Save ENERGY Now

Terra Nitrogen plant in Verdigris, Oklahoma.

Terra Nitrogen Company, L.P.: Ammonia Plant Greatly Reduces Natural Gas Consumption After Energy Assessment

Benefits

- Saves approximately $3.5 million annually
- Achieves annual natural gas savings of 497,000 MMBtu
- Achieves a simple payback of 11 months

Key Findings

- Accurately quantifying potential energy savings can provide renewed impetus to reduce energy use.
- Although Terra Nitrogen actively managed its energy use, the Save Energy Now assessment provided new insights into additional energy savings opportunities.
- By upgrading steam-powered turbines, modifying an ammonia condensing loop, and repairing steam traps and leaks, Terra Nitrogen achieved significant energy savings.
- Once companies achieve positive results in one plant, they are more likely to extend energy-saving activities to their other facilities.

Application

Ammonia plants require large amounts of steam, so steam systems are significant end-use energy consumers in such plants. By evaluating their steam systems' energy use patterns, ammonia plants can discover important energy savings opportunities that can reduce energy use, costs, and emissions and improve productivity.

Summary

In early 2006, Terra Nitrogen Company, L.P., received a U.S. Department of Energy (DOE) Save Energy Now assessment at its ammonia and fertilizer plant in Verdigris, Oklahoma. The main objective of the energy assessment was to analyze natural gas use in the plant's steam system and identify opportunities for energy savings. The assessment was performed by DOE Energy Expert Veerasamy Venkatesan of VGAEC, Inc., and it identified some important opportunities to improve the steam system's efficiency. By implementing some of these important opportunities, plant personnel were able to significantly reduce the plant's natural gas consumption.

Verdigris plant personnel wasted no time in implementing several of the assessment's recommendations to improve the efficiency of the plant's steam system. They upgraded two turbines, installed a loop dehydrator on an ammonia plant, and repaired failed steam traps and steam leaks. The aggregate annual energy and cost savings resulting from implementing these measures is approximately 497,000 MMBtu and more than $3.5 million. With project costs of around $3.1 million, the plant achieved a simple payback of less than 11 months. Additional opportunities identified in the energy assessment are still being implemented. The assessment results were shared with three of the parent company's U.S. plants.

Project Drivers

Terra Nitrogen management has consistently encouraged the Verdigris plant's efforts to improve energy efficiency. Before the Save Energy Now assessment, plant management and personnel had installed a loop dehydrator in ammonia plant #1 and therefore understood the potential for significant natural gas savings from this project. The assessment analysis performed using DOE's Steam System Assessment Tool (SSAT) confirmed the scale of potential energy savings resulting from installing a loop dehydrator and from retrofitting the back-pressure turbine with a condensing turbine in ammonia plant #2. When these and other opportunities were uncovered and quantified in the assessment, the plant's personnel did not hesitate to implement them.

One of the new condensing turbines in ammonia plant #2; these new turbines are reducing energy use by 228,000 MMBtu annually.

Company and Plant Background

Terra Nitrogen Company, L.P., an indirect wholly-owned subsidiary of Terra Industries Inc., is a major U.S. producer of nitrogen fertilizer products with annual revenues of more than $400 million. The company's manufacturing facility in Verdigris, Oklahoma, is a highly integrated manufacturing site producing 2.2 million tons of urea ammonium nitrate solutions and 1.1 million tons of ammonia per year. Terra Nitrogen also operates shipping terminals in Blair, Nebraska, and Pekin, Illinois.

Because natural gas is the primary feedstock for hydrogen (which is combined with nitrogen to make ammonia), the plant requires significant amounts of natural gas for production. In addition, natural gas is the primary fuel for the plant's steam systems, which provide critical support to the ammonia production processes. As a result, natural gas costs account for most of Terra Nitrogen's total expenses, and the Verdigris plant's management is committed to improving its production and steam system efficiency. Natural gas costs for the Verdigris plant were around $7/MMBtu during the implementation period.

