Alcoa World Alumina: Plant-Wide Assessment at Arkansas Operations Reveals More than $900,000 in Potential Annual Savings

Benefits

- Identified savings of $925,300 annually in operating and energy costs
- Identified ways to reduce annual natural gas use by 15,100 MMBtu and annual electrical use by 8.7 million kWh
- Could achieve average payback of about 3.5 months

Applications

Alcoa Arkansas Operations annually consumes approximately 1.3 million cubic feet of natural gas and 91.1 million kWh of electricity. Improvements in such areas as compressed air, oxygen trim control, and plant power factor could yield significant energy and cost savings for the alumina plant. The knowledge and experience gained from the plant-wide assessment can be extended to many of Alcoa's other plants and businesses, and to other industrial plants.

Summary

The plant-wide energy-efficiency assessment performed at the Alcoa World Alumina Arkansas Operations in Bauxite, Arkansas, identified seven opportunities to save energy and reduce costs. By implementing five of these improvements, the facility can save 15,100 million British thermal units per year (MMBtu/yr) in natural gas and 8.76 million kilowatt-hours per year (kWh/yr) in electricity. This translates into approximate annual savings of $925,300 in direct energy costs and nonfuel operating and maintenance costs. The required capital investment is estimated at $271,200. The average payback period for all five projects would be approximately 3.5 months.

DOE-Industry Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment through a competitive 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 $90,097 of the total $180,195 assessment cost.

Company Background

Alcoa World Alumina is a subsidiary of Alcoa, Inc., the world's leading producer of primary aluminum, fabricated aluminum, and alumina. Alcoa is active in all major segments of the aluminum industry, including mining, refining, smelting, fabricating, and recycling. The company provides a variety of fabricated and finished products to customers in the packaging, automotive, aerospace, construction, and other markets. Nonaluminum businesses include alumina chemicals, plastic bottle closures, packaging machinery, vinyl siding, and electrical distribution systems for cars and trucks. Alcoa operates 26 business units with 140,000 employees at 300 sites in 36 countries.

Alcoa's operations in Bauxite are part of the company's Industrial Chemicals Business Group. The facility produces alumina by calcination, digestion, grinding, and evaporation using several kilns, grinding mills, mixers, and a multi-effect evaporator. Products include tabular alumina, high-temperature cements for refractories, and alumina fillers for paper, tile, and wire applications.

Assessment Approach

To complete the plant-wide energy assessment, Alcoa formed a team consisting of Pace Global Energy Services, LLC, of Fairfax, Virginia; Cummins & Barnard, Inc., of Ann Arbor, Michigan; and SS Energy Environmental International (SSEEI), Inc., of Rockford, Illinois. The team's task was to examine departmental energy use at the Bauxite plant, identify and analyze opportunities to reduce energy consumption, and help develop an energy strategy for the facility.

The team used a methodical approach to complete the assessment at the Bauxite plant. By tracking the monthly electric, natural gas, steam, and compressed air data for the plant, the team was able to identify the major energy-consuming equipment and processes within each of the plant's operating areas (Table 1). Using this information, the team proposed methods to reduce the energy used by these major energy consumers; those with the greatest potential to save energy were selected for further analysis.

Table 1. Major Energy Consumers

Energy Type	Major Energy Consumers by Plant Operating Area
Electricity	Converter blowers, main compressors, hydrate chemicals pumping, 450 Hydral® pumping, tabular equipment drives
Natural Gas	Boilers, calcine and reactive kilns, Hydral® dryers, tabular converters
Steam	Evaporation, hydrate chemicals
Compressed air	Tabular, hydrate chemicals

Results

After reviewing the processes and equipment listed in Table 1, the team focused its analysis on the following:

- Main air compressors
- Evaporator feed tank
- Steam boilers
- Tabular converters
- Calcine kiln.

The assessment team also chose to investigate power factor correction and peak load management. Implementing these options may not save energy but may save energy costs, such as avoiding a penalty for power factors less than 0.9.

Projects To Be Implemented

By analyzing the selected areas, the assessment team developed a list of seven possible projects that offer potential savings in both energy and costs. Descriptions of these projects follow, along with a summary in Table 2 of those projects Alcoa plans to implement.

Operate the compressed air system with only one compressor

The Bauxite facility currently has three large centrifugal compressors installed at the main compressor station and several smaller compressors located at various points throughout the facility. By eliminating leaks, isolating idled portions of the air distribution system, and modifying equipment that requires compressed air, the facility could operate using only one of the existing large compressors and reduce electricity use by 8.14 million kWh per year. This plan will also save $467,000 annually and eliminate the need for a leased compressor.

