Showcase Demonstration

# CASE STUDY

a Program of the U.S. Department of Energy

# OPTIMIZING PUMP SYSTEMS AT A COAL SLURRY PREPARATION PLANT

| Project Profile | |
|---|---|
| **Industry:** | Coal Mining |
| **Process:** | Coal Slurry Separation |
| **System:** | Cyclone Pump |
| **Technology:** | Resized Pump, Energy-Efficient Motor |


## Summary

Peabody Holding Company, the largest U.S. coal producer, has completed a project to improve the performance of a coal slurry pumping system at its Randolph Coal Preparation plant. Changes to the coal washing process resulted in cyclone pump systems that were larger than necessary to meet system requirements. Finding ways to increase the efficiency of these oversized pump systems was the objective of this Motor Challenge Showcase Demonstration Project. This case study describes the performance optimization conducted by the Showcase Demonstration team on one of the six classifying cyclone pumps. Using a systematic approach, three energy-saving opportunities were identified involving the motor, belt drive, and pump components of the pumping system. The modifications saved 87,184 kWh of electricity, equivalent to $5,231 in annual energy cost savings, and overall energy consumption of the pumping system decreased by approximately 15 percent. Total costs to implement the project amounted to $15,693 yielding a simple payback of 3.3 years. When performed on each of the remaining five pumps, the performance optimization will result in an estimated 523,000 kWh in energy savings and $31,000 in annual energy cost savings.


## Company Background

Peabody Holding Company, Inc. generates more than $2 billion in annual revenues by providing policy management and strategic planning to the Peabody Group, comprised of 50 coal mining, marketing, and related corporations in the United States and Australia. Together, these corporations operate 29 mines and own or operate roughly 12 billion tons of steam and metallurgical coal reserves throughout the world. Peabody initiated this Motor Challenge Showcase Demonstration project in order to improve their motor systems and because of their heightened awareness of energy efficiency and environmental concerns.

*Randolph Coal Preparation Plant*

## Project Overview

The Randolph Coal preparation plant processes and cleans bituminous coal supplied by Peabody's Marissa Underground Mine, located in west-central Illinois near Baldwin, Illinois. The coal is removed by continuous miners using the "Room and Pillar" method, a coal extraction technique

*The energy savings network*

*Plug into it!*

involving rotary drums that shear coal, shale, and fire clay from the coal seam. After removing large non-coal fragments, water is added to the raw coal to produce a 12 percent coal slurry to separate the remaining shale, fire clay, and other particles from the coal. Six 200 hp classifying cyclone pumps transport the coal slurry from a common sump to the two classifying cyclones which separate the slurry into two types. The slurry containing smaller mesh particles is discarded while the slurry containing larger mesh particles is dewatered and discharged as clean coal.

The Randolph preparation plant was selected for process optimization due to numerous changes to the coal washing process. The six pumps used to transport slurry to the cyclones exceeded system process requirements, which can lead to inefficient operation. Alternatives to increase the energy efficiency of the pumping system were identified and evaluated. This project focuses on one (Number 5) of the six cyclone classifying pumps which is representative of all six pumps. Only one pump was selected so that multiple system optimization techniques could be explored without excessive costs.

