Recipients: Hankinson Renewable Energy, LLC
Contract Number: 039-049
Report for time period of: November 30, 2019 – December 31, 2020

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Description of Project
HRE’s current ethanol production rate is steam-limited during the winter months inhibiting the plant’s ability to produce ethanol, thereby limiting overall production. This project will address this limitation through the installation of a Stack Heat Recovery (SHR) system. The SHR system is designed to capture excess heat energy released from the plant’s dryer exhaust stack and recycle the heat back into the production process. In addition, the system will collect water condensation from the dryer exhaust stack and use it for boiler make-up and process water. In effect, the system will improve efficiency by decreasing natural gas and make-up water needed, while increasing the production of ethanol and coproducts.

The project is expected to increase ethanol production by an estimated 10 million gallons per year. The 85% cash match ($2,742,569) comes from the applicant.

This project will serve as a demonstration for other North Dakota ethanol plants interested in utilizing the technology. It will result in increased ethanol production, increased demand for corn, increased supply of coproducts, and additional revenue in the state.

HRE expects to see significant benefits, including:
- Reduction of water usage by 6.4% per gallon of ethanol.
- Reduction of natural gas usage by 8.2% per gallon of ethanol.
- Increase annual net income by $4,478,000.
- Increase in ethanol production by 10,000,000 gallons annually.

Project Tasks
The overall completion of the project was delayed two weeks because of two control valves and one steam valve being backordered. The Stack Heat Recovery (SHR) System checkout commenced on December 2, 2019. The motor rotations were checked on the two SHR fans and the two recirculation pumps. The instruments were calibrated and loop checked. The automation controls were tested to ensure proper startup and shutdown. The entire system was inspected to ensure all construction debris were removed from the system.

The final two control valves and one steam valve arrived on site December 4, 2019. The valves were installed and tested on December 5, 2019. The system was filled with water on December 6, 2019. Each recirculation pump was started, and leak checks were performed. Each SHR fan was then started to direct the hot gas stream through the heat exchanger and verify heat transfer from the hot gas to the circulating water and steam was being produced in the flash vessel.

One issue that arose during commissioning was the flow meters in the water recirculation lines were providing erratic readings. It was determined that the flow meter location as designed did not allow the flow meters to be constantly filled with water. The flow meters were moved to the other side of the heat exchangers and the issue was resolved. Except for the flow meter issue, commissioning and startup went very well with little to no issues. The system was fully operational on December 12, 2019.

**Deliverables**

The overall project is 100% complete and has been in operation for 12 months. The entire system has a robust design utilizing standard fans, pumps, instruments, and steam eductor. The heat exchangers are the only specialty equipment in the system. The system requires very little operational input to operate. The system is designed and incorporated into the process so that the system can be taken offline, and the process can still operate (all be it at a slower rate due to less overall steam production).

The SHR system steam output is dependent on several factors that include:
- Plant rates (pounds of vapor available)
- Dryer rates (water in Thermal Oxidizer exhaust vapor)
- Stack Temperature
- 1st effect evaporator pressures

Steam output is dependent on the overall mass flow of vapor. The higher the moisture content, the higher mass and available energy to be recovered. Low pressure steam is being generated by the SHR and injected in the 1st effect evaporators. If the pressure in the 1st effect evaporators increases, the low pressure steam cannot effectively be pushed into the evaporators by the eductor.

Lessons learned include Variable Frequency Drives (VFD’s) should have been installed on the existing Thermal Oxidizer Induced Draft (TO ID) Fans and the eductor motive steam pressure needs to be within the operating range as specified by the manufacturer.

The existing TO ID fans utilized dampers to control the air flow through the dryer/TO systems. Once the SHR system was in operation, the TO ID dampers are almost closed creating vibration in the ductwork which has caused some cracking in various connections. Furthermore, additional electrical energy savings can be obtained. The plant will be installing VFD’s on the TO ID fans at the next schedule maintenance shutdown.

The eductor must be supplied with the motive steam pressure per the eductor design. If the motive steam falls below the rated design pressure required by the eductor, there is not enough motive energy to move the low pressure through the eductor into the evaporators.

The effectiveness of the technology was evaluated based on the following:
• Reduction of water usage per gallon of ethanol of 2.5%
• Reduction of natural gas usage per gallon of ethanol of 8.62%
• Based on market conditions used when the system was deployed, the net income increase based on the results demonstrated and the estimated potential of an increase in 15.7 million gallons annually would be $6.8mm.
• Potential to increase ethanol production by 15.7 million gallons annually, however with demand destruction during COVID we have not ramped up to this level.

The system has averaged 12 gpm of condensate recovery. This condensate is returned to the boiler, it displaces an equivalent of two times the amount of raw well water since raw well water must go through both a reverse osmosis and a water softener before it can be used in the boiler. A total water reduction of 2.5% or 0.08 gal of water per gal of ethanol was realized. The expected 2.5% reduction is less than the original 6.4% projected water savings. After further review, the projected 6.4% savings was a miscalculation based on the assumption the total steam generated was water recovered from the TO stack condensate.

The reduction of natural gas of 8.8% exceeded the expectation of an 8.2% decrease. This is within the range expected.

Ethanol production was increased by 3.0%. As a result of the COVID-19 pandemic, market conditions created extreme demand destruction which has not allowed the plant to expand production to fully realize the ethanol production capability created with the addition of the SHR system. Baseline conditions demonstrated that on average, 12.5 lbs of steam is required to create one gallon of ethanol. Based on this ratio, the potential ethanol production increase from SHR is estimated to be 15.7 million gallons annually.

**Expenditures**

*Please provide a breakdown of expenditures. Include all sources of match. Provide supporting documentation as a separate attachment.*

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<th>Project Expense</th>
<th>NDIC</th>
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**CUMULATIVE EXPENDITURES**