ESA-029 Final Public Report

Introduction:

The United States Department of Energy (U.S.DOE) Save Energy Now Program completed an Energy Saving Training-Assessment at the National Starch Indianapolis Operations and the Citizens Thermal Energy District Heating Perry Facility. The Citizens Thermal district heating plant serves several clients in the area with National Starch being a major industrial client. This Training-Assessment targeted a portion of the district heating generation facilities and the National Starch facility. The remaining district heating generation units as well as the other industrial and city clients were not included in the scope if this investigation. The target facilities are located in the downtown Indianapolis, Indiana area. The onsite activities occurred June 7, 8, and 9, 2006. The principal investigator for the steam system assessment was Greg Harrell, Ph.D., P.E. from the Energy, Environment and Resources Center of The University of Tennessee Knoxville.

The district heating system is primarily a steam generation system. However, two steam turbine electrical power generating units are in the system as well as chilled water refrigeration machine turbine drives. The main power generating turbines are nominally rated to produce 5 MW and 15 MW of electrical power. These main turbines are extraction-condensing units.

The district heating system is supported from eight conventional boilers and three refuse-fired boilers. The refuse boilers were not targeted during this Training-Assessment. The refuse-fired boilers are typically base loaded at maximum steam production. Therefore, they are typically not impact components with the exception of displacing purchased fuels. The time allotment of the Training-Assessment did not allow targeting these components. The remaining boilers burn a variety of fuels including natural gas, fuel oil, stoker coal, pulverized coal, and coke oven gas. In general coal and coke oven gas are the fuels consumed at the main site under investigation. Typical steam production from this site is nominally 300,000 lbm/hr.

The National Starch facility is a wet corn milling facility producing specialty chemicals from corn. Steam is used throughout the production facility in drying and processing corn and starch materials. Steam is not generated on the National Starch site but is purchased from the district heating system. The National Starch site nominal steam consumption is 70,000 lbm/hr.

The Training-Assessment focused on training in steam system evaluation techniques, U.S.DOE Steam Tools training, and general steam system management training. The complete steam system incorporating all of the Citizens Thermal plants as well as all of the connected users is large and complex. As a result, the Training-Assessment focused on the National Starch facility and the Perry Generating Station of Citizens Thermal.

Prior to and during the onsite activities lists of potential investigation projects were developed. This allowed the onsite activities to proceed into significant investigation detail.

Steam is produced at two pressures in the district heating generation station—high-pressure (600 psig, 750°F) and medium-pressure (400 psig, 600°F). Steam passes from the high-pressure system to the medium-pressure system through pressure reducing valves—backpressure turbines are not present to allow this pressure reduction. Medium-pressure steam is distributed to the National Starch facility.

The National Starch facility distributes and utilizes steam at a variety of pressures. The dominant pressures are 400 psig, 250 psig, 150 psig, 130 psig, and 10 psig. Steam pressure reduction is accomplished exclusively with pressure reducing valves. Desuperheating stations accompany the pressure reduction units.

Coal and coke oven gas are the impact fuels for the district heating system. These two fuels are obviously significantly different in combustion and fuel handling characteristics. However, these fuels are essentially identical in terms of impact commodity cost. Coal and coke oven gas supplies total approximately 3,700,000 10^6Btu/yr fuel energy supply. It should be noted that this steam generation is only a portion (less than 50%) of the total district heating generation. The impact cost of coal and coke oven gas is approximately \$1.72/10^6Btu.

The National Starch facility purchases approximately 750,000 10^6Btu/yr of steam energy from the district heating generation system. The impact cost of steam is approximately \$8.00/10^6Btu.

Natural gas supplied from the general utility supplier is consumed at both the district heating plant as well as the National Starch facility. A minimal amount of natural gas is consumed in the district heating generation system. The National Starch facility utilizes natural gas in several process units. The impact cost of natural gas is estimated to be \$9.00/10^6Btu.

Electricity can be the impact commodity for any of the Training-Assessment areas. Both facilities—National Starch and Citizens Thermal—are impacted by the same electrical costs. The electrical contract is composed of several factors with electrical energy consumption and electrical peak demand being the dominant impact components. The electrical energy impact cost is generally \$35.0/MWh. The electrical demand cost is \$10.75/(kW month). This demand charge translates into a minimum peak demand impact of \$14.7/MWh. These values combine when demand and energy are impact components to be \$49.7/MWh.

