Attachment B

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT'S EVALUATION OF ABENGOA BIOENERGY BIOMASS OF KANSAS, LLC PROPOSED BACT OPTIONS

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Abengoa Bioenergy Biomass of Kansas (ABBK) conducted a BACT analysis to determine the appropriate control of emissions from the proposed biomass-to-ethanol and biomass-to-energy production facility.

This BACT analysis incorporates the relevant portions of the BACT analysis from the *2011 Updated Facility Design Prevention of Significant Deterioration, Air Quality Construction Permit Application Supplement – Source ID No. 1890231* dated May, 2011 and the *2012 Abengoa Bioenergy Biomass of Kansas, LLC Prevention of Significant Deterioration Air Quality Construction Permit Modification Application* dated October 2012, as well as including the BACT analysis for changes made to the facility as described in the *Conforming Prevention of Significant Deterioration, Air Quality Construction Permit Modification Application* dated January, 2014.

The following represents the KDHE's evaluations of the proposals for BACT supported by a summary of the analysis done for each control option. Please refer to the BACT analysis in the application documents listed above.

I. BACT ANALYSIS OF BIOMASS-FIRED STOKER BOILER AND BOILER REHEAT BURNER (EP-20001 AND EP-20002)

The facility includes one Biomass-Fired Stoker Boiler (EP-20001) and one Biomass Boiler Reheat Burner (EP-20002). The Biomass-Fired Stoker Boiler is capable of combusting raw biomass (consisting of corn stover, wheat straw, milo (sorghum) stubble, corn stover, switchgrass, and other opportunity feedstocks that are available). The exhaust is then routed through the spray dry absorber, baghouse, ID fan and gas/gas heat exchanger before reaching the Biomass Boiler Reheat Burner.

Natural gas or biogas is then fired in the reheat burner to raise exhaust temperature to an appropriate level for the oxidation catalyst (also referred to as a CO catalyst) and Selective Catalytic Reduction (SCR) systems to operate. The exhaust then flows through the CO catalyst, the SCR, and the gas/gas heat exchanger before exiting the stack. In order to meet the boiler BACT emission limits, the reheat burner was needed to raise the temperature of exhaust gases so that the CO catalyst and SCR would operate optimally. The exhaust from both the boiler and the reheat burner comingle and exhaust out the boiler stack.

A. NO_x BACT Review

NO_x emissions will result from the combustion of biomass in the 500 MMBtu/hr boiler and natural gas/biogas in the 25 MMBtu/hr boiler reheat burner. Fuel combustion NO_x emissions will result from the incomplete combustion of nitrogen compounds contained in the air and fuel. The emissions from the biomass boiler and the reheat burner are both vented out the same stack; therefore BACT is reviewed for the units together.

1. Identify Available Control Options

Based on engineering design data, there are two viable options for controlling NO_x emissions on a combustion source:

a. Good Combustion Practices

Optimization of the design, operation, and maintenance of the boiler combustion system is the primary technology available for reducing NO_x emissions. Good combustion controls involve boiler combustion designs and operating practices that improve the oxidation process and minimize incomplete combustion. Key combustion design and operating parameters include sufficient excess air, adequate residence time, and good mixing of the combustion air and fuel. Good combustion practices are considered technically feasible for the biomass boiler and reheat burner.

b. Selective Catalytic Reduction (SCR)

SCR systems have recently been used to reduce NO_x emissions as a post combustion control system on gas-fired combustion turbines, but not on biomass-fired boilers. The acceptable catalyst operating temperature range is from 300°F to 680°F for low temperature SCR, 500°F to 725°F for medium temperature SCR, 650°F to 1000°F for high temperature SCR. Medium and high temperature SCRs are less prone to complications and are more economical. A greater catalyst volume would be required to achieve the same reductions using a low temperature SCR.

The boiler's exhaust temperatures will be below 400°F and flue gas temperatures in the furnace are greater than 1,250°F. As a result, a suitable location within the boilers would be have to be created in order to provide the proper temperature range and residence time for installation of a SCR. Such a location does not exist in the current solid biomass-fired boiler configuration design. A reheat burner would need to be added to raise the temperature to a level suitable for a SCR. With a reheat burner required to raise the flue gas temperature to the appropriate temperature for the SCR to work properly, a SCR is considered technically feasible.

2. Eliminate Technically Infeasible Control Options

There are no control options that are technically infeasible to eliminate.

3. Evaluate Technically Feasible Control Options

The environmental, energy and economic impacts of the controls are discussed below. The reheat burner is located downstream of the boiler flue gas baghouse. The flue gas baghouse operates at approximately 170°F. The reheat burner supplies supplemental heat to the flue gas to raise the temperature of the flue gas to the appropriate temperatures proper function of the CO catalyst (Envicat 5314) and SCR catalyst, which operate at about 500°F. No energy from the reheat burner is used in the production of steam. The inlet temperature to the SCR controls the heat release of the reheat burner. The reheat burner is a Y-burner and auxiliary air fan, capable of providing 25 MMBtu/hr heat

release from either natural gas or biogas. Therefore, there are energy and cost implications of adding the reheat burner to obtain the correct temperature for the operation of the controls. With the addition of a reheat burner to raise the exhaust temperature, a SCR can achieve an emission rate at the stack of 0.3 lb/MMBtu. Although there are energy and economic impacts of using an oxidation catalyst, these impacts outweigh the benefits of a SCR for control of NO_x emissions.

4. Rank Technically Feasible Options

Both good combustion practices and SCR are technically feasible. Based on vendor data for the biomass boiler with a reheat burner, a SCR can achieve a control efficiency of 45% for NO_x emissions and is therefore the highest level of control of NO_x emissions.

5. Establish BACT

BACT for the biomass boiler and the reheat burner is determined to be good combustion practices along with the added control of a SCR. Based on best engineering estimates, the proposed biomass-fired boiler and natural gas/biogas-fired reheat burner with good combustion practices and a SCR can consistently achieve a NO_x emission rate of 0.30 lb/MMBtu (157.5 lb/hr) on an on-going basis.

B. CO BACT Review

CO emissions will result from the combustion of biomass in the boiler and natural gas/biogas in the boiler reheat burner. Fuel combustion CO emissions result from the incomplete combustion of carbon compounds contained in the fuel. The emissions from the biomass boiler and the reheat burner are both vented out the same stack; therefore BACT is reviewed for the units together.

1. Identify Available Control Options

Based on engineering design data, there are two viable options for controlling CO emissions on a combustion source:

a. Good Combustion Practices (GCP)

Optimization of the design, operation, and maintenance of the boiler combustion system is the primary technology available for reducing CO emissions. Good combustion controls involve boiler combustion designs and operating practices that improve the oxidation process and minimize incomplete combustion. Key combustion design and operating parameters include sufficient excess air, high combustion temperatures, adequate residence time, and good mixing of the combustion air and fuel. Good combustion practices are considered technically feasible for the biomass boiler and reheat burner.

b. Oxidation Catalysts (also referred to as CO catalysts)

Oxidation catalysts have recently been used to reduce CO emissions as a post combustion control system on gas-fired combustion turbines, but not on biomass-fired boilers. The acceptable catalyst operating temperature range is from 400°F to 1,250°F, with the optimum temperature range being 850°F to 1,100°F. Below 600°F, a greater catalyst volume would be required to achieve the same reduction. The boiler's exhaust temperatures will be below 400°F and flue gas temperatures in the furnace are greater than 1,250°F. As a result, a suitable location within the boilers would be have to be created in order to provide the proper temperature range and residence time for installation of an oxidation catalyst. Such a location does not exist in the current solid biomass-fired boiler configuration design. A reheat burner would need to be added to raise the temperature to a level suitable for a catalyst. With a reheat burner to raise the flue gas temperature to the appropriate temperature for the oxidation catalyst to work properly, an oxidation catalyst is considered technically feasible.

2. Eliminate Technically Infeasible Control Options

There are no control options that are technically infeasible to eliminate.

3. Evaluate Technically Feasible Control Options

The environmental, energy and economic impacts of the controls are discussed below. The reheat burner is located downstream of the boiler flue gas baghouse. The flue gas baghouse operates at approximately 170°F. The reheat burner supplies supplemental heat to the flue gas to raise the temperature of the flue gas to the appropriate temperatures proper function of the CO catalyst (Envicat 5314 or equivalent) and SCR catalyst, which operate at about 500°F. No energy from the reheat burner is used in the production of steam. The inlet temperature to the CO catalyst controls the heat release of the reheat burner. The reheat burner is a Y-burner and auxiliary air fan, capable of providing 25 MMBtu/hr heat release from either natural gas or biogas. Therefore, there are energy and cost implications of adding the reheat burner to obtain the correct temperature for the operation of the controls. With the addition of a reheat burner to raise the exhaust temperature, an oxidation catalyst can achieve an emission rate at the stack of 0.22 lb/MMBtu. Although there are energy and economic impacts of using an oxidation catalyst, these impacts are outweighed by the benefits of a CO catalyst and the fact that an oxidation catalyst is the only way for the boiler and reheat burner to meet the permitted CO emission limit.

4. Rank Technically Feasible Options

Both good combustion practices and oxidation catalysts are technically feasible. Based on vendor data for the biomass boiler with a reheat burner, a CO catalyst can achieve an emission rate of 0.22 lb/MMBtu for CO emissions from the boiler and reheat burner and is therefore the highest level of control of CO emissions.

5. Establish BACT

BACT for the biomass boiler and the reheat burner is determined to be good combustion practices along with the added control of an oxidation catalyst. Based on best engineering estimates, the proposed biomass-fired boiler with good combustion practices and a CO catalyst can consistently achieve a CO emission rate of 0.22 lb/MMBtu (115.5 lb/hr) on an on-going basis.

C. SO_2 BACT Review

Sulfur Dioxide (SO_2) emissions will result from the combustion of biomass in the boiler and natural gas in the boiler reheat burner. Fuel combustion SO_2 emissions result from sulfur compounds in the fuel. The emissions from the biomass boiler and the reheat burner are both vented out the same stack. However, the purpose of the reheat burner is to raise the temperature of the exhaust after it is cooled down from passing through the spray dryer absorber and baghouse. The reheat burner must be placed downstream of the boiler's SO_2 BACT control device. Therefore, the BACT analysis for the boiler and the reheat burner will be determined separately.

"Scrubber" is a general term that describes an air pollution control device or system that use absorption, both physical and chemical, to remove pollutants from the process gas stream. Scrubber systems rely on a chemical reaction with a sorbent to remove a wide range of pollutants, including acid gases, SO_2, fine particulates and heavy metals (i.e., mercury) from flue gases. When used to remove or "scrub" SO_2 from the flue gas, these devices are commonly called FGD systems. FGD systems are generally classified as either "wet" or "dry". Wet scrubbers have been applied on combustion units firing coal and oil ranging in size from 50 MMBtu/hr to 15,000 MMBtu/hr. Dry and spray dryer scrubbers are generally applied to units less than 3,000 MMBtu/hr.

1. Identify Available Control Options

Based on engineering design data, there are two viable options for controlling SO_2 emissions on a combustion source:

a. Wet Flue Gas Desulfurization (FGD)

In a wet FGD system, a liquid sorbent slurry is sprayed into the flue gas in an absorber vessel or spray tower. The gas phase or particulate pollutant comes into direct contact with the sorbent liquid and is dissolved or diffused (scrubbed) into the liquid. The liquid interface for gas and particle absorption includes liquid sheets, wetted walls, bubbles and droplets. In the wet processes, a wet slurry waste or byproduct is produced. Spent slurry from the reaction is generally disposed of, or when oxidized, results in a gypsum by-product that can be sold.

Most wet FGD systems use alkaline slurries of limestone or slaked lime as sorbents; however, sodium based reagents (sodium bicarbonate or naturally occurring sodium carbonate/sodium bicarbonate minerals, like Trona (trisodium hydrogendicarbonate dehydrate)) are also used. Sulfur oxides react with the sorbent to form solid salts.

Scrubber technologies for wet scrubbing of gaseous pollutants can achieve extremely high levels of multi-pollutant control from utility and industrial coal-fired boilers, waste-to-energy systems, and other industrial processes. New wet scrubbers routinely achieve SO_2 removal efficiencies of 90% to 95%, with some scrubbers achieving removal efficiencies of up to 98%.

b. Dry Flue Gas Desulfurization

In a dry FGD process, particles of an alkaline sorbent are injected into a flue gas, producing a dry solid by-product. In dry FGD scrubbing, the flue gas leaving the absorber is not saturated (the major distinction between wet and dry scrubbers). Dry scrubbers systems can be grouped into two categories: spray dryers and dry injection systems. A spray dryer (or semi-dry scrubber) uses much smaller amounts of liquid than a wet FGD system. With a spray dryer absorber (SDA) system, the flue gases enter an absorbing tower (dryer) where hot gases are contacted with a finely atomized slurry. Various calcium and sodium-based reagents can be utilized as the sorbent. SO_2 is absorbed by the sorbent slurry mixture and react to form solid salts. The heat of the flue gas evaporates the water droplets in the sprayed slurry, and a non-saturated flue gas exits the absorber tower where it is then routed to a particulate control device such as an ESP or fabric filter. The waste product can be disposed of, sold as a by-product or recycled to the slurry. Spray dryers commonly are designed for SO_2 removal efficiencies of 80% to 90%.

Dry injection systems involve the injection of a dry sorbent (normally lime or limestone) into the flue gas in the upper reaches of the boiler, or in the ductwork following the boiler. Sulfur oxides react directly with the dry sorbent, which are collected in a downstream particulate control device. Dry scrubbers have significantly lower capital and annual costs than wet systems because they are simpler, demand less water and waste disposal is less complex. Newer applications of dry sorbent injection on small coal-fired industrial boilers have achieved greater than 90% SO_2 control efficiencies.

Scrubbers have been used in the EPA Acid Rain Program on coal-fired boilers, which are significant sources of hydrochloric acid (HCl) and hydrofluoric acid (HF). According to the EPA and others, both wet and dry scrubbers have been shown to reduce HCl emissions by 95% and more, and wet scrubbers have been shown to reduce HF emissions by more than one-third.

2. Eliminate Technically Infeasible Control Options

There are no control options that are technically infeasible to eliminate.

3. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify technologies used to control SO_2 emissions from biomass-fired boilers with heat inputs greater than 250 MMBtu/hr. No facilities in the RBLC database burn the same types of fuels as ABBK. Most biomass boilers in the database burn various types of wood/wood waste in conjunction with other fuels, including coal, natural gas, fuel oil, wastewater sludge, tire-derived fuel, railroad ties and other non-municipal wastes or production by-products. The RBLC database indicates a wide range of SO_2 control as BACT, including sorbent injection, use of low sulfur fuels and spray dry absorber. The SO_2 BACT emission rates range from 0.010 to 1.536 lb/MMBtu.

4. Rank Technically Feasible Options

The technically feasible SO_2 control technologies for the Biomass-Fired Stoker Boiler are ranked by control effectiveness, as follows:

a. Wet FGD 90-95%

The highest removal efficiencies are theoretically achieved by wet scrubbers. However, newer dry scrubber designs are capable of higher control efficiencies, on the order of 90%. Because of the additional acid gases and air toxics to be controlled in the boiler exhaust, a dry FGD system is recommended by the boiler vendor as part of the combined SDA and fabric filter baghouse control train. A wet FGD is generally applied units larger than the proposed biomass-fired boilers, and offer no significant benefit over dry FGD; therefore, no further analysis will be performed for a wet FGD system. The addition of a baghouse following the dry scrubber system improves SO_2 and chloride capture (estimated to be 90% and 99%, respectively) as it provides additional residence time. The partially reacted sorbent sticks to the filter and builds a layer to capture additional pollutants, called "filter cake".

b. Dry FGD 80-90%

The top performing technically feasible SO_2 control identified for further evaluation as part of this BACT analysis is a dry FGD system, specifically a SDA utilizing hydrated lime.

5. Establish BACT

BACT for the biomass boiler is determined to be the implementation of a spray dryer absorber. The SDA will control particulate matter emissions from the biomass boiler, but will not control emissions from the downstream natural gas/biogas-fired reheat burner. The spray dryer absorber lowers the exhaust temperature while controlling SO_2.