**Peabody**

**SIC:** 1211

**Products:** Clean coal

**Location:** Marissa, Illinois

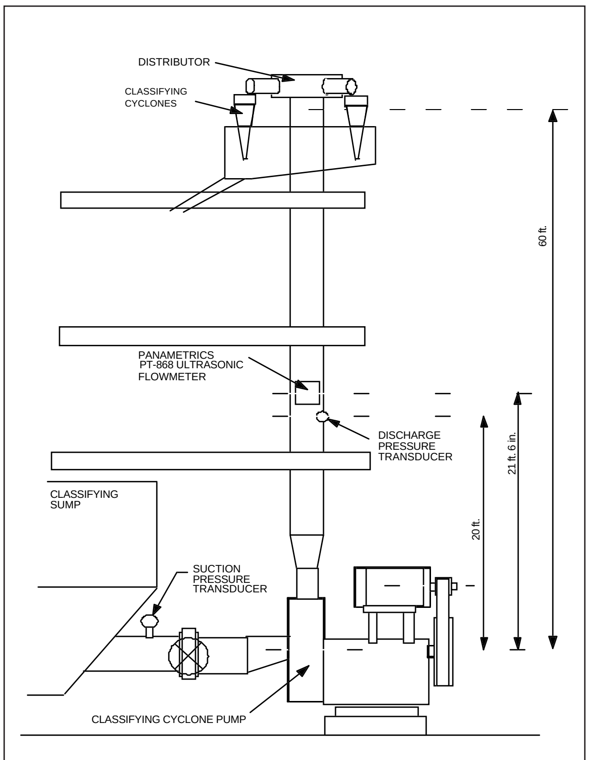
**Employees:** 66

**Showcase Team Leader:** Ronald Cross

**Company Philosophy:** Peabody is committed to implementing an energy efficiency plan that is cost-effective and supports voluntary actions to reduce greenhouse gases.

## Project Team

In addition to the host company, the Showcase Demonstration project team involved several Motor Challenge partners including U.S. Electric Motors, GIW Industries, Inc. and the local electric utility. U.S. Electric Motors and GIW Industries, Inc. supplied the equipment and performed system modifications throughout the project's implementation period. Electric metering of the pumping system for the base case and alternative scenarios was provided by the local electric utility. Other mechanical engineering services and hardware provided to the host company were performed by The Benham Group.




***Classifying Cyclone Pump***

## Project Implementation - The Systems Approach

Project engineers realized the current system was oversized, not operating at its best efficiency point, and had not received proper maintenance over the years. To determine potential improvement opportunities, the engineers applied the systems approach. The systems approach is a way to increase the efficiency of an electric motor system by shifting the focus away from the individual elements and functions to total system performance. By utilizing the systems approach, Peabody Holding was able to determine an overall strategy for optimizing the No. 5 cyclone pump.The strategy involved all three main elements of the pumping system: the pump casing and impeller, the motor, and the V-belt drive.

## The Old System

Under normal conditions, the pump runs at constant volume and operates approximately 16 hours a day for 250 days a year. The original pump system utilized a 10" x 10" casing equipped with a 32" diameter impeller designed to pump an estimated 4,650 gallons per minute (gpm) at a head of 114 feet. The pump was driven by a 200 hp, 1,750 rpm standard efficiency motor through a conventional V-belt drive. After performing system analyses, the team determined that the original system exceeded process requirements. Overall "wire-to-water" system efficiency was rated at less than 59 percent. Average volume flow was estimated at an average of 3,612 gpm at a head of 107 feet, less than the pumps most efficient operating point. Overall energy consumption was estimated at 513,766 kWh of electricity per year.

*Coal Slurry Pumping System*

## Alternatives Considered

Several alternatives were considered to optimize the pump system. One option involved slowing down the pump to reduce speed and lower energy consumption levels; however, initial calculations showed little energy savings from performing this task. Engineers also considered staging the six pumps, but this proved impractical. Another area explored was replacing the V-belt drive with a newer "toothed-belt" drive, rated at efficiency levels of 98 percent. After several tests, it was determined that the toothed-belt drive did not significantly increase the efficiency of the pump system. In addition, toothed-belt drives are less tolerant of contamination and are significantly more noisy than V-belt drives. The optimal solution proved to be a combination of system modifications which include replacing the pump's motor with a more efficient motor, downsizing the pump, and re-tensioning the V-belt.

## The New System

The modified system uses a smaller pump with an 8" x 10" casing and a 32" diameter impeller with an output that more accurately matches system flow requirements. The original motor was replaced with a new premium efficiency 200 hp, 1800 rpm motor rated at 96.5 percent efficiency. At the time of replacement, the team also determined that the motor slide base should be replaced as a result of extreme corrosion. Maintenance of the V-belt drive, to prevent corrosion and set the proper tension, was also performed.