Objective of ESA:

The Energy Savings Assessment is designed to be an onsite *Training-Assessment*. The Training-Assessment places a system specific specialist onsite to evaluate the steam system, assess the operating performance of the steam system, and chart a course for operational and management improvement of the system. The primary strength of this activity is that site personnel are trained in the field evaluation techniques, modeling techniques, and implementation strategies associated with steam system management.

The U.S.DOE Steam System Evaluation Tools are used for the investigations and the site energy assessment team is trained in the use of the tools. These tools are software based and provide the site participants with powerful evaluation components to aid in system energy management. Furthermore, because replication is a primary focal point, it is a primary goal of the program to involve all interested personnel. Personnel from other sites are invited to participate in the Training-Assessment.

There are three primary goals of the Training-Assessment. The first goal is to identify realistic energy saving projects that will satisfy acceptable economic criteria for implementation. The target projects are fundamental in nature with low technical and financial risk. The second goal is to train site personnel in the evaluation techniques, management techniques, and practical applications of steam system management. This involves field measurement methodologies, U.S.DOE Steam Tools training, and general principles training. The third primary goal is to identify BestPractices that are in use at the site. This identification is designed to highlight excellent activities that are broadly applicable and can be replicated throughout the industry.

Focus of Assessment:

The complete National Starch site steam system served as one of the focal points for this Training-Assessment. The Citizens Thermal Perry Station district heating generation system served as an additional focal point for the Training-Assessment. The systems are interconnected and involve cogeneration activities; therefore, all of the investigations included system interactions.

Approach for ESA:

This Energy Savings Training-Assessment was executed with a non-traditional approach. The non-traditional approach was required primarily because of the extent of the connected systems. The interconnected sites constitute a very large complex that encompasses a large section of the greater Indianapolis area. As a result, the time allotted for the onsite activities was insufficient to allow a traditional investigation strategy.

General Observations of Potential Opportunities:

The following subsections of this report briefly discuss the projects recommended for additional investigation or implementation. The projects presented here have an economically attractive implementation potential. In the project descriptions an indication of the implementation timing is provided. A qualifier is assigned to each project—*near-term*, *medium-term*, or *long-term*. These descriptors are identified as follows.

- *Near-term* opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment, relatively low cost actions, or equipment purchases.
- *Medium-term* opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters or the installation of a significant condensate collection system. It would be necessary to carryout further engineering and return on investment analysis.
- *Long-term* opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.

1 Boiler Combustion Set-point Adjustment

The boilers serving the Citizens Thermal Perry Station facility are all equipped with continuous flue gas oxygen monitoring and control. The typical flue gas oxygen content of these boilers is greater than 8.0% and can range above 11.0%. This flue gas oxygen content is considered significantly elevated for the types of boilers and fuels burned at the site. Typically, higher flue gas oxygen content is required for stoker coal fired boilers when compared to pulverized coal fired boiler. Pulverized coal fired boilers typically require higher flue gas oxygen content when compared to gaseous fuel fired boilers. This site operates all three types of fuels. All of the flue gas oxygen contents are considered elevated.

These boilers typically operate with a combined steam production of 300,000 lbm/hr. The boilers are generally operating with loads greater than 50% of design steam production. It is recommended to execute a trial that will reduce the flue gas oxygen content of these boilers. The flue gas oxygen content controller should be adjusted to only reduce the oxygen set-point in the medium and upper ranges of the boiler load. The adjustments are expected to allow the boilers to operate with oxygen concentrations less than 6.0% nominal range. The savings opportunity is approximately $150,000/yr based on reducing the flue gas oxygen content from 8.0% to 6.0%. The risk associated with implementing the change is considered minimal. The cost associated with executing this recommendation is negligible because all of the equipment required for implementation is in place.

Flue gas combustibles monitoring should accompany the reduction in oxygen content. The current combustibles concentrations are relatively low for the type of boilers and fuels in service. This is considered a near-term project. It is

also highly probable that the flue gas oxygen content can be reduced further. Typically, stoker coal fired boilers operate in the 5.0% flue gas oxygen content and the gaseous fuel boilers operate with less than 3.5% flue gas oxygen content.

2 Eliminate Steam Supply to Warehouses

Steam is supplied to the National Starch facility primarily for process heating purposes and vacuum generation activities. However, a portion of the steam is supplied for building heating purposes. The site is configured with three primary warehouses. The materials stored in the warehouses are not influenced by moderate temperature changes. As a result the warehouses do not require heating during the colder months. However, steam heating is supplied to the warehouses.