The reheat burner will supply supplemental heat to the flue gas to raise the temperature of the flue gas to the appropriate temperatures for proper function of the CO catalyst (Envicat or equivalent) and SCR catalyst, which operate at about 500°F. The reheat burner is required to reduce emissions of NO_x, CO and VOC from the biomass boiler. Therefore, good combustion practices and use of low sulfur fuel (natural gas/biogas) will be considered BACT for the reheat burner.

Based on best engineering estimates, the proposed biomass-fired boiler with a SDA and reheat burner can achieve SO_2 emission rates of 0.21 lb/MMBtu (110.25 lb/hr) and 0.027 lb/MMBtu (0.68 lb/hr), respectively, on an ongoing basis.

D. VOC BACT Review

VOC emissions will result from the combustion of biomass in the boiler and natural gas in the boiler reheat burner. Fuel combustion VOC emissions result from the incomplete combustion of carbon and organic compounds contained in the fuel. The emissions from both the biomass boiler and the reheat burner are both vented out the same stack; therefore BACT is reviewed for the units together.

1. Identify Available Control Options

Based on engineering design data, there are two viable options for controlling VOC emissions on a combustion source:

a. Good Combustion Practices (GCP)

Optimization of the design, operation, and maintenance of the boiler combustion system is the primary technology available for reducing VOC emissions. Good combustion controls involve boiler combustion designs and operating practices that improve the oxidation process and minimize incomplete combustion. Key combustion design and operating parameters include sufficient excess air, high combustion temperatures, adequate residence time, and good mixing of the combustion air and fuel. Good combustion practices are considered technically feasible for the biomass boiler and reheat burner.

b. Oxidation Catalysts (also referred to as CO catalysts)

Oxidation catalysts have recently been used to reduce VOC emissions as a post combustion control system on gas-fired combustion turbines, but not on biomass-fired boilers. The acceptable catalyst operating temperature range is from 400°F to 1,250°F, with the optimum temperature range being 850°F to 1,100°F. Below 600°F, a greater catalyst volume would be required to achieve the same reduction. The boiler's exhaust temperatures will be below 400°F and flue gas temperatures in the furnace are greater than 1,250°F. As a result, a suitable location within the boilers would be have to be created in order to provide the proper temperature range and residence time for installation of an oxidation catalyst. Such a location does not exist in the current solid biomass-fired boiler configuration design. A reheat burner would need to be added to raise the temperature to a level suitable for a catalyst. With a reheat burner to raise the flue gas temperature to the appropriate temperature for the oxidation catalyst to work properly, an oxidation catalyst is considered technically feasible.

2. Eliminate Technically Infeasible Control Options

There are no control options that are technically infeasible to eliminate.

3. Evaluate Technically Feasible Control Options

The environmental, energy and economic impacts of the controls are discussed below. The reheat burner is located downstream of the boiler flue gas baghouse. The flue gas baghouse operates at approximately 170°F. The reheat burner supplies supplemental heat to the flue gas to raise the temperature of the flue gas to the appropriate temperatures proper function of the CO catalyst (Envicat 5314) and SCR catalyst, which operate at about 500°F. No energy from the reheat burner is used in the production of steam. The inlet temperature to the CO catalyst controls the heat release of the reheat burner. The reheat burner is a Y-burner and auxiliary air fan, capable of providing 25 MMBtu/hr heat release from either natural gas or biogas. Therefore, there are energy and cost implications of adding the reheat burner to obtain the correct temperature for the operation of the controls.

With the addition of a reheat burner to raise the exhaust temperature, an oxidation catalyst can achieve an emission rate at the stack of 0.005 lb/MMBtu. Although there are energy and economic impacts of using an oxidation catalyst, these impacts outweigh the benefits of a CO catalyst for control of VOC emissions.

4. Rank Technically Feasible Options

Both good combustion practices and oxidation catalysts are technically feasible. Based on vendor data for the biomass boiler with a reheat burner, a CO catalyst can achieve a control efficiency of 70% for VOC emissions and is therefore the highest level of control of VOC emissions.

5. Establish BACT

BACT for the biomass boiler and the reheat burner is determined to be good combustion practices along with the added control of an oxidation catalyst. Based on best engineering estimates, the proposed biomass-fired boiler and natural gas/biogas-fire reheat burner with good combustion practices and a CO catalyst can consistently achieve a VOC emission rate of 0.005 lb/MMBtu (2.55 lb/hr) on an on-going basis.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

Particulate Matter (PM) emissions will result from the combustion of biomass in the boiler and natural gas/biogas in the boiler reheat burner. The emissions from the biomass boiler and the reheat burner are both vented out the same stack. However, the purpose of the reheat burner is to raise the temperature of the exhaust after it is cooled down from passing through the spray dryer absorber and baghouse. The reheat burner must be placed downstream of the boiler's $PM/PM_{10}/PM_{2.5}$ BACT control device. Therefore, the BACT analysis for the boiler and the reheat burner will be determined separately.

1. BACT Review for the Biomass-fired Boiler

a. Identify Available Control Options
The following control options have been identified and considered in determining BACT:

i. Fabric Filter Baghouse;

ii. Wet Electrostatic Precipitators (ESPs); and

iii. Dry ESPs.

b. Eliminate Technically Infeasible Control Options

Fabric filtration in a baghouse consists of a number of filtering bags that are suspended in housing. Particulate laden gases pass through the housing and collect on the fabric of the filter bag. Fabric filters are generally considered unacceptable for the control of biomass combustion due to the danger of fires unless there is some acid gas control preceding the fabric filter. Because acid gas control in the form of a dry (sorbent injection) scrubber will be utilized, fabric filtration is technically feasible. However, fabric filtration is not technically feasible for condensable particulate matter that is in a vapor form at stack conditions, and thus is not intercepted by the fabric.

ESPs remove particulate matter from the flue gas stream using the principle of electrostatic attraction. Particulate matter is charged with a high direct current voltage and subsequently attracted to oppositely charge collection plates. Wet

ESPs operate using the same principles as standard ESPs, but the final cleaning step of the collection plates utilizes water. Wet and dry ESP systems are technically feasible for the proposed boiler system. However, ESPs are not technically feasible for condensable particulate matter that is in a vapor form at stack conditions, and thus not significantly affected by the electric current.

c. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify technologies used to control $PM/PM_{10}/PM_{2.5}$ emissions from similar sized biomass-fired boilers. The biomass-fired boilers with heat inputs greater than 250 MMBtu/hr were listed on the RBLC database with PM/PM_{10} BACT limits between 0.0064 and 0.15 lb/MMBtu. Fabric filter baghouse, ESP and cyclone control technologies have been applied for the control of PM/PM_{10} emissions from similar sized biomass-fired boilers. The implementation of a baghouse will achieve a maximum filterable $PM/PM_{10}/PM_{2.5}$ emission rate of at the facility of 0.013 lb/MMBtu. This emission rate is consistent with other established BACT limits for wood-fired boilers, as detailed in the RBLC database review.

The overall filterable PM/PM_{10} control will be based on a 99.8% control efficiency due to the dual control technology design for HCl control. Further, ESPs offers no performance advantages over the top performing technology (baghouse). Given these facts, it was determined unnecessary to evaluate the cost of unproven and potentially infeasible technologies that are clearly more expensive than the top performing technology selected for this application.

d. Rank Technically Feasible Options

Control Technology	Reduction Efficiency
Baghouse	99+%
Dry ESP	99+%
Wet ESP	99+%

A baghouse, dry ESP and wet ESP are all capable of achieving filterable $PM/PM_{10}/PM_{2.5}$ emissions reductions of 99% or more. A fabric filter baghouse is preferred for the biomass stoker boiler as the addition of a baghouse following the dry (sorbent injection) scrubber system improves SO_2 and chloride capture (estimated to be 90% and 95%, respectively) as it provides additional residence time. The partially reacted sorbent sticks to the filter and builds a layer to capture additional pollutants.

Further, a wet or dry ESP offer no performance or cost advantages over a baghouse; therefore, no further analysis will be performed for ESPs. The top performing technically feasible $PM/PM_{10}/PM_{2.5}$ control technology identified for further evaluation as part of this BACT analysis is a fabric filter baghouse.

e. Establish BACT

The implementation of a fabric filter baghouse will achieve a filterable $PM/PM_{10}/PM_{2.5}$ control efficiency of 99+%. Based on best engineering estimates, the proposed biomass-fired boiler with a fabric filter baghouse can achieve PM10 and PM2.5 emission rates of 0.032 lb/MMBtu (16.80 lb/hr) and 0.030 lb/MMBtu (15.75 lb/hr), respectively, on an on-going basis.

The proposed BACT limit in pounds per hour applies during all times, including during SSM, and is based on a 30-day average compliance period.

2. BACT Review for the Boiler Reheat Burner

a. Identify Available Control Options

The reheat burner is required to reduce emissions of NO_x, CO and VOC from the biomass boiler. Therefore, good combustion practices and use of low ash fuel (natural gas/biogas) will be considered as BACT options for the reheat burner.

b. Eliminate Technically Infeasible Control Options

Due to the placement of the reheat burner downstream of the boiler's $PM/PM_{10}/PM_{2.5}$ BACT control device, add-on control devices are not an option.

c. Evaluate and Rank Technically Feasible Control Options

i. Good Combustion Practices (GCP)

Optimization of the design, operation, and maintenance of the boiler reheat burner combustion system is the primary technology available for reducing $PM/PM_{10}/PM_{2.5}$ emissions. Key combustion design and operating parameters include sufficient excess air, high combustion temperatures, adequate residence time, and good mixing of the combustion air and fuel. Good combustion practices are considered technically feasible for the biomass boiler and reheat burner.

ii. Low Ash Fuel (natural gas/biogas)

Natural gas and the biogas that originates from the facility waste water treatment plant are low ash fuels which produce less $PM/PM_{10}/PM_{2.5}$ emissions from their combustion.

d. Establish BACT

Based on best engineering estimates, utilizing good combustion practices and low ash fuel, the proposed reheat burner can achieve an emission rate of 0.010 lb/MMBtu (0.25 lb/hr) for both PM_{10} and $PM_{2.5}$ on an on-going basis.

F. GHG BACT Review

The cogeneration plant will employ one (1) water-cooled vibrating grate (stoker) boiler. The boiler will be capable of producing 325,000 pounds per hour of 920 pound-force per square inch gauge (psig)/750 ^{o}F steam. The high pressure steam supplies a single condensing-extraction steam turbine generator nominally rated at 22 Megawatts (MW) of electricity. Electrical power will be supplied only to the facility and power sales to the grid are proposed.

Enzymatic hydrolysis process steam is extracted from the turbine at a lower pressure from extraction ports. Boiler feedwater preheater steam and deaeration steam is also extracted from the turbine from extraction ports. Exhaust steam is condensed under vacuum against cooling water in the cooling water tower. The stoker boiler's maximum design heat input is 500 million British thermal units per hour (MMBtu/hr). The stoker boiler is capable of burning a combination of raw biomass (consisting of corn stover, wheat straw, milo (sorghum) stubble, corn stover, switchgrass, and other opportunity feedstocks that are available), enzymatic hydrolysis residuals (including lignin-rich stillage cake and thin stillage syrup), particles collected during biomass grinding, NCG vent streams, wastewater treatment sludge and biogas. Natural gas will be used during start-up periods as required per manufacturer recommendations. The stoker boiler will also be capable of firing on natural gas during normal operations as needed at a limited capacity, as well as firing on a combination of natural gas, liquid fuel (i.e. enzymatic hydrolysis thin stillage syrup) and biogas in the event of a solid fuel failure. The cogeneration process will utilize up to 812 dry tons/day of fuel feedstock.

The biomass-fired stoker boiler is the main source of GHG emissions (CO_2, CH_4, and N_2O) at the facility. For this unit, the GHG emissions are due to carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (N_2O) emissions. Global warming potentials (GWP) of methane and nitrous oxide emissions are normalized to the warming potential of carbon dioxide equivalents (CO_2e) by multiplying the methane emissions by 25 and the nitrous oxide emissions by 298. Despite the higher warming potentials of methane and nitrous oxides compared to carbon dioxide, it is expected that carbon dioxide emissions will still account for over 99 percent of the CO_2e GWP for this unit, based on emission factors for biomass-fired boilers.

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT for the biomass-fired boiler:

a. Use of low-carbon and carbon neutral fuels;

i. Corn stover

ii. Wheat straw

iii. Milo stubble

iv. Wood chips/wood residues

v. Switchgrass

vi. Other opporunity agricultural residues and energy crops

vii. Enzymatic hydrolysis residuals (including lignin-rich/ lignin-lean stillage cake and thin stillage syrup)

b. Use of lower GHG-emitting processes/practices/design;

i. Cogeneration

ii. Process integration and combustion of process co-products

iii. Heat recovery

iv. Boiler operational monitoring

v. Boiler maintenance

c. Carbon capture and storage ("CCS", also referred to as "carbon capture and sequestration");

d. Carbon capture for beneficial uses; and

e. Combination of These Control Options.

There are two (2) broad strategies for reducing GHG emissions from the boiler at the proposed facility. The first is to minimize the production of GHG through the use of low-carbon and carbon neutral fuels and through the use of lower GHG-emitting processes/practices/design. As discussed in detail in the Environmental Impact Statement (EIS) by the Department of Energy (DOE), the proposed facility will provide a net reduction in GHG emissions because of the fuel selected and the long-term land use benefits. Additionally, the use of lower GHG-emitting processes/practices/design requires less fuel for process heat, which directly impacts the amount of GHG produced. Establishing an aggressive basis for energy recovery and process efficiency will reduce GHG production. The implementation of the use of low-carbon and carbon neutral fuels and the use of lower GHG-emitting processes/practices/design are an integral part of the facility's design and are considered the baseline for this BACT analysis.

The second strategy for reducing GHG emissions is carbon capture and storage ("CCS", also referred to as "carbon capture and sequestration") or carbon capture for beneficial uses. These control options are evaluated in this BACT analysis as additional control options in addition to the baseline control options that are already included in the facility's design.

2. Eliminate Technically Infeasible Control Options

Three main options identified for control of CO_2 emissions from the boiler are:

- Low-carbon and carbon neutral fuels;
- Lower GHG-emitting processes/practices/design; and
- CCS and/or carbon capture for beneficial uses.

Table B-1 summarizes the technical feasibility/infeasibility determination for all control options discussed in this section.

Table B-1 Technical Feasibility/Infeasibility Determination Summary

Potentially Available Control Option	Determination Result	Determination Reason
Fuel Type Restriction to Low-Carbon and Carbon Neutral Fuels	Technically Feasible	Inherent part of the facility's design, and considered a baseline control option.
Lower GHG-Emitting Processes/Practices/Design	Technically Feasible	Inherent part of the facility's design, and considered a baseline control option.
Carbon Capture Using Pre-combustion Capture	Technically Infeasible	Technology would redefine the project.
Carbon Capture Using Oxygen-fired Combustion	Technically Infeasible	Technology would redefine the project.
Carbon Capture Using Post-Combustion Capture	Technically Feasible	Chemical absorption has been the most widely used method of commercial CO_2 capture and is the primary CO_2 capture technology further analyzed.

Potentially Available Control Option	Determination Result	Determination Reason
Carbon Transportation	Technically Feasible	Technical issues can be addressed through modern pipeline construction and maintenance practices.
Carbon Storage through Geologic Sequestration	Technically Feasible	In Kansas, geologic sequestration of CO_2 may be possible in all five of the geologic formations: deep saline aquifers, coal seams, oil and natural gas reservoirs, oil- and gas-rich organic shales, and basalt
Carbon Storage through Terrestrial Sequestration	Technically Feasible	Inherent part of the facility's design, and considered a baseline control option.
Carbon Beneficial Uses	Technically Feasible	The many different technologies being investigated for the beneficial use of CO_2 vary widely in their stages of development, from those being tested at the bench-scale, to technologies that are close to commercialization.
Combination of these Control Options	Technically Feasible	See reasons above.

a. Fuel Type Restriction (Low-Carbon and Carbon Neutral Fuels)

Numerous fuels are available for use in the boiler based on the proposed boiler design. The primary fuel initially to be used is corn stover. Other opportunity feedstocks that may be used if available include wheat straw, milo stubble and waste wood chips. Mixed warm season grasses such as switchgrass is a long-term

feedstock that the facility plans to transition to as it's primarily fuel. By the year 2018, ABBK anticipates approximately 240,000 acres (970 square kilometers) of mixed warm season grasses will supply approximately 1,900 dry tons (1,700 metric tons) per day, which equates to 75% of the feedstock demand.

