DOE Grant
Menominee Tribal Enterprises
Biomass District CHP Energy Project

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1.0 INTRODUCTION

Menominee Tribal Enterprises (MTE) owns a sawmill operation located in Neopit, Wisconsin. MTE uses 6 kilns to dry a combination of hardwoods and softwoods totaling approximately 3 million board feet per year. In 2013 MTE committed to upgrade an existing biomass fired district heating plant to an efficiently sized biomass combined heat and power (CHP) system with automatic fuel handling and emission controls. The new biomass CHP plant presented MTE with the opportunity to efficiently generate steam and thermally-led electricity throughout the year, decrease particulate matter (PM) emissions, and reduce shutdown periods for maintenance and repair, and reduce overall operating costs. In March of 2014 MTE was awarded a DOE Renewable Energy in Indian Lands grant for $1,032,603. This 50% matching grant helped pay for new biomass processing, storage and handling, new backpressure steam turbine generator and upgrades to the district heating distribution system. The period of performance for completing the project was March 2014 through December 2016.

Existing Energy Usage and Systems

The MTE sawmill had a central boiler plant firing on bark and wood residue to generate steam at 80 psig for heating building spaces, and kilns used for drying lumber. Woody biomass fuel was blown pneumatically into a storage silo that fed two 27,000 lb/hr steam boilers. The fuel could be sawdust blown directly into the silo from the sawmill, or bark could be processed through a hammermill and blown into the silo. The hammermill required feathering in bark with a ½ cubic yard bucket on a skid loader. The boilers were manually rotated on a lead-lag schedule since one boiler is capable of meeting the annual peak heating demand. The fuel handling system was unreliable and required frequent shutdowns for maintenance and repairs, especially in colder weather.

MTE made a concentrated effort over the period from June 2011 through May 2012 to track the annual fuel usage by tracking end loader volumes placed in storage and fuel weights. MTE tracking showed use of 20,000 tons of biomass fuel used by the central steam plant during that period.

Lumber is dried in staggered schedules using 6 kilns with capacities of approximately 40,000 board feet per kiln. In addition to kiln heating, the central plant provides space heating for multiple buildings at the mill, the largest of which is a 58,000 ft^2 warehouse/manufacturing plant. MTE provided WERC with estimated annual wood use at the central boiler plant, boiler feed water flow measurements over the course of one week during February, and corresponding kiln operation during the period that the feed water measurements were recorded. Measurements suggest that the boiler was firing at a maximum output of 9,400 lbs/hr. Only one kiln was operating during the measurements and a new building is planned for construction that would connect to the district system, therefor maximum steam demand would be anticipated to be approximately 12,000 lbs/hr.

2.0 DOE GRANT PROJECT OBJECTIVES

The DOE Grant Project Objective was to install a new CHP biomass boiler and backpressure steam turbine to achieve the following goals: generate electricity with renewable energy; reduce emissions; energy cost savings; replace obsolete equipment. The tasks associated with the grant were:

- Selection of the equipment and preparing bid documents and selecting vendors per MTE bidding policies
- Demolition of an existing boiler to make room for a new boiler in the boiler room
- Preparing design and bid documents for the installation of new storage facilities and equipment and selecting contractors per MTE competitive bidding policies
- Design and Specifications for modifications and integration of new system to existing HVAC and steam distribution system and installation by MTE personnel
- Construction management and project coordination
- Final commissioning and verification of system performance
- Electric utility interconnection agreements and automatic safety disconnect testing

3.0 INSTALLED BIOMASS SYSTEM

A biomass combined heat and power system was installed to tie into the existing district steam heating system. The CHP system was sized based on modeling of the heating demand for the facility. This modeling was based on monitoring of boiler feed water measurements, kiln load schedules, and existing and future building heat loads.

Construction of the new fuel storage building began in August 2014 and was substantially completed by November 2015. One new advanced biomass combustion unit and 300 psig rated steam boiler sized at 8,600 lbs/hr was installed and covers 95% of the steam demand over the course of an operating season. The steam boiler is trimmed to operate at 275 psig and efficiently operates over a range of 2,000 to 8,600 lbs/hr. the boiler is currently operated at 250 psig. A 190 kW backpressure steam turbine generator is installed to generate electricity while reducing the steam pressure from 250 psig to 25 psig for use in the existing steam heating system. A pressure reducing station was installed in parallel to the turbine generator to allow operation of the higher pressure boiler during periods of turbine maintenance or repair. One of the existing 27,000 lbs/hr steam boilers was refurbished and upgraded with new boiler controls to cover peak loads during the coldest times of the year.

