CHEMICALS

BestPractices
Technical Case Study

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OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Benefits

- Saves over $375,000 annually
- Reduces annual energy consumption by 170 billion Btu
- Reduces air emissions

Applications

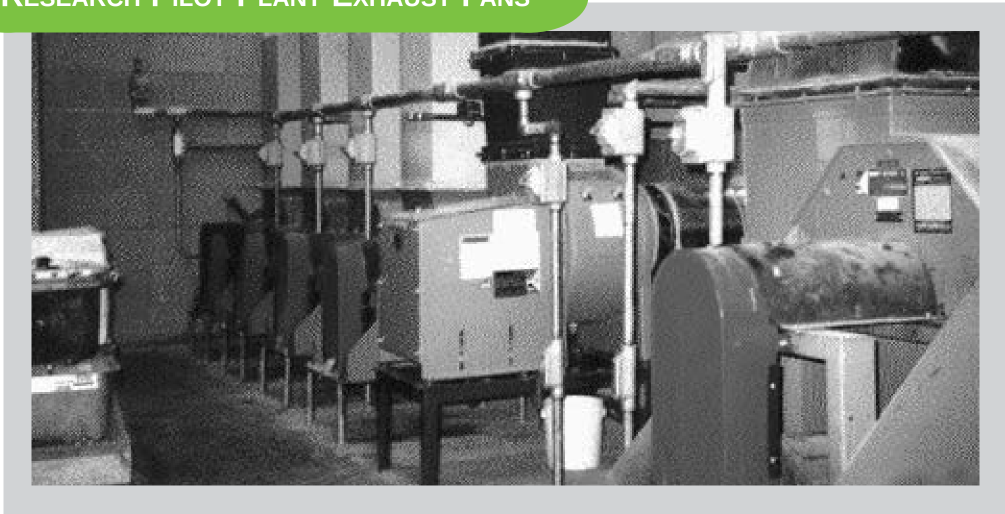
Improving control strategies can increase the performance of almost any steam system. Steam systems are found throughout industry and consume a significant portion of the energy used at manufacturing plants.

Optimizing Electric Motor Systems At A Corporate Campus Facility

Project Summary

Minnesota Mining and Manufacturing (3M) conducted an in-house motor system performance optimization project. Using a systematic facility-by-facility approach, the company formed a team that evaluated approximately 1,000 electric motor systems in 29 buildings at the 3M Center to identify feasible projects. Four key energy-saving upgrades in Building 123 reduced electricity use by 41 percent and resulted in cost savings of $77,554 per year. The systematic approach developed, and experience gained in the Building 123 project, was applied to other 3M facilities and demonstrates how a large industrial company can optimize performance of their electric motor systems at a campus-type facility.

Research Pilot Plant Exhaust Fans



Company Background

Ranked in the top 75 of the "Fortune 500" for both sales and net income, 3M is a multinational company with operations in 60 countries and 34 states. The company was founded in 1902, employs about 70,000 people worldwide, and manufactures more than 50,000 products and services for a wide variety of consumer, commercial, professional, and industrial markets.

Project Overview

This Showcase Demonstration project was conducted at 3M Center, the company's 7.5 million-square-foot corporate headquarters campus. The center employs approximately 12,000 employees and houses research and development facilities that produce research on a wide variety of new and improved products. Of the approximately 1,000 electric motor systems at 3M Center, 70 percent drive building support functions such as HVAC and water pumping, while the remaining 30 percent support research and development functions. Building 123 occupies 528,750 square feet and accommodates research pilot plants, mechanical and electrical maintenance shops, laboratories, and support functions. This building was chosen because it was one of the first facilities reviewed by the 3M team and contains electric motor systems that are representative of those throughout the rest of the campus.

Project Team

A cross-functional, cross-company Motor Challenge team was established in January 1994, led by four full-time 3M employees representing the Facilities Engineering and Plant Engineering Departments. The team also included representatives from Northern States Power Company (NSP), General Electric Supply Company, and Landis & Gyr, Inc. The team's mission was to identify, justify, participate in funding, and implement all feasible projects that would increase the efficiency of motor-driven equipment at 3M Center.

The Systems Approach

In May 1995, the project was accepted by the U.S. Department of Energy (DOE) as a Motor Challenge Showcase Demonstration Project. DOE's Independent Performance Validation (IPV) team reviewed the project results. The primary purpose of this project was to emphasize the methodology that was developed to carry out a project of such magnitude, rather than a specific technology or application. To identify projects, which could increase productivity, and reduce energy consumption, cost, and emissions, the 3M Motor Challenge team developed a methodical building-by-building approach. This 9-step approach included:

(1) Locating and identifying equipment;
(2) Documenting the type of motor system, operational requirements and use (including field measurements), type of system and motor controls, and nameplate information;
(3) Analyzing efficiency of existing system, operational use vs. operational need, and present energy consumption;
(4) Developing technical options, evaluating alternatives, calculating savings, estimating cost to implement, and determining financial and operational feasibility;
(5) Developing proposals and reports, including system description, opportunities for improvement, and recommendations;
(6) Presenting feasible proposals to management for funding approval, following up, and obtaining authority for expenditure;
(7) Implementing the projects;
(8) Following up with measurements and monitoring, comparing actual savings to calculated savings, and reporting the results; and
(9) Communicating activities and progress to steering committee and Building Energy Teams.