## Results

Prior to system modifications, the pumping system operated at an average 58.7 percent "wire-to-water" efficiency. After the motor and slide base were replaced, efficiency levels increased to 60.4 percent. By re-tensioning the V-belt drive, efficiency increased by an additional 2.5 percentage points to 62.9 percent. The most significant efficiency increase occurred after the pump was downsized to match volume flow requirements. Efficiency increased another 10.7 percent to an average "wire-to-water" efficiency of 73.6 percent. Overall energy efficiency as a result of the motor replacement, V-belt drive tensioning, and pump modifications increased by 14.9 percentage points from 58.7 percent to 73.6 percent efficiency.

### Why Oversized Pumps Decrease Performance

Many design engineers purposely oversize pumps, taking into account factors such as safety margins, potential corrosion build up, and the possibility of increased flow requirements in the future. This often leads to throttling the system with a control valve because the pump delivers more flow than the system requires. The result is a pump that is not running at its Best Efficiency Point (BEP). Possible consequences of this include noise and vibration, excessive bearing loads, cavitation, and excessive power consumption. Pumps that are being throttled and are operating far off their BEP should be considered for retrofit. Possible changes that should be considered are retrofitting with a smaller pump, using an impeller with a smaller diameter, or slowing the operating speed of the pump. In many cases, these changes will not only save energy, but also increase the reliability of the system.

The reduction in annual energy consumption is estimated to be 87,184 kWh of electricity, equivalent to approximately $5,231 in cost savings. With a cost of $15,693, the project yielded a simple payback of 3.3 years. In addition, the project resulted in lower maintenance costs for replacement parts since the new pump is smaller.

## Lessons Learned

Aside from the energy savings achieved by modifying the system, several lessons were learned during the project implementation process. The experiences gained may provide practical information for other projects targeting energy efficiency improvements. The lessons learned include: (1) To ensure that pump systems are performing at optimal levels, the volume flow rate should be calculated to determine the appropriate sized pump, rather than automatically replacing old pump casings with new pump casings of the same size when they wear out. By not only replacing the pump casing but by changing the size of the pump casing to more accurately match the required flow rate, operating costs can be reduced significantly; (2) High performance belt drives can increase energy efficiency and reduce costs; however, routine maintenance of the V-belt drive rather than replacement of the drive with high performance belt drives may yield higher savings. Also, high performance belt drives are noisy relative to V-belt drives; and (3) After a pump casing and impeller are replaced with smaller ones, the system requires less motor power than was needed prior to system modifications. A smaller motor may be sufficient to operate the system, and can reduce project costs.

| Performance Improvement Summary | |
|---|---|
| **Annual Energy and Cost Savings** | |
| Net Cost to Implement Project | $15,693 |
| Annual Energy Cost Savings | $5,231 |
| Simply Payback (years) | 3.3 |
| Demand Savings (kW) | 21.8 |
| Energy Savings (kWh) | 87,184 |
| **Total Annual Emissions Reductions** | |
| $CO_2$ | 182,633 lbs |
| Carbon Equivalent | 49,900 lbs |
| $SO_2$ | 5,115 lbs |
| $NO_x$ | 1,090 lbs |
| PM | 42.4 lbs |
| CO | 21 lbs |
| Non-Methane Hydrocarbons | 2.5 lbs |

## About Motor Challenge

The Motor Challenge is a joint effort by the U.S. Department of Energy (DOE), industry, motor systems equipment manufacturers and distributors, and other key stakeholders to put information about energy-efficient electric motor system technology in the hands of people who can use it.

Showcase Demonstration Projects target electric motor-driven system efficiency and productivity opportunities in specific industrial applications. They show that efficiency potential can be realized in a cost-effective manner and encourage replication at other facilities.

DOE provided technical assistance and independent performance validation (IPV) of energy savings. A DOE-sponsored IPV team reviewed the test plan and provided assistance, as requested by the host site, on testing procedures, instrumentation techniques, and data acquisition. The DOE team developed a detailed IPV Report thoroughly documenting the project. The Report is available by calling the number listed below. DOE did not witness the actual test data, and the conclusions in this case study are based solely on data provided by the host site and their partners.

For more information on becoming involved in the Motor Challenge or sponsoring a Showcase Demonstration, call the Motor Challenge Information Clearinghouse at (800) 862-2086.

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MOTOR CHALLENGE

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