Other process residuals and by-products that are produced at the facility such as enzymatic hydrolysis residuals (including lignin-rich/lignin-lean stillage cake and thin stillage syrup), particles collected during biomass grinding, non-condensable gas (NCG) vent streams, and wastewater treatment sludge and biogas will also be combusted in the boiler. Natural gas will be used during start-up periods as required per manufacturer's recommendations.

Table C-4 presents the primary proposed fuel types and approximate carbon content for each. Due to the facility's design, only the primary fuels were included in Table B-2. The boiler will not be able to burn the other process residuals and by-products individually and these supplemental fuels are fed to the boiler to either: 1) increase the overall efficiency of the facility's processes; or 2) combust by-products that would otherwise require off-site disposal. Because the primary fuel(s) will be blended during combustion with supplemental fuels, the nominal fuel blend and worst-case fuel blends were reviewed.

Table B-2 Primary Proposed Fuel Types and Approximate Carbon Content

Feedstock	Ultimate Analysis Carbon Content (wt. % dry basis)
Corn Stover	40.7%
Wheat Straw	46.6% ±2.8
Milo Stubble	46.1% ±1.8
Switchgrass	46.6%
EH Lignin-Rich Stillage	48.2%
EH Thin Stillage Syrup	35.0%

Note: ABBK provided carbon content values for agricultural residues and wood feedstocks. The variation in carbon content is dependent on the amount of ash in the fuel sample, which is further related to the harvesting technique. For the PTE calculations, the carbon content weight percent dry basis used is the projected overall average for the site-specific feedstock.

It should be noted that agricultural residues typically contain very similar amounts of carbon. The potential-to-emit (PTE) was developed with a best case (corn stover) and worst case (maximum wood) fuel blend in mind.

Table B-3 presents the CO_2 emission rates for the proposed fuel blends compared to other common fossil fuels used for electricity generation.

Table B-3 CO_2 Emission Rates for the Proposed Fuel Blends Compared to Other Common Fossil Fuels Used for Electricity Generation

Fuels	Emission Factors (lb/MMBtu)		
	CO_2	CH_4	N_2O
Proposed Fuel Blends			
Nominal TYPICAL Fuel Blend Corn Stover: 185.3 dry ton/day EH Lignin-Rich Stillage: 320.6 dry ton/day EH Thin Stillage Syrup: 209.5 dry ton/day Biogas: 52.7 dry ton/hr	216.00	0.071	0.009
Maximum WORST CASE Fuel Blend Corn Stover: 109.3 dry ton/day EH Lignin-Rich Stillage: 384.7 dry ton/day EH Thin Stillage Syrup: 251.4 dry ton/day Biogas: 63.2 dry ton/hr	215.54	0.071	0.009
Common Fossil Fuels Used for Electricity Generation			
Natural Gas	117.00	0.002	0.0002
Distillate Fuel Oil (#1, #2 and #4)	161.30	0.007	0.001
Electric Power (Coal Combustion)	208.26	0.002	0.004

Note 4: Fossil fuel emissions factors obtained from the California Climate Action Registry, General Reporting Protocol, Version 3.1, January 2009, Tables C.7 and C.8.

The DOE[1, 2] and IPCC[3,] have established that non-fossil fuel-based electricity generation (including both biomass and biogas) is assumed to yield no net emissions of CO_2 (i.e. these fuels are carbon neutral) because of the sequestration of biomass during the planting cycle. Other carbon reporting protocols, such as the California Climate Action Registry's (CCR), *General Reporting Protocol*,

[1] Under the carbon accounting protocol of the IPCC, use of biomass fuels for energy does not add to the net amount of carbon in the atmosphere. Multiple DOE laboratories including the National Renewable Energy Laboratory (NREL) and the National Energy Technology Laboratory (NETL), recognize and follow the IPCC carbon accounting protocol.

[2] *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program*, Office of Policy and International Affairs, U.S. Department of Energy, January 2007, Page 51 (available at: http://www.pi.energy.gov/documents/January2007_1605bTechnicalGuidelines(1).pdf)

[3] National Greenhouse Gas Inventories Program, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use* (available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html)

specifically state that CO_2 emissions from burning wood, wood waste and biogas are considered biogenic and should not be included as a direct stationary emissions in CO_2 inventories. Therefore, the proposed primary fuels are presented in this BACT as carbon neutral fuels. The natural gas used for the start-up of the boiler is a low carbon fuel as illustrated in Table C-5.

BACT based on this control option is the use of biomass as a primary feedstock that is otherwise considered to have low to no economic value or benefit (i.e. crop residuals and waste wood); and/or is a lower impacting crops (i.e. mixed warm season grasses such as switchgrass). BACT based on this control option is also limiting the boiler to using natural gas for start-up. This control option is technically feasible for the biomass-fired boiler, is an inherent part of the facility's design, and is considered a baseline control option.

b. Lower GHG-Emitting Processes/Practices/Design

There are numerous strategies for achieving a highly energy efficient design of a new condensing-extraction steam turbine electrical power generation facility. Energy efficiency in the overall design of the power production process reduces the parasitic load, which in turn requires less fuel for process heat to generate the same amount of electricity, which directly impacts the amount of GHG emissions from the facility. All identified strategies (i.e. control options) listed in this section are technically feasible for application to the biomass-fired boiler, as well as related processes, and all are an inherent part of the facility's design.

i. Cogeneration as a CO_2 Reduction Strategy – Cogeneration is the simultaneous production of electric power and thermal energy from a single fuel. The reduction in CO_2 emissions from employing cogeneration comes from the reduced fuel use at electric utility power plants; thus, the amount of CO_2 reduction is dependent upon the type of electric utility power generation displaced. The use of the direct-fired boiler system in which biomass feedstocks are burned directly will produce steam. This steam drives a turbine, which turns a generator that converts the power into electricity. The spent steam from the onsite power plant is then used in other process areas at the facility and to heat facility buildings, when feasible. Such combined heat and power systems greatly increase overall energy efficiency which has a direct impact on the amount of GHG emissions from the system.

ii. Process Integration and Combustion of Co-products – ABBK will make use of the most advanced design approaches to integrate the process units and to maximize energy efficiency. Some of the major integration measures of the power generation system with other facility processes include low pressure steam supplied to the enzymatic hydrolysis process and the combustion of process co-products such as enzymatic hydrolysis residuals (including lignin-rich/lignin-lean stillage cake and thin stillage

syrup), particles collected during biomass grinding, NCG vent streams, and wastewater treatment sludge and biogas. The largest co-product (on a mass basis and energy basis) is lignin-rich stillage cake, as detailed in the PTE calculations. The lignin-rich stillage cake adds approximately 210 MMBtu/hr to the total boiler system. The next largest co-product (on a mass basis and energy basis) is the thin stillage syrup, which adds approximately 109 MMBtu/hr. Wastewater treatment will consist of anaerobic treatment followed by aerobic treatment for the purpose of generating a biogas that can be added to the boiler as fuel. Anaerobic biogas would be treated to remove sulfur and then burned in the biomass boiler for an additional 42.30 MMBtu/hr of energy.

iii. Heat Recovery – Periodically or continuously, some water in the boiler is removed as a means of avoiding the build-up of water impurities in the boiler. The boiler's design includes blowdown waste heat exchangers with raw water makeup. The low pressure boiler feedwater will be preheated with a combination of process waste heat and low pressure steam extraction to improve the power cycle efficiency. Also, process steam condensate is recovered from indirect process steam users and returned to the boiler feedwater system. The process condensate will be cooled with reverse osmosis water, in order to meet the temperature requirements on the condensate polishing resin. The energy is recovered in the reverse osmosis makeup water. Air preheat, which is a method of recovering heat from the hot exhaust gas of a combustion process by heat exchange with the combustion air before it enters the combustion chamber, will be included in the boiler's design. In addition to process integration techniques to be utilized, the boiler's design includes economizers to improve power cycle.

iv. Boiler Operational Monitoring – Excessive amounts of combustion air used in results in energy inefficient operation because more fuel combustion is required in order to heat the excess air to combustion temperatures. Using state-of-the-art instrumentation for monitoring and controlling the excess air levels in the combustion process, will reduce the heat input by minimizing the amount of combustion air needed for safe and efficient combustion. The boiler's design includes an online stack oxygen analyzer. Oxygen levels will be monitored and the inlet air flow will be adjusted for optimal thermal efficiency within the operating limits of the boiler. Additionally, optimized air/fuel ratios, reduce not only CO_2 emissions but also NO_x emissions. The boiler will be equipped with online stack oxygen analyzers as part of the continuous emission monitoring system (CEMS).

v. Boiler Maintenance – The boiler will be maintained in accordance with the manufacturer's recommendations. Maintenance of the boiler is performed to increase efficiency, ensure safety and prevent unscheduled shutdowns. Boiler outages for 10 to 14 days each year are planned for scheduled maintenance, cleaning, and "tune-up" to optimize performance.

c. Carbon Capture

Approaches to CO_2 capture can be divided into three categories:

i. Pre-Combustion

Pre-combustion capture involves reacting a fuel with oxygen or air, and/or steam to produce a "synthesis gas" or "fuel gas" composed mainly of CO and H_2. The CO is reacted with steam in a catalytic reactor, called a shift converter, to give CO_2 and more H_2. CO_2 is then separated from the gas mixture, usually by a physical or chemical absorption process, resulting in a hydrogen-rich fuel which can be used in many applications, such as a combustion turbine or boiler. This approach would require a complete redesign of the boiler so that they would burn a gaseous fuel. The November 2010 EPA GHG guidance clearly states that control technologies with inherently lower polluting processes that would fundamentally redefine the nature of the source do not need to be evaluated.[4] The DOE is proposing to provide federal funding to ABBK to support the final design, construction, and startup of a biomass-to-ethanol and biomass-to-energy production facility. The DOE funding is based on the proposed facility design. ABBK's basic or fundamental business purpose or objective for this project is dependent on the biomass-fired boiler as proposed. Therefore, pre-combustion as a control technology is technically infeasible.

ii. Oxygen-Fired Combustion

In the oxygen-fired combustion (oxy-combustion) approach, the biomass is combusted in an enriched oxygen environment resulting in a flue gas that is mainly CO_2 and H_2O. This flue gas stream can directly be fed into a CO_2 compression and dehydration unit. Oxygen-fired combustion is simpler and less chemically intensive than post-combustion CO_2 capture, but is less mature and similarly expensive. Because the boiler is designed to use air for combustion, the use of oxygen would require substantial redesign, and as discussed previously. Therefore, oxy-combustion as a control technology is technically infeasible.

[4] *PSD and Title V Permitting Guidance for Greenhouse Gases*, supra note13, Page 27.

iii. Post-Combustion Capture

Post-combustion capture methods are applied to conventional combustion processes using air and carbon-containing fuels in order to isolate CO_2 from the combustion exhaust gases. Because the air used for combustion contains nearly 80% nitrogen, the CO_2 concentration in the exhaust gases is approximately 10% to 15% depending on the amount of excess air and the carbon content of the fuel. Additionally, post-combustion capture of CO_2 is a challenging application because:[5]

- The low pressure and dilute concentration dictate a high actual volume of gas to be treated;
- Trace impurities in the flue gas tend to reduce the effectiveness of the CO_2 absorbing processes; and
- Compressing captured CO_2 from atmospheric pressure to pipeline pressure (1200 to 2000 pounds per square inch (psi)) represents a large parasitic load.

Post-combustion capture methods require separating the CO_2 from other flue gases because sequestration of combustion gases is not feasible due in part to the cost of gas compression and storage. The most likely options currently identifiable for CO_2 separation and capture include: [6]

a) Absorption (chemical and physical). Chemical absorption has been the most widely used method of commercial CO_2 capture for over 60 years.[7] The main existing commercial applications include enhanced oil recovery (EOR), which involves increasing oil production rates by injecting CO_2 into oil wells. Liquid scrubbing is the most common form of chemical absorption, consisting of two contacting towers (one for CO_2 absorption and one for CO_2 desorption/absorbent regeneration). Chemical absorption is a chemical reaction that forms a loosely bonded intermediate compound. For the CO_2 capture application, a chemical solvent is exposed to the flue gas where it reacts chemically with CO_2 separating it from the other gases. The intermediate compound is then isolated and heated causing it to break down into separate streams of CO_2 and solvent. The solvent most often used is monoethanolamine (MEA). The primary concerns with MEA and other amine solvents are corrosion in the presence of O_2 and other impurities and high solvent degradation rates due to reactions with SO_2 and NO_x. Degradation and oxidation of the solvents over time

[5] NETL, *Carbon Sequestration, CO_2 Capture* website (available at: http://www.netl.doe.gov/technologies/carbon_seq/core_rd/co2capture.html).
[6] U.S. DOE, *Carbon Capture Research* website (available at: http://www.fossil.energy.gov/programs/sequestration/capture).
[7] Herzog, H., *An Introduction to CO2 Separation and Capture Technologies*, MIT Energy Laboratory, August 1999 (available at: http://sequestration.mit.edu/pdf/introduction_to_capture.pdf).

produces products that are corrosive and may require hazardous material handling procedures. These difficulties can be overcome, and this capture method is technically feasible. Other chemical absorption methods are at bench and laboratory scales of development. No CO_2 absorption technology demonstrations, except for liquid scrubbing using alkanolamines for CO_2 removal, have been successfully performed on similar type and sized sources[8].

Physical absorption processes are commonly used for CO_2 rejection from natural gas and operate at high pressure and low temperature. Use of physical absorption for CO_2 capture from combustion exhaust gas would entail a significant amount of gas compression capacity and a significant energy penalty. This capture method is presumed for the purposes of this analysis to be technically feasible, but because chemical absorption has been commercially demonstrated for CO_2 capture and physical absorption does not offer any capture/control, capital or operating cost benefits, this CO_2 capture technique will not be considered further in this analysis.

b) Adsorption (Physical and Chemical)

Adsorption involves ducting the exhaust gas through a bed of solid material with high surface areas, such as zeolites or activated carbon to adsorb CO_2 while allowing nitrogen and other gases to pass through. Adsorption would require either a high degree of compression or multiple separation steps to produce high CO_2 concentration from exhaust gas.

c) Low-Temperature Distillation (Cryogenic Separation)

Cryogenic separation is based on solidifying the CO_2 component of the exhaust stream by freezing it to separate it out.

d) Gas separation membranes

Gas separation membranes (or simply membranes) capture CO_2 by separating it from the other exhaust gases using different mechanisms of separation including solution-diffusion and molecular sieving.

[8] The PCO_2R December 2009 report indicated that a technology demonstration project for liquid scrubbing using ammonia as the absorbent was to be conducted at the Basin Electric Power Cooperative for the 125 MW Antelope Valley Power Station. As of December 2010, Basin Electric postponed the CO_2 capture project due to technical, operational, regulatory and financial risks for installing carbon-capture technology at the conventional coal-based power plant.

e) Mineralization and biomineralization (carbon calcification)

Mineralization offers a leak-proof, permanent solution, whereby CO_2 is fixed into a solid matrix of minerals to form thermodynamically stable carbonate minerals. The large volumes of material involved with mineralization present significant challenges for transportation and capture, these CO_2 capture technique will not be considered further in handling.

No large-scale demonstrations of most of these technologies have been performed on similar exhaust streams. These capture methods are presumed for the purposes of this analysis to be technically feasible, but because these methods have not been commercially demonstrated for CO_2 this analysis.

Based on identified post-combustion CO_2 separation and capture methods, the only commercially demonstrated method for similar exhaust streams is chemical absorption (liquid scrubbing employing alkanolamines).

d. Carbon Transport

Once captured, CO_2 must be transported to a suitable storage site in order to achieve any environmental benefit. CO_2 pipelines are the most prevalent means of bulk CO_2 transport and are a mature market technology in operation today.[9]

Pipeline transportation of CO_2 is typically accomplished with CO_2 that is compressed to its supercritical state, involving pressures of 1200 to 2000 psi. In addition, water must be eliminated from CO_2 pipeline systems, as the presence of water results in formation of carbonic acid, which is extremely corrosive to carbon steel pipe. In overall construction, CO_2 pipelines are similar to natural gas pipelines, requiring the same attention to design, monitoring for leaks, and protection against overpressure, especially in populated areas. All of these technical issues can be addressed through modern pipeline construction and maintenance practices.

e. Carbon Storage

Deploying carbon storage in commercial-scale applications requires adequate geologic formations capable of: 1) sequestering large volumes of CO_2; 2) receiving CO_2 at an efficient and economic rate of injection; and 3) retaining CO_2 safely over extended periods.