A new 3,200 ft^2 fuel storage with live floor was constructed to receive and store wood residue from the pneumatic sawdust system or from a refurbished fuel processing system. The design of the fuel handling and storage system allows MTE the flexibility to use the lowest value fuel in the boiler plant. This will provide additional flexibility for fuel utilization. Appendix A contains a site plan showing the layout of the new equipment

In addition the district heating system was expanded to include a hot water loop to heat the new fuel storage to eliminate problems with frozen fuel and to heat a new small diameter sawmill building that previously was heated by an outdoor wood boiler. Adding the hot water loop to the steam system increased the amount of renewable electricity that could be generated by the backpressure steam turbine and reduced the labor required for fueling the cord wood boiler.

Biomass Project Costs

The project was supported by three grants that each funded a portion of the project, USDA's Woody Biomass Fuel Utilization Grant helped to cost share the automation and refurbishing of one of the existing boilers to act as a backup, USDA's -Rural Energy for America Program (REAP) helped fund the purchase of the new boiler. DOE Renewable Energy in Indian Lands helped pay for the balance of the project which included: fuel storage, automatic fuel handling system, fuel processing equipment, high temperature bag house for emission control, backpressure steam turbine generator, interconnection with the existing steam distribution piping and upgrades to the district heating system and boiler plant infrastructure. For the portion of the project that DOE's grant supported the cost was $2,203,140 with the grant award at $1,032,602.

Table 1 – DOE Project Support

System Description	Cost
DOE CHP Project Cost	$2,203,140
DOE Grant Funding	$1,032,602

The capital cost for the total project is $3,731,641. The complete summary of funding sources is contained in table 2.

Table 2 – DOE Project Support

System Description	Cost
Total Project Cost	$3,731,641
DOE Grant Funding	($1,032,602)
USDA-Woody Biomass Utilization Grant	($250,000)
USDA-REAP Grant	($250,000)
BIA-Renewable Energy Study Grant	($24,566)
WI Focus on Energy Incentive Payment	($150,000)
MTE Capital and Financing	($2,024,473)

4.0 RESULTS

Problems encountered during the first winter

While the new biomass unit has been operating since November 2015 additional commissioning and adjustments were required throughout the first winter. The most significant problems were encountered with the automatic ash auger cleaning system, and the compressed air system that is used for blowing dust from the boiler tubes and cleaning the baghouse filters. The problems with the ash auger were related to the clearances between the auger and the auger tube at a transition point where small pieces of clinkers and refractory from the grate would become jammed. A redesign ash auger and tube were installed along with new grate refractory with rounded edges to alleviate the problem.

The compressed air system problems affected both the operation of the turbine and ability to effectively clean the boiler tubes. Whenever the baghouse filters were blasted or the boiler tubes blown with compressed air, the line pressure would drop and the turbine would trip off line. The compressed air is used to regulate the governor valve that controls steam flow through the turbine to maintain outlet pressure. When the line pressure would fall the turbine would trip off line. The air system capacity problems were related to the size of the pressure reducing valve that limited flow from the compressed air accumulator tank. l

The compressed air issues were addressed by early spring however load during the spring and summer months would fall below the level needed to keep the turbine on line as it only will operate down to 2,000 pounds per hour of steam. By fall the turbine was back on line and from November 2016 through March 2017 the 271,000 kWh or electricity has been generated reducing operating costs by approximately $12,000. Future plans call for connecting radiators from pre-drying sheds to the steam system to keep the turbine continuously on line.

Another problem encountered was with the installed steam meter for the new boiler. Four separate attempts by the manufacturer to solve the problem failed and it was late summer 2016 before steam meter readings were available. The new boiler system is set up to track fuel usage based on auger revolutions with the operator responsible for inputting the fuel density to get an accurate picture of fuel through the boiler. MTE boiler operators record the daily readings from the steam meter and the fuel meter in a log; however the fuel readings do not correlate well with the steam usage.

Emissions Reductions

During the winter of 2016, 2017 the new boiler was able to carry the plant load down to -20 °F. However due to lack of experience with the new boiler the reworked standby boiler was kept warm and on standby if needed. Also during the last year the reworked boiler was used more than anticipated as problems with the ash auger and compressed air system resulted in the new boiler being off line more than anticipated. It is estimated that over the last year the reworked boiler carried 15% of the load and the new boiler covered the remaining 85% of the load. Visible stack emissions from the old boiler were dramatically reduced after automation and rework (see figures 1 and 2).