Site engineering personnel have determined that the heating season thermal energy requirement for the all of the warehouses combined is approximately 12,500 10^6Btu/yr. This is representative of $100,000/yr of steam purchases. The energy related unit cost for steam is approximately the unit cost of natural gas. Implementation of this project can be accomplished with no economic investment. Additional savings are anticipated with this activity in the form of reduced steam trap losses and reduced thermal loss from piping. These savings result as the steam supply piping serving the warehouses are no longer charged with steam.

This is a steam purchase reduction of more than 1.5%. The project is an economically attractive and fundamentally sound. This is considered a near-term project.

3 Eliminate Steam Supply to SO_2 Scrubber

The National Starch facility is equipped with a sulfur dioxide (SO_2) scrubber to control environmental emissions of sulfur from a process unit. The scrubber system incorporates steam injection as an atomization aid. Steam is injected in a portion of the unit's spray nozzles to enhance atomization, which promotes mixing and reaction.

The site environmental management team has completed extensive tests on the SO_2 scrubber system that have proven the steam atomization activity is not required for the effective and efficient operation of the equipment. As a result, the team is applying for an environmental permit that will allow the steam atomization to be eliminated.

The steam supply to the SO_2 scrubber system nominally averages 5,000 lbm/hr. This is representative of approximately $300,000/yr of steam purchases. It has been noted previously that the energy related unit cost for steam is approximately the unit cost of natural gas. Implementation of this project can be accomplished with no economic investment. This is a steam purchase reduction of approximately 5%. The project is an economically attractive and fundamentally sound. This is considered a near-term project.

4 Eliminate Steam Leaks

Steam supplied to the National Starch facility is a relatively high-cost energy commodity. Site operations and engineering personnel have initiated what is considered a **Best Practice** steam leak management program. The program incorporates a site-wide comprehensive steam leak survey. The survey activity identifies the location of the leaks as well as the severity of the individual leaks. The severity assessment is couples with a "gross order of magnitude" leak rate for each leak identified. It is understood that the leak rate assigned to each location is simply an indicator to aid in prioritization of repair work. The leak rate is connected to an economic impact of each leak, which is of course a gross estimate.

Leak repairs are prioritized based on apparent cost and difficulty of repair. It should be noted that some repairs require partial or complete steam system outages or relatively expensive repair activities. The order of magnitude loss estimate for the entire site is 10,000 lbm/hr. This is representative of approximately $500,000/yr of steam purchases. The implementation cost associated with eliminating leaks is not completely known but general indications are that repairs can be accomplished with a cost that is 10% of the cost of the leak. In other words, the leaks are expected to be repaired with a cost that is on the order of $50,000. It is interesting to note that more than 200 leaks were identified throughout the site; however, the majority of steam loss is resulting from 8 leaks.

Steam leaks apparently represent 5% to 10% of the total steam consumption of the National Starch site. This project activity is economically attractive, fundamentally sound, and is identified as a **Best Practice** approach. This is considered a near-term project.

5 Continue Steam Trap Program

The National Starch facility is initiating what is considered a **Best Practice** steam trap management program. The program incorporates a site-wide comprehensive steam trap survey. The survey activity investigates every steam trap in the plant and evaluates each trap based on specific criteria. The primary points of investigation include functionality, installation, trap type appropriateness, condensate recovery, and history. Steam trap functionality is determined through ultrasonic, temperature, and visual means. Failure modes are noted and steam loss estimates are based on failure severity. The maximum steam loss from a trap failed open and blowing "live steam" is based on the restricting orifice diameter of the individual trap and the steam pressure supplied to the device. Repairs are prioritized based on site impact. Often steam traps failed in the closed position result in more economic loss than steam traps losing live steam. This results from process throughput or quality issues. It is understood that the leak rate assigned to each location is simply an indicator to aid in prioritization of repair work. The leak rate is connected to an economic impact of each leak, which is of course a gross estimate. A computer based database is used to maintain system-wide information.

The order of magnitude loss estimate associated with steam trap failures is 2,900 lbm/hr. This is representative of approximately $200,000/yr of steam purchases. The site-wide steam trap population is 542 traps. The recent survey identified approximately 26 traps (5% of the population) with a failure mode resulting in lost steam. The total number of failed traps (in-service) was identified to be approximately 22%. This is a typical failure percentage observed in industrial facilities with annual steam trap surveys. The implementation cost associated with replacing the steam traps is not completely known but the purchase and installation cost of steam traps is generally not oppressive. Therefore, the cost estimate associated with replacing the 80 failed traps is approximately $100,000.