[9] Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, § 5.4: *CO_2 Transport*, 2006, Page 5.8 (available at: http://www.ipcc- nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_5_Ch5_CCS.pdf).

In south-central and southwest Kansas, potential geologic sequestration sites within saline aquifers and depleted oil reservoirs within the Ozark Plateau Aquifer System (OPAS) are being studied. Starting in December 2009, the University of Kansas, BEREXO Inc., Bittersweet Energy Inc., the Kansas Geological Survey, and the Kansas State University, began to evaluate potential CO_2 sequestration sites within saline aquifer and depleted oil reservoirs within the Ozark Plateau Aquifer System (OPAS). The study is focusing on the Wellington Field, with evaluation of the CO_2-EOR potential of its Mississippian Chert Reservoir and the sequestration potential in the underlying Cambro-Ordovician Arbuckle Group Saline Reservoir.[10] The purpose of the study is to provide a more detailed analysis of the storage potential of a local area within OPAS (an area covering approximately 17 counties in south-central Kansas) by modeling CO_2 injection within the Arbuckle Group Saline Aquifer and Mississippian Chert Oil Reservoir at Wellington Field (Sumner County, Kansas).

Currently, CO_2 is only captured in Kansas at a few facilities that produce high-purity CO_2.[11] In Kansas, geologic sequestration of CO_2 may be possible in all five of the geologic formations: deep saline aquifers, coal seams, oil and natural gas reservoirs, oil- and gas-rich organic shales, and basalt (the most problematic because no one knows how much CO_2 the ancient rock--deeply buried in parts of Kansas--can hold). Altogether, researchers estimate Kansas has at least 2.7 to 5.4 billion tons of potential geologic sequestration space, enough to hold almost 70 years worth of the state's stationary CO_2 production.[12] Stevens County, Kansas is located in an area known for oil and gas production, as well as deep saline formations. The proposed facility will be constructed in Section 18, Township 33S, Range 37W. Within this area are the Hugoton Gas Area, Panoma Gas Area and Gentzler oil and gas fields. Table B-4 summarizes the oil and gas production for the state and county in 2009.[13, 14]

Table B-4 Summary of Oil and Gas Production in State of Kansas and Stevens County For 2010

Oil Production	Production (bbls)	No. of Wells	Cumulative (bbls)
State-Wide	40,467,966	45,999	6,353,888,940
Stevens County	678,852	139	26,956,160
County Percentage	1.67%	0.30%	0.42%

[10] U.S. DOE, National Energy Technology Laboratory, *Modeling CO_2 Sequestration in a Saline Reservoir and Depleted Oil Reservoir to Evaluate The Regional CO_2 Sequestration Potential of The Ozark Plateau Aquifer System, South-Central Kansas*, FE0002056, May 2010 (available at: http://www.netl.doe.gov/publications/factsheets/project/FE0002056.pdf).
[11] Kansas Geological Survey, Geologic Sequestration of Carbon Dioxide in Kansas, Public Information Circular 27, December 2008 (available at: http://www.kgs.ku.edu/Publications/PIC/pic27.html).
[12] *Geologic Sequestration of Carbon Dioxide in Kansas*, supra note 27.
[13] Kansas Geological Survey, *State Production and Historical Information* website (available at: http://www.kgs.ku.edu/PRS/petro/state.html).
[14] Kansas Geological Survey, *Stevens County – Oil and Gas Production* website (available at: http://www.kgs.ku.edu/PRS/County/rs/stevens.html).

Gas Production	Production (mcf)	No. of Wells	Cumulative (mcf)
State-Wide	331,539,924	25,232	39,055,863,258
Stevens County	48,758,979	2,195	8,747,453,719
County Percentage	15.0%	8.70%	22.40%

Note: Units are barrels (bbls) and 1000 cubic feet (mcf*)*.

In Kansas, concerns have been raised about regulating CO_2-EOR and other geologic sequestration activities and whether the CO_2 would be trapped in these reservoirs or move back to the surface over time. Because Kansas has long been drilled for oil and gas and some areas have been very densely drilled, concerns also exist that CO_2 could move back to the surface through poorly plugged or long-forgotten wells.

According to the Kansas Geological Survey, sequestration in Kansas needs to be studied in more detail to determine if oil and natural gas reservoirs and coal beds have the capacity to take and hold CO_2. In addition, a variety of legal issues, such as ownership of the underground pore space used for sequestration, would need to be resolved, and a workforce would have to be developed. Ultimately, regulatory decisions, economics, and a well-defined environment for GHG management will highly influence any decisions concerning the feasibility of geologic sequestration.[15]

In addition to the CO_2 storage options already discussed, the other primary storage option available includes using terrestrial applications. Terrestrial sequestration is the enhancement of CO_2 uptake by plants that grow on land and in freshwater and, importantly, the enhancement of carbon storage in soils where it may remain more permanently stored.

In general, croplands store less carbon than grasslands which store less carbon than forests. Grasslands are particularly good at storing carbon in soils because they often have extensive and deep roots. DOE determined in the EIS that "warm season grass production would likely occur on marginal and non-harvested cropland, pasture, and former CRP lands. Bioenergy crops have the potential to reduce atmospheric carbon by building up soil carbon levels, especially when planted on lands where soil carbon levels have been reduced by intensive tillage, such as marginal cropland. In instances where pasture or former CRP lands would be converted to warm season grass production, exchanging one system of perennial vegetation for another would be expected to involve minimal environmental changes, including greenhouse gas emissions. A 2007 study on the Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types[16] concluded that cellulosic ethanol produced from switchgrass [switchgrass is a type of warm season grass] clearly offers the greatest energy and [greenhouse gas] benefits (by far)."[17] Based on these considerations, DOE concluded that in the event

[15] *Geologic Sequestration of Carbon Dioxide in Kansas*, supra note 27.
[16] Michael Wang, et. al., Center for Transportation Research, Argonne National Laboratory *Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types*, first published May 22, 2007 (available at: http://iopscience.iop.org/1748-9326/2/2/024001/pdf/1748-9326_2_2_024001.pdf).
[17] *Final Environmental Impact Statement for the Proposed Abengoa Biorefinery Project near Hugoton, Stevens County, Kansas*, supra note 11, Page 4-30.

warm season grasses were to replace corn stover as the dominant feedstock, the net result to greenhouse emissions would be beneficial. By the year 2018, ABBK anticipates approximately 240,000 acres (970 square kilometers) of mixed warm season grasses will supply approximately 1,900 dry tons (1,700 metric tons) per day, which equates to 75% of the feedstock demand. The change from corn stover to grasses is dependent first on the construction of the facility to generate the crop demand, and second on the negotiation of contracts with local farmers to change their farming practices from corn to grasses. ABBK's long-term operational plan for this facility is based on the feedstock change to mixed warm season grasses.

Terrestrial sequestration provides an opportunity for low-cost CO_2 emissions offsets. Storing carbon in terrestrial ecosystems can be achieved through maintenance of standing aboveground biomass, utilization of aboveground biomass in long-lived products, or protection of carbon (organic and inorganic) compounds present in soils.[18] Because the proposed source consists of biomass-fired boiler, this type of CO_2 storage is essentially being implemented as part of the facility's design; therefore, terrestrial sequestration is considered a baseline control option.

f. Carbon Beneficial Uses

In addition to using CO_2 for enhanced oil recovery (EOR), there are many other possible beneficial and revenue-generating uses for captured CO_2 in various stages of development. Technologies are being developed today that synthesize solid materials such as plastics, or carbonates that can be used in cement or glass, from a CO_2 feedstock. There are other technologies under development that do not provide long-term storage of CO_2, but which still could reduce overall GHG emissions by either 1) using CO_2 in a way that displaces the emission of other GHGs, or 2) converting CO_2 into a chemical that can in turn displace the emission of other GHGs. An example of the former is using CO_2 as a refrigerant that substitutes for chemicals currently used in refrigeration that are far more potent greenhouse gases than CO_2, such as hydrofluorocarbons (HFCs). An example of the latter is the wide array of "CO_2-to-fuel" technologies being researched with the goal of producing liquid fuels ranging from methanol or ethanol to gasoline or diesel out of CO_2 and water, along with an energy input (preferably from a CO_2-free source such as solar or wind). Fuels produced from waste CO_2 could displace the use of petroleum-derived fuels, which would result in reduced net GHG emissions.

Some of the better-known types of CO_2-to-fuel technologies are biologically based and use algae and other photosynthetic microorganisms in the conversion of CO_2, water, and sunlight into liquid fuel. A number of different companies are trying to commercialize technologies that use photosynthetic microbes to convert CO_2 to fuel. Some other uses of CO_2 that are being researched do not clearly reduce GHG emissions directly or indirectly, but still provide some other public benefit such as displacing the use of the toxic chemicals or saving water. Examples include using CO_2 as a solvent in place of perchlorethlyene for dry cleaning, or using CO_2 as a non-toxic grain silo fumigant.

[18] Gary K. Jacobs, et. al., Oak Ridge National Laboratory, Oak Ridge, TN, *Carbon Sequestration in Terrestrial Ecosystems: A Status Report on R&D Progress*, August 2000 (available at: http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/3C1.pdf).

The many different technologies being investigated for the beneficial use of CO_2 vary widely in their stages of development, from those being tested at the bench-scale, to technologies that are close to commercialization. They also vary widely in their potential to impact overall GHG emissions. There is a need to better understand the viability of the various technological options for CO_2 use and their potential to incentivize industrial carbon capture and provide substantive GHG emissions reductions.

The majority of CO_2 in the merchant market[19] is used for EOR (approximately 70-80%),[20] along with a significant portion used in the food processing industry. CO_2 currently being utilized that has been separated from flue gas or chemical process streams is generally either captured from relatively pure flue gas streams or from process streams where CO_2 capture and separation is necessitated by a need for product purity (e.g., natural gas pipelines or ammonia production).[21]

For the purposes of this BACT analysis, the feasibility of CO_2 capture, including economic, energy and environmental impacts, must first be established before storage and beneficial use options can be fully explored.

3. Evaluate Technically Feasible Control Options

CCS in biomass-fired power plants may result in net CO_2 removal from the atmosphere. However, biomass plants are typically small (25 to 50 MWe verses 500 to1000 MWe coal power plants). Thus the CCS cost per kW is roughly twice as high as the cost in coal plants.[22] For the purposes of this BACT analysis, the feasibility of CO_2 capture, including economic, energy and environmental impacts will be evaluated first. If CO_2 capture is determined to be cost-effective, storage and beneficial use options will be evaluated. As established above, the only commercially demonstrated post-combustion CO_2 separation and capture method for similar exhaust streams is chemical absorption. The general method involves exposing a gas stream to an aqueous amine solution which reacts with the CO_2 in the gas by an acid-base neutralization reaction to form a soluble carbonate salt:

$$2RNH_2 + CO_2 + H_2O = (RHN_3)_2CO_3$$

This reaction is reversible, allowing the CO_2 gas to be liberated by heating in a separate stripping column. Therefore, the major advantage to this technique is that, in the ideal situation, the amine is not consumed and may be continuously recycled through the process. The amine used in this process is most commonly one of several alkanolamines

[19] Market in which CO_2 is bought and sold competitively by multiple market participants.
[20] Tiina Koljonen, Hanne Siikavirta, Ron Zevenhoven, *CO_2 Capture, Storage and Utilization in Finland*, Project Report, VTT Processes, Systems and Models, August 29, 2002 (available at: www.vtt.fi/inf/julkaisut/muut/2002/co2capt.pdf).
[21] Reed, John, California Carbon Capture and Storage Review Panel, *Technical Advisory Committee Report – Beneficial Use of Carbon Dioxide*, October 4, 2010, Page 1 (available at: http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/2010-10-21/white_papers/Beneficial_Use_of_Carbon_Dioxide.pdf)
[22] International Energy Agency (IEA), *IEA Energy Technology Essentials, CO_2 Capture and Storage*, ETE01, December 2006, Page 3 (available at: http://www.iea.org/techno/essentials1.pdf).

including monoethanolamine (MEA). The technology was originally developed not for the purpose of carbon sequestration, but in order to "sweeten" natural gas streams by removing CO_2. More recently, it was successfully adapted for recovery of CO_2 from flue gas of coal-fired electric power generating plants. Currently, there are three (3) electric power generating stations in the U.S. that capture CO_2 from flue gas and six (6) other major flue gas CO_2 capture facilities worldwide. All nine (9) use MEA as the chemical sorbent.[23]

The disadvantage of the chemical absorption process is that it would consume a significant amount of the energy produced. A typical "energy penalty", which is defined as the percentage of the net power output consumed for the chemical absorption process installed on a conventional coal-fired power plant is between 25%-37%.[24] This does not include transportation and injection costs, which would increase the economic burden even further. It is expected that the energy penalty for the biomass-fired boiler would be equivalent to that of a coal-fired power plant due to the similar CO_2 emission rates.

Certain factors affect the chemical absorption process implementation costs. These factors include the following:

i. The primary concerns with MEA and other amine solvents are corrosion in the presence of O_2 and other impurities and high solvent degradation rates due to reactions with SO_2 and NO_x. Post-combustion control of SO_2 and NO_x before the chemical absorption system can reduce the affects of these pollutants.

ii. The flue gas should be cooled to around 40 ºC for the CO_2 absorption to take place. This requires additional cooling water.

iii. Steam heat is required to heat the solvent to release the CO_2 during regeneration.

iv. Parasitic power is required for pumping the fluids through the chemical absorption system.

v. Heat exchangers, scrubber towers, absorption towers, and heaters are required for the process.

vi. Replacement cost of the chemical solvent is high because regeneration is only for few cycles.

vii. Degradation and oxidation of the solvents over time produces products that are corrosive and may require hazardous material handling procedures.

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[23] National Energy Technology Laboratory, *Degradation of Monoethanolamine Used in Carbon Dioxide Capture from Flue Gas of a Coal-fired Electric Power Generating Station* (available at: http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/4b3.pdf)

[24] *Technical Overview of Carbon Dioxide Capture Technologies for Coal-Fired Power Plants*, supra note 18, Page 5.

viii. Work to date has used chemical absorption on a small scale. Issues involved with scaling up the existing technology will need to be addressed.

ix. Reliable operation of packed towers used in chemical absorption systems will need to be demonstrated.

Economic and Energy Impacts

Another shortcoming of the chemical absorption process is that it has a relatively high capital cost. The large size of the major components significantly influences the capital cost. The footprint of the biomass-fired boiler footprint is expected to increase approximately 60% with the addition of chemical absorption-based CO_2 capture.

Because post-combustion CO_2 capture has not been commercially demonstrated on biomass-fired electricity generating systems, there are no specific reference documents or demonstration projects that can be relied upon. Site-specific cost estimates for the purpose of constructing a commercial scale CO_2 capture system would require significant time and engineering investment, as well as an initial bench-scale/pilot test prior to full scale application. Therefore, for the purposes of this BACT analysis, the Plains CO_2 Reduction (PCOR) Partnership, the PCOR report, *Regional Emissions and Capture Opportunities Assessment – Plains CO_2 Reduction (PCOR) Partnership (Phase II)* was relied upon for comparison purposes of the estimates CO_2 capture costs presented herein. A copy of the PCOR report has been included in the application.

Although the state of Kansas is not specifically included in the PCOR report, ABBK is a member of the PCOR Partnership and the cost analyses presented in the report were assumed comparable as the PCOR report included the neighboring states: Missouri and Nebraska. Capture and compression costs and power requirements for ethanol plants, gas-processing plants, and electricity-generating facilities were estimated in the PCOR report using the Integrated Environmental Control Model (IECM), Version 5.22 (released January 28, 2008) (IECM, 2008). The IECM is a desktop computer model that was developed at Carnegie Mellon University with funding from NETL, which is design to support a variety of technology assessment and strategic planning activities for the fossil fuel-fired power plants: pulverized coal plant, natural gas combined-cycle (NGCC) plant, coal-based integrated gasification combined-cycle (IGCC) plant, and oxyfuel combustion plant.