For the first year of operation of the new system emissions are estimated based on 85% of the steam produced by the new boiler and 15% produced by the reworked boiler. Annual particulate matter (PM) emissions are estimated using AP-42 estimates and 50% net efficacy for the reworked boiler and 0.07 pounds per mmBtu of input and 65% efficiency for the new boiler. Table ES3 summarizes the estimated annual PM emissions released by the existing biomass plant, anticipated annual PM emissions with a baghouse, and the annual reduction of PM emissions in tons/year.

Table 3 – PM Emission Comparison

Fuel/Boiler	Annual Energy Input, mmBtu	Net Energy Output, mmBtu	Annual Emissions, tons			
			PM	NOx	SOx	Total
Existing Wood System, Wood	200,000	50,000	155	18	0.20	173
New systems 85% New, 15% Reworked Boilers	86,813	50,000	6	8	0.09	14
Decrease with new system	**113,187**		**149**	**10**	**0.11**	**159**

Note: PM emission values are calculated for the existing system that was replaced using AP-42 numbers and estimated fuel use by owner. New system calculation assumes 85% of net output from new boiler and 15% from reworked boiler.

Annual biomass fuel use decreased due to efficiency gains realized from using an efficiently sized biomass boiler with modern combustion controls. The existing system is over 40 years old, and does not automatically track wood fuel use. System efficiency tests were conducted during an energy audit that suggests the current biomass boilers have a fuel to steam efficiency of 25%. The new high pressure biomass steam boiler is assumed to have a fuel to steam efficiency of 65%, and the existing boiler retrofitted with new controls will improve to 35%.

Operating Cost Reductions

The major savings from the biomass system is from reduced fuel use due to the higher efficiency of the new boilers compared to the oversized existing boiler that was replaced. In addition the rework and automation of the existing boiler that remains for backup and is estimated to have covered 15% of the load during the past year operates more efficiently due to reductions in airflow and installing VFD drives on all fan motors. Residual values vary seasonally and based on market demand fluctuations, the new boiler, fuel processing and handling system provides MTE with greater flexibility in choosing the most economical fuel to use in the boiler. Savings are realized not only on the reduction in fuel use but also the ability to switch fuels to burn the least valuable residual.

Fuel savings are estimated at a reduction of 11,320 tons of fuel with a value of $25 per ton. In addition 270,000 kWh of electricity were generated during the last year. Future generation is estimated at 1,000,000 kWh per year based on increased time on line of the turbine. In addition labor required to operate the boilers has been reduced by 4 full time positions with an estimated savings of $163,000 per year. Table 4 is a summary of estimated savings over the last 12 months. Estimated operating savings for the first full year of operation is $462,227.

Table 4 – First Year Operating Savings

Item	Tons	kWh	$/unit	Annual Savings ($)
Annual Fuel Savings	11,319		$25	$282,967
Electricity Generated		271,000	$0.060	$16,260
Labor Savings			$163,000	$163,000
Total				**$462,227**

5.0 SUMMARY

The DOE Renewable Energy in Indian Lands Grant provided a major incentive to move forward with the MTE Biomass CHP Renewable Energy Project. As a result of the project MTE has improved its ability to compete in the forest products and manufacturing business sectors. The improvement in efficiency of the boiler and ability to use multiple residual types for fuel in the new system allows MTE to maximize future residual revenue and the ability to generate electricity allows a hedge against future utility cost increases. MTE matched DOE's grant of $1,032,602 with an additional $1.1 million. Total project cost was $3.7 million with $1.7 million in grant and incentive funding and $2.0 million in MTE funding.