Assessment Overview

The Save Energy Now assessment at the Verdigris plant was sponsored by the DOE Industrial Technologies Program (ITP). The assessment was performed by an Energy Expert who is a qualified specialist in the use of DOE's steam system assessment tool (SSAT) software. In addition to evaluating the steam system, the assessment's purpose was to introduce DOE's SSAT software to plant employees and encourage them to use it in the future to analyze the steam system. The Energy Expert formed an assessment team with two plant employees and installed SSAT on their computers. This enabled them to learn the software and review the data together to best determine how they could improve the steam system's efficiency.

Assessment Recommendations

After finalizing the data collection, the assessment team analyzed it using SSAT and identified potential energy efficiency opportunities. Each opportunity was evaluated for technical and economic feasibility. These opportunities were then grouped into near-, medium-, and long-term projects, depending on expected energy savings and payback periods.

Near-term opportunities

- **Recover Flash Steam from Blowdown Water—**The assessment found that, after flashing to a low-pressure header, a substantial amount of blowdown water was being sent to a cooling tower at 50 psig and 300°F. The analysis indicated that routing the blowdown water directly to a deaerator could help generate more than 1,200 lb/hr of flash steam for the plant. Estimated savings would be 14,982 MMBtu and $105,000 per year.
- **Implement a Steam Trap Maintenance Program—**Although a steam trap audit was not performed during the assessment, the team realized that some steam traps were poorly positioned and some were not even operating. Adopting better trap installation techniques and maintaining the existing steam traps could result in estimated annual energy and cost savings of 12,264 MMBtu and $86,000.
- **Implement a Steam Leak Maintenance Program—**Although few leaks were found, the assessment recommended performing a leak audit and fixing all visible steam leaks. The resulting estimated annual energy and cost savings would be 876 MMBtu and $6,000. Project costs were estimated to be $2,500 to $4,000.

Medium-term opportunities

- **Modify Synthesis Loop—**The assessment found that the existing synthesis loop in the site's ammonia plant #2 was operating inefficiently, requiring large amounts of high-pressure steam. Reversing the circulation in the ammonia condensing loop would improve the ammonia plant's efficiency and reduce its demand for high-pressure steam. The assessment estimated that this measure would increase the ammonia plant's efficiency by 0.4% and thereby lower high-pressure steam demand by approximately 20,000 lb/hr. Energy savings were estimated at 0.4 MMBtu per ton of output, yielding estimated annual natural gas savings of 274,000 MMBtu. The resulting annual energy cost savings were estimated to be about $1.9 million.
- **Turbine Upgrade—**Ammonia plant #2 uses two back-pressure turbines to let down 545-psig steam to the 50-psig steam used for some low-pressure steam applications. The back-pressure turbines powered methyldiethanolamine pumps and were supplemented by hydraulic turbines. The assessment found that excess 50-psig steam was being vented and recommended that the existing turbines be upgraded with more efficient condensing turbines. The recommended condensing turbines could reduce high-pressure steam demand and low-pressure venting, yielding estimated annual energy and cost savings of 178,000 MMBtu and about $1.2 million.
- **Improve Operation of Condensing Turbines—**The vacuum in the surface condensers of the condensing turbines in ammonia plant #1 is maintained at between 24 in. and 26 in. of Hg, depending on the season. Installing an absorption chiller powered by low-level waste heat that could cool the supply-side cooling tower water could increase the vacuum by an additional 0.5 in. of Hg. The assessment estimated that this would reduce energy consumption by approximately 170,000 MMBtu and save approximately $1.2 million per year.