The results from the IECM simulations conducted for the PCOR report show a significant cost and energy penalty for capturing 90% of the CO_2 emitted from electricity-generating facilities. The PCOR report used a minimum 100 MW limit primarily because the economics and power requirements of capturing CO_2 at units smaller than 100 MW would make electric generation at these units no longer feasible. In addition, the IECM has a lower estimation boundary level of 100 MW, meaning that values calculated using the IECM for units smaller than 100 MW may not depict the true costs and power requirements.

For the purposes of the GHG BACT analysis, the data contained in the PCOR report was relied upon to fully demonstrate to KDHE that the cost of add-on CO2 control at the proposed biomass-to-energy system is not economically feasible. The PCOR report estimated the costs associated with capture, drying, compression separately from the cost of CO_2 transportation by pipeline for sequestration or EOR. Injection costs for sequestration or any monetary value assigned to the CO_2 for EOR have not been included in the cost or energy estimates.[25] Including the cost of replacement power, the per-ton cost associated with CO_2 capture, drying, and compression of 90% of the CO_2 produced at the PCOR region's power plants would be $71 per short ton CO_2 avoided.[26] The increase in the cost of producing electricity caused by the capture, compression, and transport of the CO_2 was estimated in the PCOR report to be 159% to 189% with CO_2 capture, drying, and compression of 90% of the CO_2 produced.[27]

The nearest commercial CO_2 pipeline terminus is at Guymon Oklahoma, approximately 40 miles south of the proposed facility at the Mobil Exploration and Producing U.S. Postle Field Unit. ABBK estimated that the capital investment to install a CO_2 pipeline to connect to the Mobil Exploration and Producing U.S. Postle Field Unit would be $35 per linear foot, or $7,392,000, excluding right-of-way acquisitions, dehydration equipment, compressors, surge storage tanks, booster pumps, and operation and maintenance. The preparation of the CO_2 for transport via pipeline will result in additional energy penalties, as well as additional emissions (including CO_2). Because evaluations of the OPAS are ongoing,[28] it has not been fully demonstrated that geologic sequestration in Kansas is technically feasible, therefore, transportation via pipeline for EOR is currently the only commercially demonstrated control option available.

The CO_2 value of $45 per metric ton ($41 per short ton) delivered at pressure to the field is presented as the base case in the NETL report, *Storing CO_2 with Enhanced Oil Recovery*.[29] Other estimates indicate that the CO_2 costs with EOR as low as $10 per short ton. Based on the costs presented in the PCOR report, the per-ton cost associated with CO_2 capture, drying, and compression of 90% of the CO_2 produced would be $71 per short ton CO_2 avoided. It is assumed that because the proposed biomass-to-energy system will be sized will be nominally rated at 22 MW and because the flue gases from biomass combustion will be similar to coal combustion (similar CO_2 concentration, pollutants and control technologies (SO_2 scrubber and SNCR), the PCOR costs are similar to the expected costs for CO_2 capture, drying and compression at the proposed facility.

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[25] *Regional Emissions and Capture Opportunities Assessment – Plains CO_2 Reduction (PCOR) Partnership Phase II*, supra note 26, Pages vi through viii.
[26] *Regional Emissions and Capture Opportunities Assessment – Plains CO_2 Reduction (PCOR) Partnership Phase II*, supra note 26, Table 12.
[27] *Regional Emissions and Capture Opportunities Assessment – Plains CO_2 Reduction (PCOR) Partnership Phase II*, supra note 26, Table 13.
[28] Kansas Geologic Survey, *South-central Kansas CO_2 Project* website (available at: http://www.kgs.ku.edu/PRS/Ozark/index.html).
[29] NETL, *Storing CO_2 with Enhanced Oil Recovery*, DOE/NETL-402/1312/02-07-08, February 7, 2008 (available at: http://www.netl.doe.gov/energy-analyses/pubs/Storing%20CO2%20w%20EOR_FINAL.pdf)

Comparing the CO_2 value of $41 per short ton for EOR to the CO_2 capture cost of $71 per short ton, the implementation of CO_2 capture at the ABBK facility is not cost effective. Further, CO_2 capture would result significant and adverse energy and environmental impacts due to the parasitic consumption of steam and electricity, additional emissions generated during CO_2 dehydration and compression and raw material usage.

Environmental Impacts

The EPA's *PSD and Title V Permitting Guidance for Greenhouse Gases*, states that, "EPA believes that it is appropriate for permitting authorities to account for both existing federal and state policies and their underlying objectives in evaluating the environmental, energy and economic benefits of biomass fuel. Based on these considerations, permitting authorities might determine that, with respect to the biomass component of a facility's fuel stream, certain types of biomass by themselves are BACT for GHGs.

Under the Energy Policy Act of 2005 (EPAct 2005), Congress directed the DOE to carry out a program to demonstrate the commercial application of integrated biorefineries for the production of biofuels, in particular ethanol, from lignocellulosic feedstocks. Accordingly, in February 2006, DOE issued a funding opportunity announcement for the design and construction of commercial-scale integrated biorefineries intended to demonstrate the use of a wide variety of lignocellulosic feedstocks to produce combinations of liquid transportation fuels (biofuels), bio-based chemicals, substitutes for petroleum-based feedstocks and products, and energy in the form of electricity or useful heat (biopower). In that announcement, DOE also encouraged the use of a wide variety of lignocellulosic feedstocks, but not those biomass components specifically grown for food, and encouraged the use of various technologies to collect and treat the wide variety of biomass feedstocks.

On February 28, 2007, DOE, announced the selection of six biorefinery projects for negotiation of financial assistance awards, one of which was the ABBK biomass-to-ethanol and biomass-to-energy production facility. ABBK proposed an innovative approach to biorefinery operations that would involve production of a biofuel and energy in the form of steam that can be used to meet energy needs and displace fossil fuels, such as coal and natural gas. ABBK proposed to locate the facility in Kansas to qualify for state tax credits for the construction of cellulosic ethanol facilities (Kansas Energy Development Act of 2006; Kansas Senate Bill 303), which would make the bio-refinery a more viable commercial operation.

4. Rank Technically Feasible Options

Table B-5 presents the ranked technically feasible control options as follows:

Table B-5 Ranked Control Options

Control Technology	Emission Rate (tons CO_2/year, excludes CH_4 and N_2O)	Reduction Efficiency	Emissions Reduction (tons CO_2/year, excludes CH_4 and N_2O)
Carbon Capture and Storage (CCS)	~ 48,000	90%	~ 433,500
Carbon Capture for Beneficial Uses	~ 48,000	90%	~ 433,500
Baseline (Fuel Type Restriction, Use of Lower GHG-emitting Processes/Practices/Design and Terrestrial Sequestration	481,652	N/A	N/A

The use of low-carbon and carbon neutral fuels, use of an aggressive lower GHG-emitting processes and practices through an energy-efficient design to reduce CO_2 emissions, and terrestrial sequestration control options are an inherent part of the facility's design and considered baseline control options. No emissions reduction credit is taken for the implementation of the baseline control options. The baseline presented above represents the design with the highest efficiency improvements limited to the maximum worst-case fuel blend discussed in Section 2.4.2.2. of the GHG BACT analysis prepared by ABBK. A detailed analysis of the baseline CO_2 control option (excluding terrestrial sequestration benefits) and three different operational cases (Case 1, Case 2 and Case 3) are shown in Table B-6.

Table B-6 Detailed Comparison of the Impacts of Certain Heat Recovery Strategies on the Cogeneration System

Heat Recovery Strategies on the Cogeneration System	Heat Recovery Strategy Implemented (Yes/No)			
	Baseline Case (Proposed System)	**Case 1**	**Case 2**	**Case 3**
Biomass Boiler (Fuel Type Restriction)	Yes	Yes	Yes	Yes
Air Preheat	Yes	Yes	Yes	No
Economizer	Yes	Yes	Yes	No
High Pressure Boiler Feedwater Preheater	Yes	Yes	No	No
Low Pressure Boiler Feedwater Preheaters	Yes	Yes	No	No
Process Waste Heat Integration	Yes	No	No	No
Impacts from Implementing Each Heat Recovery Strategy				
Gross Power Production, MWe	21.8	19.3	20.8	20.8
Estimated Net Power to Grid, MWe	2.8	0.3	1.8	1.8
Heat Rate, Btu/kW-hr	21,431.2	24,207.3	23,802.9	27,543.3
Cycle Efficiency, %	15.92%	14.10%	14.33%	12.39%
Overall Efficiency, %	183.6	183.6	183.6	183.6
Boiler Steam Production, lb steam/hr	325,000	325,000	325,000	325,000
CO_2e Production (Maximum WORST CASE Fuel Blend), lb CO_2e/hr	109,966	109,966	116,645	135,165

Heat Recovery Strategies on the Cogeneration System	Heat Recovery Strategy Implemented (Yes/No)			
	Baseline Case (Proposed System)	Case 1	Case 2	Case 3
CO_2e/Steam Ratio (Maximum WORST CASE Fuel Blend), lb CO_2e/lb steam produced	0.34	0.34	0.36	0.42

The technically feasible control options for further controlling CO_2 emissions or reducing overall CO_2 impacts from the biomass-fired stoker boiler is carbon capture with either long term storage through geologic sequestration or beneficial use of the CO_2 as a consumer product. For the purposes of this BACT analysis, chemical absorption is assumed to represent the best post-combustion CO_2 capture option that has been commercially demonstrated. The evaluation of the control options in this BACT analysis focuses first on the effectiveness of CO_2 capture, including economic, energy and environmental impacts; and then if CO_2 capture is determined to be cost-effective, storage and beneficial use options will be evaluated.

5. Establish BACT

ABBK proposes that GHG BACT for the biomass-fired stoker boiler consist of the following:

a. Restriction of the fuel type to biomass that is otherwise considered to have low to no economic value or benefit (i.e. crop residuals and waste wood); and/or is a lower impacting crops (i.e. mixed warm season grasses such as switchgrass);

b. Energy efficient design, incorporating cogeneration, process integration, combustion of co-products, heat recovery and operational and maintenance monitoring.

BACT for the biomass boiler and the reheat burner is determined to be the combustion of low-carbon fuel and the use of lower GHG-emitting processes and practices through an energy-efficient design. The use of these technologies can consistently achieve a GHG emission rate of 112,925 lb CO2e/hr on an on-going basis.

The BACT limit for the biomass-fired stoker boiler and boiler reheat burner shall be 0.35 lb CO_2e/lb of steam produced averaged over 30 day rolling periods including periods of startup and shut-down.

II. BACT ANALYSIS OF THE FLUE GAS DESULFURIZATION SYSTEM (EP-20512)

The Flue Gas Desulfurization System is the SO_2 BACT control for the Biomass-fired Boiler and includes the injection of sorbent (lime), which include one (1) hydrated lime storage silo (T-20512), pneumatic truck off-load system and hydrated lime handling conveyors.

A. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems;

b. Pneumatic conveying of materials through pipes and duct work; and,

c. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

i. Fabric Filter Baghouse;

ii. Wet ESPs;

iii. Dry ESPs;

iv. Venturi Scrubbers; or

v. Cyclones

2. Eliminate Technically Infeasible Control Options

Enclosures reduce particulate emissions by containing the material and preventing release of particulates or by reducing the wind that can entrain small exposed particles. Enclosures are typically used to capture emissions from operations like grinding and material transferring/handling so that the dust emitted can be collected and vented to a control device.

Types of enclosures typically used for handling dry solids are buildings, silos, hoppers, bins and conveyor covers. In the case of building enclosures, the degree of control is proportional to the degree to which the operation is enclosed. However, in well-designed systems, these types of enclosures are totally enclosed.

Solid transfer operations include gravity and pneumatic flow, conveying on belts, front-end loaders and buckets. Pneumatic flow is always enclosed in pipes. All the other types of transfer operations can be conducted with or without enclosure.

Due to health and safety reasons, most enclosed operations require ventilation to remove the particulates generated by the operations. Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures, or pipes and duct work, is the fabric filter baghouse. A baghouse has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air.

Other control devices, such as ESPs, induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Wet ESPs, Venturi scrubbers and cyclones are considered technically feasible for use in the receiving operations.

3. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the boiler fuel and materials handling operations.

The most effective, technically feasible option identified for control of the emissions from the lime handling operations for the Flue Gas Desulfurization system is the use of a baghouse.

4. Rank Technically Feasible Options

A baghouse, wet ESP and Venturi scrubber are all capable of achieving emissions reductions of 99% or more when employed with an enclosure or pipes and duct work. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency; and a wet ESP or Venturi scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste. Venturi scrubbers will be utilized in the process design for control of PM when the collected PM can be recovered and either reintroduced into the process stream for further processing, or when the collected PM is viewed as trash (i.e., dirt or other material that will interfere with production). Systems equipped with Venturi scrubbers will also be designed with baghouse control; therefore, the baghouse is the final dust control system of the exhaust stream.

Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology. Enclosures, piping and duct work must be maintained under negative pressure to achieve maximum control. Negative pressure is created by exhausting air, which is subsequently controlled by a baghouse.

Control Technology	Reduction Efficiency
Enclosure	50% to 99+%
Pipes and Duct Work	99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

5. Establish BACT

The use of an enclosed system equipped with a baghouse is technically feasible.

The BACT emissions of PM/PM_{10} are limited to 0.11 lb/hr.

The BACT emissions of $PM_{2.5}$ are limited to 0.06 lb/hr.

III. BACT ANALYSIS OF BIOMASS-FIRED STOKER BOILER MATERIALS HANDLING SYSTEMS (EP-20143, EP-20111-1, EP-20111-2, EP-20111-3, AND EP-20119)

A. $PM/PM_{10}/PM_{2.5}$ BACT Review

Materials handling systems and material storage have the potential to release particulate matter (PM) emissions. The PM sources for the biomass-fired boiler materials handling systems are as follows:

- One (1) Fly Ash Silo Bin (T-20110)
- One (1) Fly Ash Truck Loadout Slide Gate (EP-20111-1)
- Two (2) Fly Ash Rail Loadout Slide Gates, # 1 and # 2 (EP-20111-2 and EP-20111-3)
- One (1) Bottoms Ash Loadout (EP-20119)

1. $PM/PM_{10}/PM_{2.5}$ BACT Review for Fly Ash Silo Bin (T-20110)

a. Identify Available Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the fly ash silo and enclosed conveyors that are part of the fly ash production, collection and transport system to the storage silo

The only control option identified for the emissions generated from the totally enclosed fly ash production, collection and transport to the storage silo conveyance system is a dust collection system which collects and controls particulate emissions from the silo bin vent with the use of either a:

- Fabric filter dust collector
- Cyclone
- Electrostatic precipitators (ESPs), Dry and Wet
- Venturi scrubber
- Wet scrubber

b. Eliminate Technically Infeasible Control Options

Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures is the fabric filter dust collector. A fabric filter dust collector has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air. A wet scrubber, cyclone or Venturi scrubber may also be used instead of a fabric filter dust collector; however, none of these control emissions as well as a fabric filter dust collector. ESPs induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the particulates from ash load-out is a safety hazard as the particulate dust may explode if exposed to an ignition source such as a spark between the charged ESP plates. Therefore, dry ESPs are not considered a feasible option for controlling fly ash silo bin vent particulate emissions. Wet ESPs are considered technically feasible; however, wet ESPs do not control emissions as well as a fabric filter dust collector.

Venting the fly ash silo bin vent to a fabric filter dust collector is technically feasible. For the BACT analysis, only the most common and effective vent control, a fabric filter dust collector was further evaluated.

c. Evaluate Technically Feasible Control Options

The most effective, technically feasible option identified for control of the emissions from the fly ash silo bin vent is the use of a fabric filter dust collector based on the RBLC database. No further BACT evaluation is required for selection of the most effective, technically feasible option.

d. Rank Technically Feasible Options

The fly ash silo (T-20110) cannot operate without the fly ash silo bin vent dust collector (EP-20143) operating properly. The fly ash silo vent dust collector (EP-20143) is an inherent part of the fly ash collection system and is considered

baseline for purposes of BACT. The calculated control efficiency for this source based on a BACT limit of 0.004 gr/dscf for the filter efficiency. Generally, it is assumed that this type of dust control will achieve an effective control efficiency of greater than 99%.

e. Establish BACT

ABBK has contracted to purchase a DCL Shaker Style Dust Collector. This dust collector is a mechanical fabric filter bag shaker/cleaner. The dust collector specifications are provided in Appendix B with the Operating and Maintenance Manual for the fly ash handling and water conditioning system.

