Chemicals BestPractices Plant-Wide Assessment Case Study

Benefits

- Identified potential annual cost savings of nearly $3.3 million from reduced resource consumption and improved productivity
- Found ways to reduce annual electricity consumption by almost 9.6 million kWh and annual fuel consumption by 338,000 MMBtu
- Identified ways to decrease fresh water consumption and wastewater generation
- Resulted in short-term plans for immediate benefit, such as steam trap and lighting surveys, and long-term plans for optimizing the site's utility profile for the next 5 years

Application

The Steam, Electricity, Cooling Utility Reduction Exercise (SECURE) methodology allows an assessment team to address energy generation and use. Solutia's team focused on finding ways to reduce the site-wide use of steam, electricity, compressed air, and water, considering the site as an integrated entity rather than as a collection of individual processes.

Solutia: Massachusetts Chemical Manufacturer Uses SECURE Methodology to Identify Potential Reductions in Utility and Process Energy Consumption

Summary

Solutia Inc. recently completed a plant-wide energy assessment at its chemical production facility in Springfield, Massachusetts; the assessment team focused on finding ways to reduce the site-wide use of steam, electricity, compressed air, and water. The assessment treated the facility as a single entity, addressing energy and cost conservation opportunities in both supply-side (utility) systems and demand-side (production) processes. Solutia's energy management team conducted the assessment to help ensure that process designs maximize energy conservation while minimizing waste generation. If all projects identified during the study were implemented, the total estimated annual energy savings would be about 9.6 million kWh in electricity and more than 338,000 MMBtu in natural gas. At an investment of $6.3 million, total annual cost savings were estimated to be nearly $3.3 million.

Public-Private Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment through a competitive solicitation process. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness, while reducing waste and environmental emissions. In this case, DOE contributed $100,000 of the total $305,000 assessment cost.

Plant Description

Solutia Inc. manufactures polymers, intermediates, and chemicals; it was formed in 1997 from one of the Monsanto Company's chemical divisions. Solutia produces performance films for laminated safety glass and after-market film applications, and it manufactures specialty products such as water treatment chemicals, heat transfer fluids, and aviation hydraulic fluid. The company is a service provider for process development and scale-up services for pharmaceutical fine chemicals, and it is one of the few vertically integrated nylon producers in the world.

Solutia's Springfield, Massachusetts, facility occupies 180 acres, employs about 500 workers, and is the largest chemical manufacturing facility in New England. Management at the Springfield site is concerned with energy conservation, safety, and environmental consciousness. Therefore, Solutia has established goals to ensure that process designs maximize energy conservation and minimize waste generation. Total annual electricity consumption at the site is about 95 million kWh, energy generated from gas and coal amounts to 1.25 million MMBtu, and fresh water usage is 2.5 billion gallons.

The site's five primary production processes include batch and continuous processing systems and solvent recovery processes that use steam-intensive distillation. Production processes focus on polymer resin and chemicals manufacture, extrusion of the resin into sheet, and related applications. The utility generation and distribution facility is centralized. Utilities generated on site include steam (from coal and natural gas), electricity, compressed air, and nitrogen. An on-site cogeneration facility, owned and operated by Mass Power, supplies steam.

Assessment Approach

The assessment team focused on finding ways to reduce the site-wide use of steam, electricity, compressed air, and water. The team was composed of Solutia's process experts, utility engineers, research and development scientists, cost estimators, accountants, process and project engineers, and external consultants.

The assessment employed the Steam, Electricity, Cooling Utility Reduction Exercise (SECURE) methodology to address both the process and utility sides of the site's operations. This methodology considers the site as an integrated entity rather than a disparate collection of individual processes. For production processes, the assessment team collected data on steam, electricity, water, and wastewater usage and costs. They also compiled data on energy use for individual process equipment. They then analyzed this information to identify the primary energy users and each one's potential for energy savings.

Following the analysis, the assessment team evaluated potential opportunities to reduce the amount of energy used by the equipment and processes identified as significant energy users. To identify those opportunities, the assessment team reviewed historical DOE plant-wide assessment case studies, compiled a list of energy savings ideas and best practices, and evaluated the potential for integrating equipment, e.g., whether hot effluent from a distillation column could be used to preheat feed to the column. Finally, the team considered site-wide projects such as recycling steam condensate, which would impact several different processes.

Results and Projects Identified

Using the analysis, the assessment team generated an initial list of about 80 potential projects. Table 1 lists projects determined to be technically and economically feasible. Additional details about some of the projects follow.

Project 1. The assessment team used a chilled water system simulation model to determine the range of optimum operating temperatures for chiller and cooling tower water based on ambient conditions. The team recommended resetting chiller water temperature set points.

Project 2. Steam is supplied primarily by a coal boiler, though a gas boiler can also supply it when the process load fluctuates. Most boilers have a "minimum fire" level that corresponds to the minimum steam generation required to keep the boiler ready to come on line. Solutia's gas boiler has a relatively high minimum fire level because its burner system is almost 30 years old. The assessment team recommended installing a new high-capacity pilot on the existing burner system in the gas boiler so it could be operated at a lower minimum fire level. The pilot would allow the boiler to ramp up to required operating conditions more quickly and would ignite the fuel immediately, without the need for purging.

Project 3. The coal boiler has a feedwater preheating system; the gas boilers do not. So, fuel burned in the gas boilers provides both the latent heat of vaporization and the sensible heat needed to increase the feedwater temperature to the boiler's operating temperature. However, the sensible heat needed for the gas boilers can be derived by using coal-generated steam rather than burning natural gas. The assessment team recommended connecting the preheating systems of the coal and gas boilers to transfer the heat load from the gas-fired boilers to the coal-fired boiler whenever the gas-fired boilers are producing steam.