Steam trap failures apparently represent 3% of the total steam consumption of the National Starch site. Steam trap management is economically attractive, fundamentally sound, and is identified as a **Best Practice** approach. This is considered a near-term project.

6 Explore Biomass Fuel

Some of the process operations at the National Starch facility produce waste starch. The starch material is composed primarily of carbon, oxygen, and water (liquid). Typically, water constitutes somewhat more than 50% of the mass of the material. Carbon is generally 20% of the mass of the material and oxygen is typically 10% of the mass of the material. Additional components are nitrogen, hydrogen, sulfur, and ash.

This material has a fuel energy value on an “as-received” basis of approximately 4,600 Btu/lbm (higher heating value basis). It is very common in the pulp and paper industry to utilize a very similar material (paper-mill sludge) as the fuel supply to a boiler. Generally, the paper-mill sludge is supplied to a boiler that is designed to burn wood or coal.

It is recommended to explore the possibility of burning the National Starch waste starch in the Citizens Thermal boilers. There is approximately 4 10^6lbm/month (as-received) of waste material available for fuel. This waste material could produce approximately 15,000 lbm/hr of steam and displace 1,600 lbm/hr of coal consumption. This steam production is equivalent to $1,100,000/yr of National Starch steam purchases or $400,000/yr of Citizens Thermal coal (or coke oven gas) fuel purchases.

This project is in the development phase. The potential problems associated with handling and burning the material have not been fully explored. A general opinion is that the material should be targeted for the stoker fired boilers at Citizens Thermal—the gas fired and pulverized coal fired boiler would be difficult to retrofit for this service. The stoker boilers are “spreader-stoker” type units. This has the potential of complicating the material handling but a trial is recommended. This is considered a long-term project with the potential of impacting 20% of the National Starch steam consumption.

7 Insulation Repair

The thermal insulation throughout the National Starch site is observed to be in fair condition. A large majority of the piping is generally appropriately insulated with adequate jacketing. However, there is a significant amount of piping observed to have missing insulation or severely damaged insulation. Site operations and engineering personnel have initiated what is considered a **Best Practice** insulation management program. The first stage of the program has been initiated. This stage is designed to survey the site piping and equipment in detail to identify and quantify the amount of insulation related issues. Prioritization of insulation remediation areas will focus on energy savings potential, expected life of the process area, complexity of the installation, and implementation staging.

A general abbreviated survey was completed during the onsite Training-Assessment. This piping only survey identified an energy savings potential of approximately $25,000/yr—3,125 10^6Btu/yr. This translates into approximately 0.4% of total steam energy input to the site. A re-insulation cost estimate for the identified piping is $7,000.

The steam system will be evaluated in detail in the near-term. Preliminary investigations indicate the energy loss from the steam system (resulting from damaged or missing insulation) will be more than four times this representative survey. Steam is distributed throughout all areas of the site and steam piping is exposed to significant outer covering hazards. As a result a gross projection of steam system insulation savings potential including the sample discussed above is $100,000/yr—12,500 10^6Btu/yr. This is approximately 1.7% of steam energy input. This is a high-priority focus area that is considered a near-term project.

8 Spray Dryer Insulation

The National Starch facility is equipped with three similar spray dryers in the one process unit. These spray dryers are large vertical cylindrical vessels that have liquid process fluids inside. The process fluids are generally 200°F and enter the upper sections of the vessels, travel down the vessels, and exit through a relatively large diameter duct at the bottom of a conical transition section.

One of the spray driers has been insulated with a 1 inch nominal thickness insulation layer. This unit was compared to the other two units to compare the effectiveness of the thermal insulation. The investigation indicated the insulated unit operates with less than 40% of the thermal loss that one of the un-insulated units operates with. A heat transfer analysis indicates the thermal energy reduction potential is approximately $60,000/yr—7,500 10^6Btu/yr—for the two remaining spray dryers combined. This translates into approximately 1.0% of total steam energy input to the site. The cost of insulating the first spray dryer was $75,000. Therefore, the total project cost associated with insulating the two remaining spray dryers is approximately $150,000. This is considered a medium-term project.

Management Support and Comments:

All of the support provided for this activity was exceptional. The Training-Assessment was well planned and preparations were excellent. It is notable that the site has developed a significant energy management focus. These participants have accomplished substantial improvement in the management of the steam system.

DOE Contact at Plant/Company:

Ray Snyder, National Starch Utility Manager, (317) 656-2236, ray.snyder@nstarch.com.
Ray Proud, Citizens Thermal Energy Project Coordinator, (317) 693-8824, rproud@cgcu.com.