The proposed BACT for the fly ash silo bin vent to a fabric filter dust collector is as follows:

- PM/PM10 = 0.004 gr/dscf
- PM2.5 = 0.002 gr/dscf

This proposed BACT is consistent with the other fabric filter dust collectors permitted at the facility. The BACT emission rates for this source are presented in Table B-.7

Table B-7 Fly Ash Silo Bin Vent BACT Emission Rates

Emission Point	Pollutant	Hourly Emissions (lb/hr)	Annual Emissions (tpy)
EP-20143	PM	0.0057	0.025
	PM_{10}	0.0057	0.025
	$PM_{2.5}$	0.0029	0.013

1. $PM/PM_{10}/PM_{2.5}$ BACT Review for Fly Ash Truck Loadout Slide Gate (EP-20111-1), Fly Ash Rail Loadout Slide Gates, # 1 and # 2 (EP-20111-2 and EP-20111-3), and One (1) Bottoms Ash Loadout (EP-20119)

a. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

i. Water conditioning

Water conditioning is used to control particulate emissions by applying water and/or wetting agents to dry fly and bottoms ash. The amount of water and/or type of wetting agents applied is dependent on the end use of

the ash being treated. Fly ash is most commonly used in Portland cement concrete (PCC) applications. The unique spherical shape and particle size distribution of fly ash also makes good mineral filler in hot mix asphalt (HMA) applications and improves the fluidity of flowable fill and grout. The consistency and abundance of fly ash in many areas present unique opportunities for use in structural fills and other highway applications.

Fly ash utilization, especially in concrete, has significant environmental benefits including: (1) increasing the life of concrete roads and structures by improving concrete durability; (2) net reduction in energy use and greenhouse gas and other adverse air emissions when fly ash is used to replace or displace manufactured cement; (3) reduction in amount of combustion products that must be disposed in landfills; and (4) conservation of other natural resources and materials. Because of the many benefits of ash, ABBK assessed the potential end uses of the ash and evaluated those markets in the surrounding area that would have a need for ash. The implementation of water conditioning at the facility was deemed the most appropriate beneficial way to process the ash for marketing as a soil amendment product.

Water conditioning is technically feasible for all ash load-out emission points.

ii. Total or partially enclosure without dust collection system;

Enclosures reduce particulate emissions by containing the material and preventing release of particulates or by reducing the wind that can entrain small exposed particles. Enclosures are typically used to capture emissions from operations like the ash load-out such that the dust emitted can be collected and vented to a control device.

The effectiveness of the enclosure is directly impacted by the degree to which the operation is enclosed. Totally enclosed buildings offer the highest degree of control. Partial enclosures at truck and rail load-out stations are generally less effective due to the openings required for the railcar and truck passage. The effectiveness of partial enclosures can be increased through the use of doors or flexible curtains, where feasible.

A partial enclosure is technically feasible for the bottoms ash load-out station.

iii. Total enclosure with dust collection systems which collect and control particulate emissions with the use of control device such as:

a) Fabric filter dust collector
b) Cyclone

c) Electrostatic precipitators (ESPs), Dry and Wet
d) Venturi scrubber
e) Wet scrubber

Due to health and safety reasons, most enclosed operations require ventilation to remove the particulates generated by the operations. Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures is the fabric filter dust collector. A fabric filter dust collector has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air. A wet scrubber, cyclone or Venturi scrubber may also be used instead of a fabric filter dust collector; however, none of these control emissions as well as a fabric filter dust collector. For this BACT analysis, only the most common and effective vent control, a fabric filter dust collector will be further evaluated.

ESPs induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the particulates from ash load-out is a safety hazard as the particulate dust may explode if exposed to an ignition source such as a spark between the charged ESP plates. Therefore, dry ESPs are not considered a feasible option for controlling ash load-out particulate emissions. Wet ESPs are considered technically feasible for use in the ash load-out operations; however, wet ESPs do not control emissions as well as a fabric filter dust collector. A total enclosure vented to a fabric filter dust collector is technically feasible for the bottoms ash load-out station.

b. Eliminate Technically Infeasible Control Options

i. Total or partially enclosure without dust collection systems:

A total enclosure without ventilation for dry fly ash load-out is technically infeasible due to safety and health concerns. Ventilation is necessary to minimize fire and explosion hazards in enclosed spaces.

ii. Total enclosure with dust collection systems:

For the truck and rail fly ash load-out station, it was determined that an enclosure of any kind was not technically feasible to install due to the due to the proximity of the rail line to the buildings and fly ash storage silo.

c. Rank and Evaluate Technically Feasible Control Options

Water conditioning is the most stringent technically feasible control technology for the load-out points: Fly Ash Truck Load-out Slide Gate (EP-20111-1); Fly Ash Rail Load-out Slide Gate #1 (EP-20111-2); and Fly Ash Rail Load-out Slide Gate #2 (EP-20111-3).

Water conditioning and a total enclosure with a fabric filter dust collector are equally the most stringent technically feasible control technology for the load-out emission point: Bottoms Ash Load-Out (EP-20119), as shown in Table B-8.

Table B-8 Fly Ash and Bottoms Ash Load-Out Technically Feasible Control Options

Emission Point	Control Technology	PM/PM10 Control Efficiency (%)
Fly Ash Loadout Points – (EP-20111-1) (EP-20111-2) (EP-20111-3)	Water Conditioning	>99%
Bottoms Ash Loadout	Water Conditioning	>99%
	Total Enclosure with Fabric Filter Dust Collector	>99%
	Partial Enclosure	50%

Because water conditioning of the ash is designed to achieve a minimum 20% moisture content, it is expected that the water conditioning load-out points will not be a source of emissions; however the emission calculations are based on a worst-case scenario that assumes emissions will be generated during the dropping of the material into the transportation container (either truck hopper trailer, rail hopper car or roll-off dumpster. The calculated control efficiency for these sources based on the use of water conditioning to increase the moisture content to 20% is 99.43%.

There is no appreciable difference in the control efficiencies for water conditioning or mechanical dust collection; however, water conditioning provides additional control of fugitive emissions after the ash is loaded for transport and

water conditioned fly ash is more readily marketed as a soil amendment product; therefore, water conditioning was determined to be the preferred control option at the facility. No further cost analysis comparing water conditioning to mechanical dust collection was performed for this BACT analysis.

d. Establish BACT

The proposed BACT for the ash load-outpoints is water conditioning to a minimum of 20% moisture content.
The fly ash will have a minimum moisture content of 20% after processing in the mixer and prior to discharge to the load-out screw conveyor (CV-20110). The amount of water spray can be varied to suit the end-use needs. The moisture content in this water conditioning system can be up to 40% as needed.

The bottoms ash will have a minimum moisture content of 20% prior to discharge to the roll-off dumpster. This moisture content will be achieved through water spray designed to apply 60,000 lb/hr of water to the ash in the submerged ash drag chain conveyor (CV-20119).

The BACT emission rates for this source are presented in Table B-9.

Table B-9 Summary of Ash Load-Out Points BACT Emission Rates

Emission Point	Pollutant	Hourly Emissions (lb/hr)	Annual Emissions (tpy)
EP-20111-1	PM	0.0025	0.0108
	PM_{10}	0.0012	0.0051
	$PM_{2.5}$	0.0002	0.0008
EP-20111-2	PM	0.0025	0.0108
	PM_{10}	0.0012	0.0051
	$PM_{2.5}$	0.0002	0.0008
EP-20111-3	PM	0.0025	0.0108
	PM_{10}	0.0012	0.0051
	$PM_{2.5}$	0.0002	0.0008
EP-20119	PM	0.00005	0.00021
	PM_{10}	0.00002	0.00010
	$PM_{2.5}$	0.000003	0.000015

IV. BACT ANALYSIS OF BIOMASS RECEIVING, GRINDING and STORAGE OPERATIONS (EP-11600, EP-11610, EP-11100, EP-11200, EP-11500, EP-11700, EP-11400, FUG_WSL, FUG_DP, FUG_DO, FUG_WCP, AND FUG_WCE)

A. $PM/PM_{10}/PM_{2.5}$ BACT Review for Biomass Storage and Receiving

The biomass (e.g., agricultural residues and energy crops) handling operations such as receiving, loading and unloading are sources of fugitive $PM/PM_{10}/PM_{2.5}$ (EP-11100FUG). Biomass will be delivered in bale form primarily on flatbed / module / custom trucks. The baled biomass will either be unloaded directly onto conveyors supplying the grinding lines or unloaded at the biomass overnight staging area or biomass storage field.

The particulate emissions generated from the unloading of material from the trucks and the loading of the material into roll-off dumpsters were assumed equivalent to the particulate emissions generated by the drop operation for aggregate handling and storage piles, as calculated in AP-42, Section 13.2.1, *Aggregate Handling and Storage Piles*, November 2006. The bound agricultural residues and energy crops will typically not be a source of suspended $PM/PM_{10}/PM_{2.5}$ emissions until grinded; however, any particulate matter emissions from the biomass stored on-site will result from wind erosion of the piles. The amount of particulate emitted is a result of the exposed surface area from the tightly bound bales, which reduces the particulate emitted.

1. Identify Available Control Options

Possible control strategies are as follows:

- Fabric filter/bin vent filter
- Best operating practices
- Enclosure/wind screens
- Water spray/ wet suppression

2. Eliminate Technically Infeasible Control Options

Due to the nature of the biomass storage piles, they will be a fugitive source. Physical covers to reduce wind erosion are technically infeasible given the size of the storage piles. As such, it is not possible to capture emissions and route them to a fabric filter or bin vent filter.

Likewise, the large nature of the storage piles will not allow enclosure or wind screens to be constructed. Therefore, fabric filter/bin vent filter and enclosure/wind screens are not technically feasible control options. With the dry windy conditions in SW Kansas, any water sprayed on the biomass would quickly evaporate.

Due to the size of the piles, it would take a large tanker truck to carry enough water to spray the piles. Also, keeping the bales dry prevents spontaneous combustion, as well as keeps odor and mold growth down. Adding moisture to the biomass material is therefore not technically feasible.

3. Evaluate and Rank Technically Feasible Control Options

The only control practice that is technically feasible is a best operating practices, such as compaction of the baled biomass material.

Dust control from the biomass bales in the storage piles can be obtained through maintaining the bales in a tightly compacted matter to reduce loose material available for wind erosion.

4. Establish BACT

A Fugitive Dust Management Plan, similar to that already required for the in-plant haul roads, will be developed for the biomass storage piles. The Plan will include maintaining each bale in a tightly compaction of baled biomass material.

B. $PM/PM_{10}/PM_{2.5}$ BACT Review for Wet Cake Production, Wet Cake Emergency Pad, Washed Sand, Dirt Production, and Dirt Offloading (FUG_WSL, FUG_DP, FUG_DO, FUG_WCP, AND FUG_WCE)

1. Identify Available Control Options

The RBLC database was queried for fugitive dust sources, which includes agriculture activities, ash storage/handling/disposal, construction activities, paved roads, unpaved roads, and other fugitive dust sources. A second query was run for biomass to ensure that all possible control strategies were identified. Possible control strategies are as follows:

a. Fabric filter/bin vent filter;

A fabric filter is technically feasible for fly ash production. Fugitive dust from fly ash handling can be enclosed and routed to the fly ash storage silo, where it can be controlled by the fly ash storage silo bin vent. All other material handling emissions cannot be captured and routed to a point source and remain fugitive in nature, making a fabric filter technically infeasible.

b. Best operating practices;

Best management practices include adding additional moisture as needed to control dust and developing a Fugitive Dust Control Plan to specifically address measures that can be taken at each specific emission process.

c. Covered conveyors/enclosure/wind screens; and

Some of the listed processes can be enclosed in whole or in part. Enclosing the fly ash production, wet cake emergency pad & reclaim and dirt production can minimize fugitive PM emissions from these processes. In the case of the fly ash production, it is feasible to vent the system to the storage silo and its filter. The wet cake emergency pad & reclaim can be enclosed on three sides of the pad to cut down on the wind erosion. Likewise, enclosing the vibrating screens on the dirt production process will control fugitive dust.

d. Water spray/ wet suppression

Fugitive emissions from each process can be minimized through addition of water to increase the moisture content and will be considered further in the fugitive PM BACT review. A water spray or misting system is typically added to an open dumping process. Water is sprayed or misted as material is dumped in order to capture and settle fugitive dust emissions that are created as the dry material lands on the pile. Water spray or misting systems are applicable to all coal handling activities and some piling activities. However, they are not applicable to all material handling activities reviewed here. For example, water spray or misting systems are not applicable to the bottom ash pile as the material is wetted prior to dumping, thus additional water will not further reduce PM emissions.

2. Rank and Evaluate Technically Feasible Control Options

The most effective control is a fabric filter, but that process is not feasible for these processes. The degree of control for water spray/wet suppression is dependent on the level of moisture maintained in the material. The RBLC entries do not specify the level of moisture maintained in the comparable facilities' operations. Likewise, the RBLC entries do not specify a control percentage from the implementation of best operating practices or enclosure.

3. Establish BACT

Wet suppression, best operating practices and enclosure will be considered equally effective for purposes of this BACT analysis, as described in Table B-10

Table B-10 Summary of BACT Results: Material Handling Transfer Points.

Emission Point	Pollutant	Hourly Emissions (lb/hr)	BACT Control
Wet Cake Production	PM	0.0101	Wet Suppression
	PM_{10}	0.0048	
	$PM_{2.5}$	0.0007	Enclosure Fugitive Dust Control Plan

Emission Point	Pollutant	Hourly Emissions (lb/hr)	BACT Control
Wet Cake Emergency Pad & Reclaim	PM	0.0051	Wet Suppression
	PM_{10}	0.0024	
	$PM_{2.5}$	0.0004	Enclosure Fugitive Dust Control Plan
Washed Sand	PM	0.0012	Enclosure
	PM_{10}	0.0006	
	$PM_{2.5}$	0.0001	Fugitive Dust Control Plan
Dirt Production	PM	0.0038	Wet Suppression
	PM_{10}	0.0018	
	$PM_{2.5}$	0.0003	Enclosure Fugitive Dust Control Plan
Dirt Offloading	PM	0.0281	Fugitive Dust Control Plan
	PM_{10}	0.0133	
	$PM_{2.5}$	0.0020	

C. $PM/PM_{10}/PM_{2.5}$ BACT Review for Dust Collection Systems: DC#1, Dust Collection System DC#2, Floor Sweep System Baghouse, EH Storage Bin # 1 DC, EH Storage Bin # 1 DC, Boiler Feed System DC, Boiler Feed System DC and Biomass Boiler Storage Bin (EP-11600, EP-11610, EP-11100, EP-11200, EP-11500, EP-11510 EP-11700, EP-11400)

Generally, the entire biomass grinding/milling, handling, and storage operations begins at the process infeed conveyor line. Once the retrieved bales are delivered to the process infeed conveyor line, the biomass grinding, handling and storage system will be a closed system designed with high velocity pickup of particles; therefore, a capture efficiency of 100% is anticipated throughout the system. The biomass grinding/milling and handling systems will aspirate to fabric filter dust collectors (baghouses) for control of particulate emissions. Building openings and ventilation will be kept to a minimum consistent with required operations and good industry safety and health practices.

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

a. Total or partial enclosed buildings, conveyors, or silos/surge bins without dust collection systems;

b. Pneumatic conveying of materials through pipes and duct work; and,

c. Total enclosures with dust collection systems which collect and control particulate emissions with the use of:

i. Fabric Filter Baghouse;
ii. Wet ESPs;
iii. Dry ESPs;
iv. Venturi Scrubbers; or
v. Cyclones.

2. Eliminate Technically Infeasible Control Options

Enclosures reduce particulate emissions by containing the material and preventing release of particulates or by reducing the wind that can entrain small exposed particles. Enclosures are typically used to capture emissions from operations like grinding and material transferring/handling so that the dust emitted can be collected and vented to a control device.

Types of enclosures typically used for handling dry solids are buildings, silos, hoppers, bins and conveyor covers. In the case of building enclosures, the degree of control is proportional to the degree to which the operation is enclosed. However, in well-designed systems, these types of enclosures are totally enclosed.

Solid transfer operations include gravity and pneumatic flow, conveying on belts, front-end loaders and buckets. Pneumatic flow is always enclosed in pipes. All the other types of transfer operations can be conducted with or without enclosure.