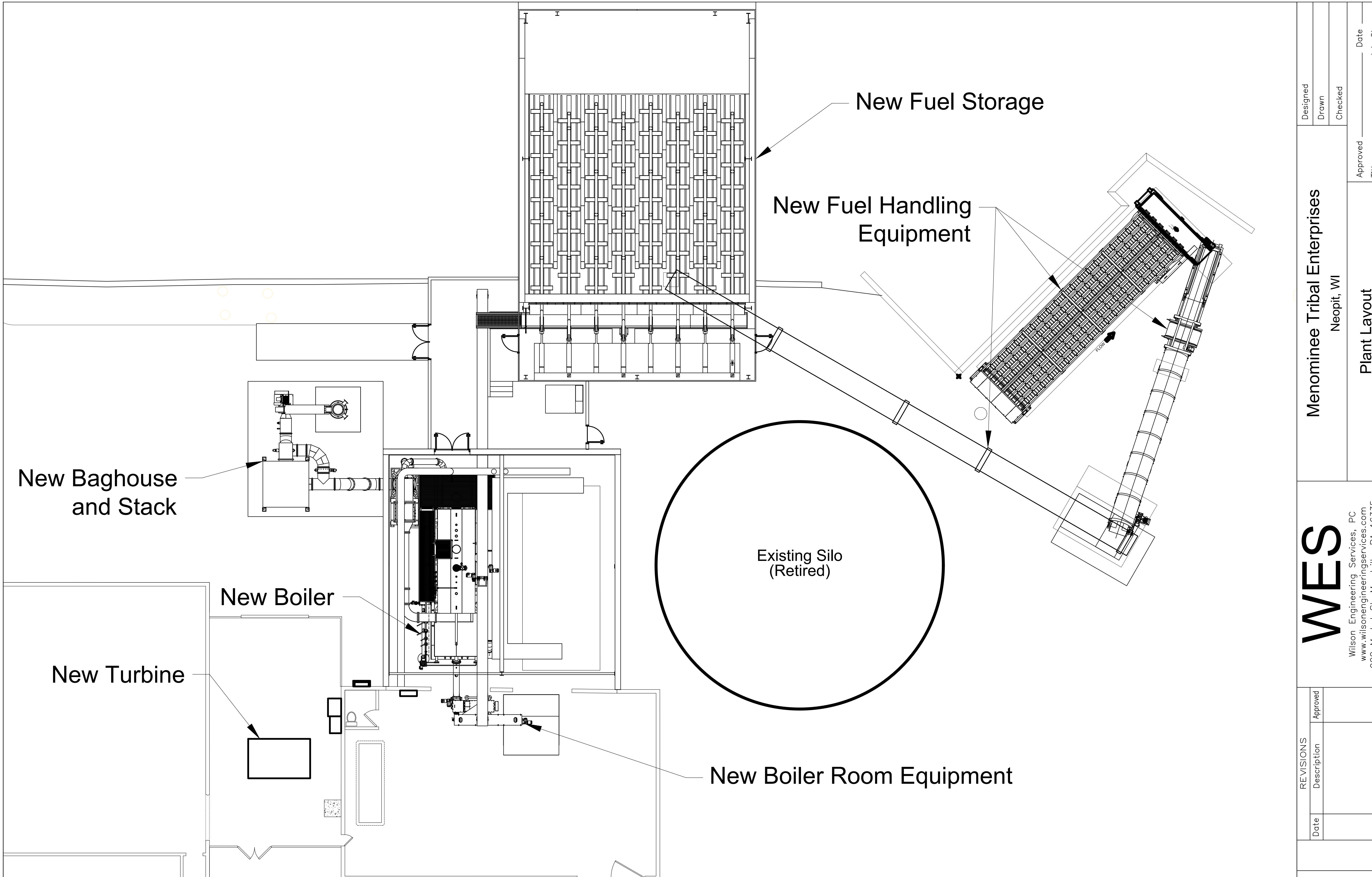
Savings for the first full year of operating the new biomass system is estimated at $462,227. Future improvements planned to keep the turbine generator on line promise increased future savings. Emission reductions from the new system are dramatic with a net reduction of 159 tons annually of criteria pollutants.

Appendix A includes a site plan showing the layout of the new boiler plant.

Appendix B contains photos of the project and installation.

Appendix A

Site Plan


New Fuel Storage
New Fuel Handling Equipment
New Baghouse and Stack
Existing Silo (Retired)
New Boiler
New Turbine
New Boiler Room Equipment
Designed
Drawn
Checked
Approved
Title
Date
Job Class
Menominee Tribal Enterprises
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Plant Layout
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REVISIONS
Date
Description
Approved

Appendix B

Installation Pictures

Figure 1 – Automation & Rework of Existing Boiler

Figure 2 – Dramatic reduction in emissions after rework

Figure 3 – Demo Old Boiler

Figure 4 – Install New Boiler

Figure 5 – Old Fuel Storage

Figure 6 – New Fuel Processing

Figure 7 – New Fuel Storage

Figure 8 – Deaerator Serves New and Existing Boilers

Figure 9 – Backpressure Steam Turbine Generator

Figure 10 – Bag House and New Stack

Figure 11 – Ribbon Cutting Ceremony with Project Partners