Eliminate the evaporator feed tank

The Hydrate Chemicals process produces a waste stream of dilute liquor that is processed in a four-effect evaporator to produce concentrated liquor and steam condensate. Currently, the dilute liquor is transferred from the Hydrate Chemicals spent liquor tank to the evaporator feed tank using pumps driven by 150-horsepower (hp) motors, and then to the evaporator via either a 100-hp or a 150-hp feed pump. The evaporator feed tank also has a 20-hp mixer and a 7.5-hp sump pump. Eliminating the evaporator feed tank and pumping the dilute liquor directly from the spent liquor tank to the evaporator train will eliminate the motors driving the evaporator feed pumps, tank mixer, and sump pump. Also, new 40-hp motors will replace the 150-hp motors at the spent liquor tank. These modifications will save 619,000 kWh/yr in electricity. In addition, using the evaporator condensate in the filtrate system instead of steam condensate will save 11,100 MMBtu/yr. The estimated annual cost savings for this project are estimated at $77,800.

Install oxygen control on the steam boiler

The facility operates five firetube boilers that produce steam for several processes and winter-time heating. Demand can range from 50,000 pounds per hour (lb/h) in the summer to 100,000 lb/h in the winter. Excess air in boilers is currently controlled by manually adjusting the burner system on a periodic basis. By installing an oxygen trim control system, Alcoa can improve boiler efficiency at

Table 2. Summary of Savings Potential by Project Opportunity

		Projected Annual Savings			Projected Economic Impact	
No.	Identified Opportunity	Natural Gas (MMBtu/yr)[1]	Electricity (kWh/yr)[2]	Financial ($/yr)	Capital Cost ($)	Payback Period (years)
1	Reduce air consumption to levels requiring only one of the existing compressors	N/A[3]	8,140,000	467,000	85,000	0.18
2	Eliminate evaporator feed tank and associated pumps; use evaporator condensate instead of steam condensate in filtrate system	11,100	619,000	77,800	91,200	1.17
3	Install automatic oxygen trim control system on two steam boilers	4,000	N/A	40,000	40,000	1
4	Manage plant peak load	N/A	1,000	150,000	N/A	N/A
5	Improve plant power factor	N/A	N/A	190,500	55,000	0.29
	Total Project Savings	**15,100**	**8,760,000**	**925,300**	**271,200**	**0.29**

[1]MMBtu = million British thermal units
[2]kWh = kilowatt-hour
[3]N/A = Not applicable

part-load operation by up to 3%. The control system would allow the plant to achieve the best flame properties, reasonable gaseous emissions, and maximum flame heat transfer. Converting two boilers to oxygen trim control will save 4,000 MMBtu/yr in natural gas and $40,000 in annual energy costs.

Replace vertical shaft kiln burner

The current premix burners on the vertical shaft kiln (used in the tabular refractory process) have limited operating flexibility. Turndown capability and precision control, as well as the ability to accept preheated combustion air, are all restricted. Replacing these burners with oxy-fuel burners may increase efficiency and productivity. The project could save 16,200 MMBtu/yr in natural gas and $80,600 in annual energy costs. However, with a capital cost of approximately $250,000, this project does not meet Alcoa's economic criteria for cost reduction and will not be pursued at this time.

Preheat air in calcine kiln

The assessment team considered trying to recover heat from the calcine kiln exhaust and use it to preheat the combustion air. The project could save 22,200 MMBtu/yr in natural gas and $66,000 in annual energy costs. However, with a capital cost of approximately $128,000, this project does not meet Alcoa's economic criteria for cost reduction and will not be pursued at this time.

Manage peak electricity load

The plant load factor for the Bauxite facility is approximately 80%, indicating high utilization of electric power. The best opportunity for peak load management is to operate the facility's many batch processes in a campaign fashion. With the processes running in series instead of parallel, the demand level and the electric cost can be reduced. Expected annual savings are 1,000 kWh in electricity and $150,000 with little or no capital costs.

Improve power factor

The power contract for the facility includes a penalty for power factors less than 0.9. The low power factor can be corrected by redistributing existing capacitance to the proper locations in the plant. This will maintain the power factor at or above 0.9 and save $190,500 in yearly penalty costs.

Results and Recommendations

As indicated in Table 2, implementing the five remaining projects identified during the departmental energy use assessment is estimated to yield annual savings of $925,300 in direct energy costs and non-fuel operating and maintenance costs. The initial capital requirement is estimated to be $271,200. The average payback period for all five projects would be approximately 3.5 months.

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.

Project Partners

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DOE/GO-102003-1647
July 2003