Due to health and safety reasons, most enclosed operations require ventilation to remove the particulates generated by the operations. Although there are numerous devices that are effective at removing particulates from air streams, the most common and effective vent control for enclosures, or pipes and duct work, is the fabric filter baghouse. A baghouse has been established by the industry as the most effective control device for removing particulates from ventilation and conveying air.

Other control devices, such as ESPs, induce an electric field between oppositely charged plates where charged particulates are removed from the exhaust stream. The use of a dry ESP with the suspended particulates is a safety hazard as the particulate dust may explode if exposed to an ignition source such as spark between the charged ESP plates. Wet ESPs, Venturi scrubbers and cyclones are considered technically feasible for use in the receiving operations.

3. Rank Technically Feasible Control Options

A baghouse, wet ESP and Venturi scrubber are all capable of achieving emissions reductions of 99% or more when employed with an enclosure or pipes and duct work. However, based on previous performance and application experience, a baghouse is more likely to achieve and maintain 99+% efficiency (Table B.4-1); and a wet ESP or Venturi

scrubber offer no performance or cost advantages. Two disadvantages of a Venturi scrubber are the requirement for water and disposal of a wet waste. Venturi scrubbers will be utilized in the process design for control of PM when the collected PM can be recovered and either reintroduced into the process stream for further processing, or when the collected PM is viewed as trash (i.e., dirt or other material that will interfere with production). Systems equipped with Venturi scrubbers will also be designed with baghouse control; therefore, the baghouse is the final dust control system of the exhaust stream.

Total enclosure of an emission unit coupled with a dust collection/ventilation system vented to a fabric filter baghouse is the most stringent control technology. Enclosures, piping and duct work must be maintained under negative pressure to achieve maximum control.

Negative pressure is created by exhausting air, which is subsequently controlled by a baghouse.

Control Technology	Reduction Efficiency
Enclosure	50% to 99+%
Pipes and Duct Work	99+%
Baghouse	99+%
Wet ESP	99+%
Venturi Scrubber	70% to 99+%
Cyclone	≤90%

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify particulate control technologies that were potentially applicable to the agricultural residues and energy crops grinding and handling operations.

The most effective, technically feasible option identified for control of the emissions from the agricultural residues and energy crops grinding and handling operations is the use of a baghouse. This is the top performing control technology.

5. Establish BACT

Based on the review of EPA's RBLC, recent PM/PM_{10} BACT limits range from 0.004 to 0.005 grains per dry standard cubic foot (gr/dscf).

In all of the RBLC cases, the BACT limits for these sources are based on the use of a baghouse to control the grinding/hammermilling and handling PM/PM_{10} emissions. The use of an enclosed system equipped with a baghouse is technically feasible and will be

employed. Table B-11 lists the $PM/PM_{10}/PM_{2.5}$ proposed BACT limits. The $PM_{2.5}$ emission limits are based on the estimated weight fraction used to estimate potential emissions (17% by weight $PM_{2.5}$).

6. BACT Compliance

ABBK proposes to meet the agricultural residues and energy crops grinding and handling operations PM/PM_{10} BACT limit based on the average of at least three test runs conducted at each baghouse, and a visible emissions limit of 0% opacity.

Table B-11 $PM/PM_{10}/PM_{2.5}$ Proposed BACT Limits

Stack ID	Equipment/ Process	Pollutant	Proposed BACT Emission Limit(s)	BACT Device(s) or Operational Limitation(s)
EP-11700	Floor Sweep System Baghouse	PM/PM_{10}	0.011 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 lb/hr.	
EP-11200	EH Storage Bin # 2 DC	PM/PM_{10}	0.72 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.12 lb/hr	
EP-11500	Boiler Feed System DC	PM/PM_{10}	0.044 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.008 lb/hr.	
EP-11510	Boiler Feed System DC	PM/PM_{10}	0.044 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.008 lb/hr.	
EP-11100	EH Storage Bin #1 DC	PM/PM_{10}	0.72 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.12 lb/hr	
EP-11600	Dust Collection System DC # 1	PM/PM_{10}	0.625 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.11 lb/hr	Fabric Filter Baghouse
EP-11610	Dust Collection System DC # 2	PM/PM_{10}	0.625 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.11 lb/hr	Fabric Filter Baghouse
EP-10507	Dirt/Fines Silo Vent	PM/PM_{10}	0.01 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.002 lb/hr	Fabric Filter Baghouse
EP-11400	Biomass Boiler Storage Bin Baghouse	PM/PM_{10}	0.72 lb/hr	Fabric Filter Baghouse
		$PM_{2.5}$	0.122` lb/hr	Fabric Filter Baghouse

V. BACT ANALYSIS OF ENZYMATIC HYDROLYSIS (EH) ETHANOL MANUFACTURING PLANT (EP-18185)

The CO_2 generated from the biomass co-fermentation process (Area 16000) will be routed through the enzymatic hydrolysis fermentation CO_2 scrubber (EP-18185). The rated control efficiency will be equal to or greater than 99%. The CO_2 generated from the biomass ethanol recovery process (Area 18000) will be routed through the enzymatic hydrolysis distillation vent scrubber (EP-18180). The distillation vent scrubber vent feeds into the enzymatic hydrolysis fermentation CO_2 scrubber (EP-18185) for further control efficiency. The non-condensable emissions generated in areas 12000, 16000, and 19000 from the biomass process vents will be routed to either the biomass-fired boiler or thermal oxidizer for destruction.

The vent streams routed to the scrubbers are expected to be saturated with water since the process tanks contain primarily CO_2 and water. These vent streams also are expected to contain VOC and HAPs. The scrubbers will be packed-tower wet scrubbers, which allow for ethanol vapors to be collected in order for a higher product yield; however the unit also provides VOC and HAP emission control. The scrubber systems will recover nearly all of the ethyl alcohol (ethanol) from the vapor stream and return the ethanol to the process downstream. The water from the wet scrubbers is pumped back into the process for recycling. The distillation vent scrubber vent feeds into the enzymatic hydrolysis fermentation CO_2 scrubber (EP-18185) for further control efficiency and is discharged through the fermentation CO_2 scrubber stack (EP-18185).

A detailed engineering evaluation of the fermentation and distillation vent streams identified the potential for other PSD pollutants, including condensable PM, NO_2 and H_2S. Although this source's VOC and H_2S emissions do not require PSD review, the condensable PM and NO_2 must undergo PSD review. It should be noted that the wet scrubbers are an integral part of the process, as well as a control device for VOC, HAPs, PM, H_2S and NO_2. Wet scrubbers allow for product that would otherwise be lost in the vent streams to be captured and returned to the process stream. Wet scrubbers increase the efficiency of the process and the bio-refinery would not operate without the wet scrubbers.

A. Condensable PM and NO_2 BACT Review

1. Identify Available Control Options

Condensable PM is formed after the stream exhausts from the scrubber and is due to fine particles, including aerosols, condensing at ambient air conditions. Wet scrubbers often achieve higher levels of condensable PM control as the scrubbers help to condense the condensable PM during the scrubbing. NO_2 is a trace containment present in the vent streams ducted to the fermentation packed-tower wet scrubber for control. NO_2 control through the use of the scrubber is estimated to be greater than 95% control.

Packed-tower wet scrubbers been identified and considered in determining BACT. A packed-tower wet scrubber is an absorption system in which the waste stream is dissolved by passing it through a medium containing a solvent. Water is the most

commonly used solvent. Other solvents may be used depending on the components of the waste stream. Also, application of a wet scrubber in the ethanol production process is used to increase the process efficiency. This technology is considered technically feasible.

Based on the review of the RBLC database and other technical sources of information, there are no additional control options for condensable PM and NO_2 in addition to the packed-tower wet scrubbers that will be employed as part of the fermentation and distillation process.

2. Establish BACT

Based on the use of the packed-tower wet scrubbers for VOC and HAP control, the most effective, technically feasible option identified for the control of condensable PM and NO_2 is also the use of packed-tower wet scrubbers only for the fermentation and distillation operations associated with ethanol production.

This results in PM BACT emissions of 0.10 lb/hr and NO_2 emissions of 0.07 lb/hr.

B. VOC BACT Review

1. The packed tower wet scrubber is technically feasible control technology for VOC control.

2. Establish BACT

BACT for ethanol fermentation is the use of a CO_2 scrubber. The use of a packed-tower wet scrubber was selected as BACT for VOC for the EH Fermentation process. This results in VOC BACT emission of 0.30 lb/hr, averaged over 30 day rolling periods including periods of startup, shut-down or malfunction.

C. GHG BACT Review

1. Identify Available Control Options

The following control options were identified and considered in determining BACT:

a. Monitoring enzymatic hydrolysis process efficiency;

b. Carbon capture and storage ("CCS", also referred to as "carbon capture and sequestration");

c. Carbon capture for beneficial uses;

d. Develop and implement an LDAR program, in accordance with NSPS, Subpart VVa (40 CFR 60.480a through 60.489a), as proposed for the other fugitive pollutants: VOC and HAP; and

e. Combination of these control options.

There are two (2) broad strategies for reducing GHG emissions from the two enzymatic hydrolysis scrubbers at the proposed facility. The first is to minimize the production of GHG through monitoring enzymatic hydrolysis process efficiency. The EH process efficiency is an integral part of the facility's design and is considered the baseline for this BACT analysis.

The second strategy for reducing GHG emissions is carbon capture and storage ("CCS", also referred to as "carbon capture and sequestration") or carbon capture for beneficial uses. Because of the low CO2 concentration in the scrubber vent streams (88%), the CCS and carbon capture for beneficial uses discussion presented in the biomass-fired boiler section #2 is applicable. Although the CO_2 concentration is 88%, this stream is still not considered a "high purity CO_2 Stream" like other traditional starch plant fermentation vent streams, where the CO_2 concentration is greater than 95% and usually 98% to 99% before CO_2 capture is performed for commercial applications.

Implementation of an LDAR program is not intended to control emissions beyond the baseline. The LDAR program is used to monitor equipment leaks for repair. For the fermentation and distillation operations, CO2 emissions from equipment leaks were estimated to be less than 1 lb/hr.

2. Eliminate Technically Infeasible Control Options

Two main options identified for control of CO_2 emissions from the enzymatic hydrolysis scrubber: 1) monitoring enzymatic hydrolysis process efficiency; and 2) CCS and/or carbon capture for beneficial uses.
Table B-12 summarizes the technical feasibility/infeasibility determination discussed in this section.

Table B-12 Technical Feasibility/Infeasibility Determination Summary

Potentially Available Control Option	Determination Result	Determination Reason
Monitoring Enzymatic Hydrolysis Process Efficiency	Technically Feasible	Inherent part of the facility's design, and considered a baseline control option.
Carbon Capture Using Post-Equipment Capture	Technically Feasible	Chemical absorption has been the most widely used method of commercial CO2 capture and is the primary CO2 capture technology further analyzed.

Table B-12 Technical Feasibility/Infeasibility Determination Summary

Potentially Available Control Option	Determination Result	Determination Reason
Carbon Transportation	Technically Feasible	Technical issues can be addressed through modern pipeline construction / maintenance practices.
Carbon Storage through Geologic Sequestration	Technically Feasible	In Kansas, geologic sequestration of CO2 may be possible in all five of the geologic formations: deep saline aquifers, coal seams, oil ad natural gas reservoirs, oil- and gas-rich organic shales, and basalt
Carbon Storage through Terrestrial Sequestration	Technically Feasible	Inherent part of the facility's design; considered a baseline control option.
Carbon Beneficial Uses	Technically Feasible	The many different technologies being investigated for the beneficial use of CO2 vary widely in their stages of development; from those in bench-scale, to those close to commercialization.
Combination of these Control Options	Technically Feasible	See reasons above.

The technical feasibility of the control options are discussed below.

a. Monitoring Enzymatic Hydrolysis Process Efficiency

There are numerous strategies for achieving a highly efficient enzymatic hydrolysis process. All identified strategies (i.e. control options) listed in this section are technically feasible for application to the scrubbers, and all are an inherent part of the facility's design.

i. Monitoring the Enzymatic Hydrolysis Process Efficiency Related to CO_2 Production in Fermentation – This strategy is the primary GHG BACT control technology option. CO_2 production in fermentation is a function of the yeast, and selected micro-organism. A healthy and optimized organism will produce more ethanol and less CO_2.

ii. Energy Efficient Heat Integration – The enzymatic hydrolysis process is integrated with the cogeneration facility to maximize energy efficiency. This integration is discussed in Section 2.4 of the GHG BACT analysis prepared by ABBK. Energy efficient heat integration is more important to the boiler GHG than the CO_2 scrubber (EP-18185) and distillation vent scrubber (EP-18180) GHG.

iii. Water Recycling – Process-related water will be recycled whenever possible to reduce the facility's consumption.

iv. Co-product Production – Valuable co-products will be generated during the enzymatic hydrolysis process. The valuable co-products include products such as enzymatic hydrolysis residuals (including lignin-rich/lignin-lean stillage cake and thin stillage syrup) and wastewater treatment biogas. These products can either be sold as a consumable product or combusted as a supplemental fuel in the biomass-fired boiler.

b. Carbon Capture

Section 2.4 of GHG BACT analysis prepared by ABBK in the May 19, 2011 Updated Facility Design, Prevention of Significant Deterioration, Air Quality Construction Permit Application details the carbon capture control option technical feasibility determination. The information presented in the biomass-fired boiler section is not repeated herein. For the fermentation and distillation scrubbers, the pre-combustion and oxy-combustion approaches are not applicable. Carbon capture using post-equipment capture is equivalent to post-combustion capture. The only commercially demonstrated method for similar exhaust streams (low CO_2 concentrations) is chemical absorption.

c. Carbon Transport and Storage

Section 2.4 of GHG BACT analysis prepared by ABBK in the May 19, 2011 Updated Facility Design, Prevention of Significant Deterioration, Air Quality Construction Permit Application details the carbon transport and storage technical feasibility determination. The information presented in Section II above is not repeated herein.

Terrestrial sequestration applies to the fermentation and distillation scrubbers because the emissions associated with these scrubbers are biogenic CO_2 emissions. Because the proposed source will utilize biomass in the production of ethanol, this type of CO_2 storage is essentially being implemented as part of the facility's design; therefore, terrestrial sequestration is considered a baseline control option.

d. Carbon Beneficial Uses

Section 2.4 of GHG BACT analysis prepared by ABBK in the May 19, 2011 Updated Facility Design, Prevention of Significant Deterioration, Air Quality Construction Permit Application details the carbon beneficial uses control option technical feasibility determination. The information presented in Section II above is not repeated herein.

3. Rank Technically Feasible Options

Table B-13 presents the ranked technically feasible control options. The use of monitoring enzymatic hydrolysis process efficiency to reduce CO_2 emissions, and terrestrial sequestration control options are an inherent part of the facility's design and considered baseline control options. No emissions reduction credit is taken for the implementation of the baseline control options. The baseline presented in Table B-13 represents the design with the highest efficiency improvements.

Table B-13 Ranked Control Options

Control Technology	Expected Emission Rate (tons CO_2/year)	Reduction Efficiency	Expected Emissions Reduction (tons CO_2/year)
Carbon Capture and Storage (CCS)	~ 8,800	90%	80,000
Carbon Capture and Storage (CCS)	~ 8,800	90%	80,000
Baseline (Monitoring Enzymatic Hydrolysis Process Efficiency and Terrestrial Sequestration)	88,360	N/A	N/A

4. Evaluate Technically Feasible Control Options

The implementation of CCS and carbon capture for beneficial uses on the fermentation and distillation scrubbers is similar to the implementation of these control options on the biomass-fired boiler. The CO_2 concentrations in the scrubber's vent streams are similar to the CO_2 concentrations expected in the biomass-fired boiler's flue gases. The low purity (88% CO_2 concentration) in the fermentation and distillation vents makes these vent streams undesirable for CO_2 processing companies.

Because the largest CO_2 emission sources at the facility are the biomass-fired boiler, the implementation of a CCS control option (excluding terrestrial sequestration) is based on the cost-effectiveness of such a system applied to the boiler. As discussed in detail in the biomass-fired boiler section, using CCS or carbon beneficial uses to reduce CO_2 emissions from the boiler is technically feasible but would entail significant, adverse economic, environmental and energy impacts due to increased fuel usage in order to meet the steam and electric load requirements of the CCS systems. Therefore, the use of CCS and carbon beneficial uses technologies were determined not to be cost effective for control of CO_2 from the boiler and subsequently, are not cost effective for the fermentation and distillation CO_2 emissions, which are less than 88,360 tons/yr CO_2e.