Long-term paybacks

- **Build a High-Pressure Natural Gas Pipeline—**The energy assessment found that the plant's local utility delivers natural gas to the Verdigris plant at 185 psig. Because the plant requires high-pressure natural gas (550 psig) for its processes, it currently operates steam-driven gas compressors to achieve the required pressure level. The assessment explored the possibility of building a high-pressure gas pipeline from the plant and connecting it to a high-pressure pipeline owned by the plant's natural gas utility. If such a pipeline could be constructed, and the utility would be willing to sell high-pressure natural gas directly to the plant, the plant could save an estimated 851,000 MMBtu and nearly $6 million per year.
- **Improve Efficiency of Auxiliary Boiler—**The assessment found that the efficiency of the auxiliary boiler in ammonia plant #1 could be improved by reducing the stack temperatures from 400°F to 320°F. This could be done by installing an air preheater on the boiler's stack to recover some of its heat. Estimated annual energy and cost savings are 135,000 MMBtu and $945,000.

A loop dehydrator installed in ammonia plant #2 is also saving the plant 228,000 MMBtu per year.

If all these measures were implemented, the total resulting annual energy cost savings would be about $11.5 million.

Results

Verdigris plant personnel implemented two of the most important recommendations in the Save Energy Now energy assessment soon after it was conducted and then began working on several others. They upgraded the back-pressure turbines with condensing turbines and installed a loop dehydrator on ammonia plant #2. Each of these two measures resulted in annual energy savings of 228,000 MMBtu, for a combined savings of 456,000 MMBtu per year. The annual energy cost savings resulting from implementing the two measures is just under $3.2 million. In addition, the plant hired a consultant to audit and repair broken or poorly functioning steam traps, and it purchased an infrared leak detector to detect and repair steam leaks. Total energy and cost savings from all the implemented measures to date are approximately 497,000 MMBtu and $3.5 million. At total implementation costs of just over $3.1 million, the simple payback is slightly less than 11 months. The Verdigris plant is sharing the results of the assessment and the recommended measures that were implemented with several other Terra Industries facilities.

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Verdigris plant personnel carefully reviewed other opportunities uncovered in the assessment and took some other steps to improve steam system efficiency. They examined the boiler in ammonia plant #1 and found that all the boiler's coils were dirty and one was leaking. They estimated that cleaning and repairing the coils could improve process efficiency by 0.3 MMBtu/ton. They also evaluated the condensing turbines in ammonia plant #1. Rather than installing an absorption chiller, they decided to overhaul the condensing turbines by changing the rotors, cleaning the cooling units, and replacing the low-pressure steam ejector nozzles during a 2007 plant shutdown for maintenance. Other recommended measures either had lengthy paybacks or were too difficult to implement. For example, many difficult permitting and right of way issues were associated with the high-pressure natural gas pipeline, and it would have required renegotiating the plant's contract with its natural gas utility.

Lessons Learned

Independent, alternative evaluations of industrial process systems can confirm many known opportunities to reduce energy consumption and uncover important additional ones that help to achieve significant energy cost savings. Employees at Terra Nitrogen's Verdigris plant were highly knowledgeable about the steam system's energy use, and they regularly performed steam balance analyses. They also knew from prior experience that efficiency gains could result from upgrading steam system components. However, a system-level analysis using the SSAT quantified these and similar opportunities and uncovered new ones that were highly compelling. This energy assessment's results persuaded management to carry out many of the recommendations and encouraged performance of more rigorous future analyses. DOE software tools such as the SSAT and AIRMaster+, the Fan System Assessment Tool (FSAT), MotorMaster+, the Process Heating Assessment and Survey Tool (PHAST), the Pumping System Assessment Tool (PSAT), and 3EPlus can all be used to analyze industrial systems and processes and generate energy efficiency opportunities.

Save Energy Now

Save Energy Now (**www.eere.energy.gov/industry/saveenergynow**) is a national campaign started in 2005 in response to a rapid rise in energy prices. This campaign helps U.S. industry reduce energy use and supports national goals for energy security. Through Save Energy Now, DOE's Industrial Technologies Program helps industrial plants operate more efficiently and profitably by identifying ways to reduce energy use in key industrial process systems.

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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