, depending upon the volume of flow in the plant . The larger benefits from a rise in wetwell level at the effluent pumps compared to the intermediate pumps is due to the increased gravity flow.

The recommended changes in the operation of the Oxygen plant has been delayed due to past problems with the Vacuum Swing Adsorption process. The evaluation of this measure will take place in the summer or fall of 1996.

Summary

The process of improving electrical efficiency at this plant will continue for some time. The HDR report provided three recommendations that were acceptable to plant management. While the original savings estimate for these three measures totaled between 756,000 kWh and 1,274,850 kWh annually, practical considerations will reduce these savings. If total annual savings of 1,000,000 kWh are achieved they will be worth $ 35,000 to the County each year.

The benefits of the three-pronged approach at the West Point wastewater plant are shown by the plant management's acceptance of the recommendations from an HDR Engineering, Inc, and by the subsequent effort by the plant engineers to adapt the suggestions to the reality of the plant conditions.

The additional work by SCL to assure that power data are included in the plant SCS is essential both for the optimization of the electricity savings from HDR's recommended measures, and for the future identification other electricity efficiency measures. Neither of these products would have been achieved in the near future by the plant staff alone, since they remain extremely busy with day-to-day operations and additional SCS programming. SCL funding was responsible for both these products.

Discussion

The projects described here presented unique problems to SCL field staff. It is fair to surmise that the projects at the glass plant and at the wastewater treatment plant would not have gotten off the ground without the use of effective consultants. Utility field staff cannot keep up to date on the wide variety of industrial processes and process technologies. Vendors do have knowledge of equipment performance and maintenance, but are not likely to be viewed as objective, and are not likely to look at energy efficiency from a systems point of view. Furthermore, vendors do not have the time to collect and analyze data about system performance that is needed to support project proposals.

The unique contribution of the utility field staff can be their focus on energy efficiency as a separate topic requiring an objective look at system energy use. Field staff also provide the glue that brings a project together, by taking the time to bringing together vendors, consultants, plant maintenance staff and plant managers. This paper should make it clear that field staff can effectively document the performance of equipment. Plant engineering staffs are usually so lean that they cannot carry out this documentation.

While the foundry project would have occurred without the intervention of the consultant, the achieved energy savings would not have been as large. The EPRI consultant for that project Dr. John Svoboda, convinced the plant engineer that covers on the furnaces would save more electricity. The consultant also provided a quantitative attainable goal for reduction in electricity use per ton of steel poured which was reassuring to the company , given the large investment in new furnace equipment that the project required. The energy efficiency projects at the wastewater plant and the glass factory would not have occurred without the intervention of SCL which provided large amounts of staff time for project development, as well as free expert consultation. These two projects are not complete yet, and SCL will expend much more staff time to support them in the coming months.