Table 1. Projects Identified During Solutia's Plant-Wide Assessment						
Project ID Number	**Project Description**	**Cost Savings ($/year)**	**Capital Cost ($)**	**Payback (years)**	**Fuel Savings (MMBtu/year)**	**Electricity Savings (kWh/year)**
1	Optimize chiller water temperatures	46,000	NA	NA	NA	536,000
2	Upgrade boiler burner system	240,000	70,000	0.3	89,000	NA
3	Transfer heat load for feedwater preheating from gas-fired to coal-fired boiler	25,000	60,000	2.4	9,000	NA
4	Repair steam traps	151,000	60,000	0.4	29,000	NA
5	Upgrade lighting fixtures	78,000	130,000	1.7	NA	918,000
6	Install new cooling tower to reduce process water usage	750,000	3,200,000	4.3	NA	NA
7	Use air compressor waste heat to preheat boiler feedwater	208,000	58,000	0.3	35,000	159,000
8	Reduce boiler blowdown frequency and automatically control blowdown	9,000	8,000	0.9	1,700	NA
9	Recover boiler heat and water losses	376,000	296,000	0.8	82,000	NA
10	Recycle steam condensate	396,000	608,000	1.5	62,000	NA
11	Recycle process cooling water to the power plant	195,000	160,000	0.8	21,000	NA
12-23	Install variable-frequency drives on chilled water pumps, cooling tower water pumps, cooling tower fans, chiller motors, hot water pump east, boiler feedwater pump, biofilter supply fan, dryer exhaust fan, biofilter scrubber pump, boiler fans, and B crude pump	555,000	1,295,000	2.3 (avg.)	NA	6,505,000
24-27	Install variable-air-volume systems on process air-handling units	136,000	198,000	1.5 (avg.)	2,700	819,000
28	Recover air knife waste heat	33,000	90,000	2.7	6,200	NA
29	Upgrade air knife blowers	6,000	22,000	4	NA	66,000
30	Optimize air knife blower system	32,000	60,000	1.9	NA	378,000
31	Automate control of extrusion process supply and wind fan to operate fans only when needed for process conditions	27,000	9,000	0.3	500	173,000
	Total	**$3,263,000**	**$6,324,000**	**2 (avg.)**	**338,100**	**9,554,000**

Project 4. The team recommended repairing the failed steam traps—i.e., those that were blowing through, leaking, plugged, or flooding. They found that, out of 700 traps inspected, about 100 had failed.

Project 5. The team recommended retrofitting fluorescent light fixtures with new electronic ballasts and replacing older T12-style light bulbs with high-efficiency T8 bulbs. They also recommended replacing metal halide high-intensity discharge lamps with new higher efficiency metal halide lamps.

Project 7. The air compressors in the site's centralized air compressor system generate a significant amount of waste heat. In the current configuration, the compressors have a closed-loop cooling system; coolant-to-air heat transfer is accomplished using several undersized heat exchangers. The heat exchangers operate at elevated temperatures in summer and must be cooled by a water spray system. The assessment team recommended capturing waste heat from the air compressors and using it to preheat the boiler feedwater. Inadequate air coolers could also be replaced with two new plate-type heat exchangers.

Power plant boilers at the Solutia site

Projects 8, 9. Boiler blowdown is now controlled manually. The blowdown frequency for the coal boiler is based on the silica concentration in the boiler feedwater. The assessment team recommended installing a reverse osmosis system upstream of the boiler. This system would remove silica from the boiler feedwater, reducing the required frequency of the blowdown. Automatic boiler blowdown controls (based on measurements of conductivity and residual silica concentration) could also be installed. These projects would also reduce water consumption.

Project 10. Currently, the plant recycles only about 5% of its steam condensate—mostly within the power plant—because of the site's large geographic area and the distance between the two biggest steam users, located at opposite ends of the site. An analysis done during the plant-wide assessment revealed that heat and water savings from recovered condensate would cover the installation cost of a condensate recovery system. To reduce costs, the team recommended that condensate return lines be installed on existing steam headers to eliminate the need for new pipe racks or supports.

Project 11. The assessment team developed a simulation model that quantified fresh water demand, wastewater generation, and steam demand in the five major production processes. The water balance indicated that a significant amount of warm water could be recycled to the power plant, so the team recommended that the plant consider recycling this water.

Projects 24, 25, 26, 27. The team investigated several projects that involved installing a variable-air-volume system on air-handling units for some production processes. Building cooling loads fluctuate throughout the year because of seasonal changes in outdoor temperatures, so the air volume could potentially be matched to the load; this would allow the average air flow and the required fan motor power to be reduced. The team recommended installing variable-frequency drives on the supply fans, modulating the air volume to maintain the dry bulb temperature in the storage areas, and adding temperature-controlled volume dampers.

Projects 28, 29, 30. The extrusion process creates a water-covered polymer sheet. Air knives (fans) blow high-pressure air onto the extruded sheet to remove unwanted residual water. The air knives generate a significant amount of heat, but to maintain the required product temperature, the air must be cooled before being directed onto the sheet. The assessment team proposed recovering the heat generated by the air knives and using it in a parallel process. They recommended replacing the current air knife blowers with new high-efficiency blowers, and consolidating existing air knife blowers into fewer high-power, high-efficiency units.

Taken together, projects like these have the potential to save Solutia more than $3 million in operating costs each year.

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BestPractices is part of the Industrial Technologies Program, and it supports the Industries of the Future strategy. This strategy helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and energy-management best practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

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