Together with building management, the team decided whether to implement a project based on the financial and operational evaluations. After project implementation, follow-up metering was conducted to verify that projected savings were achieved and that operation of the system was satisfactory.

Project Implementation

Using this systematic approach, the 3M Motor Challenge team identified numerous energy-saving upgrade projects to implement in Building 123. Four of these improvements were chosen for an in-depth study by DOE's IPV team. They are:

Upgrade of Research Pilot Plant Air Supply. Air supply is maintained in a research pilot plant in Building 123 by nine 5-hp exhaust fans and one 40-hp makeup air fan. Air was previously supplied 24-hours per day at full speed. Ventilation requirements, however, depended on the level of activity in the process area. The team optimized the supply system by adding a direct digital control system (DDCS) that controlled the level of ventilation to the area based on whether the research pilot plant was in use. A timer in the DDCS initiated the turning on and off of some of the exhaust fans. The team also retrofitted the supply makeup air fan motor with a variable frequency drive (VFD) and installed a differential static pressure sensor. The DDCS used a signal from the sensor to control the speed of the supply fan in order to maintain a slight negative pressure in the process area.

Upgrade of Reheat Water Supply System. The reheat water supply system—part of the overall building HVAC system—pumps hot water to the building supply air reheat coils. The air supply flow to the reheat coils is constant, so temperature control is achieved by regulating the flow of hot water. The building has five reheat water supply pumping systems, each with two 7 1/2-hp motors. Because continuously operating the pumps at full flow and diverting the unneeded flow through a bypass valve was clearly inefficient, the team optimized the system with energy-efficient motors and VFDs to better match the amount of water being pumped with the system requirements. In addition, tests conducted revealed that the system could perform satisfactorily with a lower differential pressure setting across the pump. This resulted in additional energy savings.

Upgrade of Supply Air Fans. Air is supplied to many parts of Building 123 by two 50-hp fans. The volume of supply air required varies with the number of exhaust fans running, which in turn depends on process activity and building occupancy. Fans were run constantly and controlled with dampers. To optimize the system, the team installed a VFD on each fan to control airflow more efficiently and installed an energy-efficient motor on the one fan that did not have one.

Energy-Efficient Motors Retrofit. An evaluation of all electric motors in the building larger than 1 1/2-hp identified 50 older, standard-efficiency motors that operated more than 6,000 hours per year and could therefore benefit from retrofit to energy-efficient motors. Twenty-eight of these motors were retrofit to energy-efficient motors and studied in detail as part of the Showcase project. An improvement of 2 to 5 percent was expected from each retrofit. In some cases, other measures were taken, such as sheave changes to slow down the driven load, downsizing of the motor to more closely match system requirements, and repair and cleaning of components to reduce efficiency losses. These four upgrade projects constituted a large percentage of the electrical and cost savings achieved in Building 123 and are typical of the projects identified and implemented at 3M Center. By focusing on these key upgrades, DOE's IPV team was able to validate the methodology used by 3M and quantify the savings achieved.

Results

After factoring in demand-side management incentives offered by Northern States Power, the net cost of the project to 3M was $79,499 with an annual cost savings of $77,554. This yields a simple payback on all four projects of 1.03 years. The individual projects had simple paybacks of 1.35 years, 2.61 years, 0.81 years, and 3.06 years, respectively. In addition to saving energy, the projects also provided up-to-date information on the building's motor systems, identification of required maintenance (especially in the case of one of the building air supply fans), and additional savings from matching flow or pressure supply to system requirements.

When applied to all buildings at 3M Center, the systematic approach to performance optimization is estimated to save approximately 10,821 MWh and reduce demand by 468 kW annually. With estimated annual savings of $823,000 and a net project cost of $1,600,000, the projects will have a net payback of 1.9 years.

Annual Energy and Cost Savings

	Validated Projects		Entire Campus (est.)	
Electricity Savings	939,400 kWh	$31,583	10,821,000 kWh	$363,800
Utilities (reduce steam and chilled water use)		$45,971		$441,200
Maintenance Savings				$18,000
Total		**$77,554**		**$823,000**

Total Annual Power Plant Emissions Reductions

	Validated Projects	Entire Campus (est.)
CO_2	1,205,200 lbs	13,883,300 lbs
Carbon Equivalent	328,690 lbs	3,786,400 lbs
SO_x	2,900 lbs	34,000 lbs
NO_x	3,400 lbs	39,300 lbs
TSP	240 lbs	2,800 lbs
VOC	33 lbs	380 lbs

Industry of the Future—Chemicals

*The chemical industry is one of several energy- and waste-intensive industries that participate in OIT's Industries of the Future initiative. In December 1996, the chemical industry published a report entitled **Technology Vision 2020: The U.S. Chemical Industry** that helps establish technical priorities for improving the industry's competitiveness and develops recommendations to strengthen cooperation among industry, government, and academia. It also provides direction for continuous improvement through step-change technology in new chemical science and engineering technology, supply chain management, information systems, and manufacturing and operations.*

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BestPractices is part of the Office of Industrial Technologies' (OIT's) Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together the best-available and emerging technologies and 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.

Project Partners

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