5. Establish BACT

ABBK proposes that GHG BACT for the fermentation scrubber vent stream consist of an efficient design, incorporating energy efficient heat integration, water recycling, and co-product production that make the overall process efficient and economical.

These control options are technically feasible for the enzymatic hydrolysis process and are an inherent part of the facility's design. ABBK proposes that the BACT limit be 5.89 lb CO_2e/gal anhydrous ethanol produced for the enzymatic hydrolysis fermentation CO2 scrubber stack (EP-18185), averaged over a 30-day rolling period. These proposed emission limits are based on the average continuous flow CO_2 concentrations.

CO_2e emissions will be determined based on the required stack testing to be completed upon startup. Continuous stack monitoring equipment will be installed to monitor operational indicators and CO_2. Emissions will be averaged over a 30-day rolling period for compliance.

VI. BACT ANALYSIS OF COOLING WATER TOWER SYSTEM FOR COGENERATION AND ENZYMATIC HYDROLYSIS (EP-04001)

The production process will be cooled by circulating water through heat exchangers, a chiller, and the cooling water tower. The cooling tower is an essential utility in the ethanol production and refining process. At the cogeneration plant, exhaust steam is condensed under vacuum against cooling water in the cooling water tower. Enzymatic hydrolysis process steam is extracted from the turbines at a lower pressure from uncontrolled extraction ports. Boiler feedwater preheated steam is also extracted from the turbines from uncontrolled extraction ports. The cooling water tower (EP-04001) will contain three (3) cells, with a total water circulation rate of 52,000 gallons per minute. The cooling water tower will be equipped with a drift (mist) eliminator.

Cooling towers are a source of particulate matter emissions due to the loss or drift of droplets of cooling water containing dissolved solids from the tower. The particulate emissions are assumed all condensable, and therefore all assumed to be less than 1.0 micrometer in diameter. The water generated from the cooling towers will not come into contact with the production processes, thus no VOC emissions are expected.

A. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

a. Drift Eliminators;

b. Total Dissolved Solids (TDS) Limit;

c. Total Dissolved Solids (TDS) Removal System; and

d. Combination of these control options.

2. Eliminate Technically Infeasible Control Options

Drift elimination is the removal of entrained liquid droplets from a vapor stream. The installation of high efficiency drift eliminators and the use of water treatment technology to further reduce TDS in the cooling water are considered feasible control technologies. The only feasible TDS removal technology identified was demineralization using softeners and ion exchange beds to remove additional TDS from the cooling water makeup stream. Both reverse osmosis and distillation are rejected as TDS reducing options due to their high energy requirements and high annual operating costs relative to ion exchange based on demineralization. Demineralization is not considered technically feasible and was not evaluated in this analysis, as the substantial additional cost of treating and/or disposing of by-product sludge, spent resin and wastewater generated by the demineralization process are cost prohibitive and this technology has not been implemented at similar facilities.

3. Rank Technically Feasible Control Options

The use of a drift eliminator is the most technically feasible control technology. A TDS limit for the circulating water is usually viewed as a measure that benefits air quality by reducing the dissolved salts that can be precipitated from drift aerosols. To reduce TDS, the facility must introduce a higher volume flow of make-up water to the tower. This has the potential disadvantage of increasing the overall plant water requirements.

4. Evaluate Technically Feasible Control Options

EPA's RBLC database was reviewed to identify $PM/PM_{10}/PM_{2.5}$ control technologies that were potentially applicable to cooling tower, including a review of cooling towers located at similar facilities and cooling towers permitted within the last year.

According to EPA's RBLC database, the use of a mist eliminator designed for a 0.0005% drift with TDS limit is ranked as the top control and has been established as BACT technology for cooling towers. Mist eliminators designed for drift loss factors ranging from 0.005% to 0.0005% have been established as BACT at similar facilities and for cooling towers permitted within the last year.

5. Establish BACT

ABBK proposes the use of the top performing control technology, drift eliminators, to control $PM/PM_{10}/PM_{2.5}$ emissions from the cooling water towers. ABBK also proposes the use of a TDS concentration limit, which is a measurable limit that will be used to demonstrate compliance. The TDS concentration to be used for compliance will be based on a 24-hour average concentration.

The BACT emissions of $PM/PM_{10}/PM_{2.5}$ for the cooling water tower (EP-04001) is the installation of high efficiency mist eliminators that will limit drift to 0.0005% and a maximum total dissolved solids (TDS) limit of 1,575 ppm by volume. This results in a PM BACT limit of 0.20 lb/hr, PM_{10} BACT limit of 0.14 lb/hr and a $PM_{2.5}$ BACT limit of 0.09 lb/hr.

VII. BACT ANALYSIS OF LIGNIN STORAGE AND LOADOUT (EP-19001FUG)

The facility design will incorporate a lignin-rich stillage cake storage. VOC emissions result from the evaporation of trace organics dissolved in the water fraction. Emissions increase with increased temperature. Therefore, maintenance of the material at ambient temperature will reduce the potential for fugitive VOC emissions.

A. VOC BACT Review

1. Identify Available Control Options

The most common control for a source such as this is to store the material at ambient temperature to reduce the potential for VOC emissions. The only potential add-on control option for this process would be to capture the VOC emissions and vent them to an add-on control device such as a wet scrubber or thermal oxidizer.

2. Identify Technically Feasible Control Options

Maintenance of the material at ambient temperature and venting emissions to a control device such as a wet scrubber or thermal oxidizer are both considered technically feasible for the lignin-rich stillage storage for the purposes of this BACT.

3. Rank Technically Feasible Control Options

Controlling VOC emissions through a control device such as a wet scrubber or thermal oxidizer is considered technically feasible. Typical collection efficiencies for wet scrubbers range from 70% to greater than 99%, and thermal oxidizers generally achieve greater than 98% reduction in VOC. Therefore, collecting and venting VOC emissions is considered the top rated control technology.

The only other control technology, and therefore the second highest rated, is maintenance of the material at ambient temperature.

4. Evaluate Technically Feasible Control Options

Controlling VOC emissions through a control device such as a wet scrubber or thermal oxidizer is considered technically feasible. However, the potential uncontrolled VOC emissions from the process are calculated to be only 1.29 tons per year, which is very low compared to the other VOC emitting sources at the facility.

Based on this low emission rate, capturing and controlling these emissions with an add-on control device would cost much more than $50,000 per ton of pollutant removed. Maintenance of the material at ambient temperature is considered feasible and cost effective.

5. Establish BACT

The selected BACT is maintaining the lignin-rich stillage storage at ambient temperature to reduce VOC emissions. This will limit the lignin-rich stillage storage VOC emission to 0.39 lb/hr.

VIII. BACT ANALYSIS OF BIOGAS THERMAL OXIDIZER (EP-09001)

The facility design will incorporate a thermal oxidizer for control of biogas from the water treatment plant. All PSD pollutants except VOC were analyzed for BACT in previous applications; therefore, the VOC BACT is included in the *Conforming Prevention of Significant Deterioration, Air Quality Construction Permit Modification Application* dated January, 2014.

A. $PM/PM_{10}/PM_{2.5}$, NO_x, CO and SO_2 BACT Review

1. Identify Available Control Options

The following control options have been identified and considered in determining BACT:

a. Flare; and

b. Fuel Gas in Other Facility Processes.

2. Eliminate Technically Infeasible Control Options

There are no other combustion sources at the facility except for the biomass-fire boiler. Flaring is the only technically feasible option available when the vent streams cannot be vented to the boiler.

3. Evaluate Technically Feasible Control Options

Flares can be used to control almost any hydrocarbon (including VOC) laden streams and can handle fluctuations in hydrocarbon (including VOC) concentrations, flow rate, heat content, and inert content, provided that the gas has a heating value greater than 300 Btu/scf.

Flaring is appropriate for continuous, batch and variable flow vent stream application. Some streams, such as those containing halogenated or sulfur-containing compounds, are usually not flared because they corrode the flare tip or cause formation of secondary pollutants (such as acid gases or sulfur dioxide). A flare normally provides a VOC

destruction efficiency of greater than 98% and is considered technically feasible. Because flares are primarily safety devices which deal with flows of short durations (generally an upset condition or an accidental release from a process) rather than a control device which treats a continuous waste stream, it is not entirely appropriate to compare the cost effectiveness of flares to other control devices. Cost per ton of pollutant controlled largely depends upon the annual hours of operation.

Emissions from flaring include carbon particles (soot), unburned hydrocarbons, CO, and other partially burned and altered hydrocarbons. Also emitted are NO_x and, if sulfur-containing materials are flared, SO_2. The quantities of hydrocarbon emissions generated relate to the degree of combustion. The degree of combustion depends largely on the rate and extent of fuel-air mixing and on the flame temperatures achieved and maintained.

Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the exhaust gas stream. The tendency of a fuel to smoke or make soot is influenced by fuel characteristics and by the amount and distribution of oxygen in the combustion zone. For complete combustion, at least the stoichiometric amount of oxygen must be provided in the combustion zone. Complete combustion to reduce soot requires sufficient combustion air and proper mixing of air and waste gas.

EPA's RBLC database was reviewed to identify other potential control technologies that were potentially applicable to flares. The BACT control technologies included low NO_x burners, fuel sulfur content limits, and good combustion practices.

4. Establish BACT

There are no known technically feasible control options available in addition to flaring; therefore, BACT is the use of a flare.

ABBK proposes that the BACT limits for the biogas flare consist of the following:

a. Hours of operations limit to 3,960 hours per year;
b. Limit pilot fuel to natural gas;
c. Smokeless design;
d. Treatment of biogas to remove sulfur to ≤100 ppm;
e. Use of low NO_x burner; and
f. Good combustion practices.

B. VOC BACT Review

1. Identify Available Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

2. Eliminate Technically Infeasible Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for the ethanol load-out thermal oxidizer.

3. Evaluate Technically Feasible Control Options

Combustion control is the only feasible control technology so there is nothing to rank.

4. Rank Technically Feasible Options

Combustion control was selected as BACT for VOC for the thermal oxidizer. The thermal oxidizer will be able to achieve 0.14 lb/hr of VOC emissions on an on-going basis.

5. Establish BACT

The BACT emission of VOC shall be limited to 0.14 lb/hr on an on-going basis. The VOC emissions shall be controlled by good combustion practices.

C. GHG BACT Review

The facility design will incorporate a thermal oxidizer (EP-09001) for control of biogas.

The thermal oxidizer will have the PTE of GHG emissions (CO_2, CH_4, and N_2O) because it is used to combust biogas. Combustion of the biogas, natural gas in the thermal oxidizer results in the emissions of NO_x, SO_2, CO, VOC, $PM/PM_{10}/PM_{2.5}$, and GHG emissions (CO_2, CH_4, and N_2O). Flaring destroys 2,119 lb/hr CH_4 (44,503 lb/hr CO_2e), and generates 10,170 lb/hr CO_2, for a total net reduction of CO_2e equal to 34,333 lb/hr. Total CO_2e emissions from this source (including emissions from natural gas combustion in the thermal oxidizer's pilot) are 10,185 lb/hr.

1. Identify Available Control Options

The thermal oxidizer is incorporated in the process design as a type of control technology. Because the combustion of biogas in a thermal oxidizer was selected as BACT for all other NSR pollutants, there was no consideration of other combustion controls performed in this analysis. The following control options have been identified and considered in determining BACT:

a. Installation of a thermal oxidizer. There are no effective combustion controls to reduce the GHG emissions from thermal oxidizers, and there are currently no available post-combustion controls. The only achievable technological approach to reducing GHG emissions from the thermal oxidizer is to use the most efficient thermal oxidizer that meets the final design requirements.

b. Develop and implementation of an LDAR program, similar to NSPS, Subpart VVa (40 CFR §60.480a through §60.489a), and modified to be source- and pollutant-type specific.

2. Eliminate Technically Infeasible Control Options

There were two (2) options identified for control of CO_2 emissions from the thermal oxidizer: 1) low-carbon fuel; and 2) energy efficient design. These control options are technically feasible for the thermal oxidizer and are an inherent part of the facility's design.

The following discusses each of these control options.

a. Fuel Type Restriction (Low-Carbon Fuel)

The biogas thermal oxidizer will combust biogas as the primary fuel and natural gas in the pilot. Biogas has the lowest direct GHG emissions of all common fuels. [30] Natural gas is defined as a "clean fuel" under the CAA. [31] Natural gas has the lowest direct GHG emissions of all common fuels, excluding biogas. Carbon dioxide is a common impurity in natural gas which must be removed by the supplier to improve the heating value of the gas or to meet pipeline specifications. It is expected that natural gas utilized at the facility would not benefit significantly from additional pre-combustion CO_2 removal activities such as membrane or cryogenic separation. Therefore, no further analysis of natural gas treatment options will be performed.

b. Energy Efficient Design

There are numerous strategies for achieving a highly energy efficient design of a new thermal oxidizer. Design of the thermal oxidizer is dependent on the final process design of the facility. Specifically, the thermal oxidizer will be equipped with an electric igniter will be a smoke-less design.

[30] *General Reporting Protocol, Version 3.1*, supra note 39.
[31] Supra note 38.

3. Rank Technically Feasible Options

The only achievable technological approach to reducing GHG emissions from the thermal oxidizer is to use the most efficient thermal oxidizer that can perform to the specification required by the facility's process. There is no effective combustion or post-combustion controls to reduce the GHG emissions from the 51.10 MMBtu/hr thermal oxidizer.

As there are no other control technologies to choose from, no additional steps in the top-down BACT analysis are required for the selection of these control technologies as BACT.

4. Establish BACT

ABBK proposes that GHG BACT for the thermal oxidizer consist of the following:

a. Use of lower GHG-emitting processes and practices through an energy-efficient design, incorporating a fuel efficient thermal oxidizer pilot; and

b. Develop and implement a written LDAR program.

ABBK proposes that the process vents flow, biogas flow and product loadout vapors will be inferred based on flow measurements upstream of the thermal oxidizer diverting valve and diverting valve position. ABBK further proposes that the pilot natural gas usage records be based on the vendor engineering calculations for the pilot's natural gas demand. No additional natural gas monitoring at the thermal oxidizer is proposed.

These control options are technically feasible for the thermal oxidizer and are an inherent part of the facility's design

The proposed BACT limit is 10,170 pounds CO_2e per hour (20,166 short tons CO_2e per year on a 12 month rolling average).

The facility will demonstrate compliance with the BACT limit by recording fuel usage and using the emissions factors approved by KDHE to determine resulting CO_2e emissions.

IX. BACT ANALYSIS OF ETHANOL LOADOUT THERMAL OXIDIZER (EP-02100)

A change now incorporated by the *Conforming Prevention of Significant Deterioration, Air Quality Construction Permit Modification Application* dated January, 2014 is the installation of a thermal oxidizer solely dedicated to the product loadout emissions. Previous product loadout was proposed to be controlled by thermal oxidizer (EP -09001). The facility design will incorporate a thermal oxidizer (EP-02100) for combustion and control of product load-out vapors. Ethanol vapors will be collected from truck and rail load-out operations, and routed to the thermal oxidizer. The thermal oxidizer will have the

ability to operate for up to 1,500 hours per year. The thermal oxidizer will combust ethanol and natural gas (to fire a pilot), resulting in the emission of NO_x, SO_2, CO, VOC, $PM/PM_{10}/PM_{2.5}$, H_2SO_4, and GHG emissions (CO_2, CH_4, and N_2O).

A. NO_x BACT Review

1. Identify Available Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for the ethanol load-out thermal oxidizer.

2. Eliminate Technically Infeasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

3. Evaluate Technically Feasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for NO_x for the thermal oxidizer. The thermal oxidizer will be able to achieve 0.55 lb/hr of NO_x emissions on an on-going basis.

B. CO BACT Review

1. Identify Available Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for the ethanol load-out thermal oxidizer.

2. Eliminate Technically Infeasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

3. Evaluate Technically Feasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for CO for the thermal oxidizer. The thermal oxidizer will be able to achieve 1.35 lb/hr of CO emissions on an on-going basis.

C. SO_2 BACT Review

1. Identify Available Control Options

There are no add-on control technologies for controlling SO_2 emissions from a thermal oxidizer. As with the combustion turbines, using low sulfur fuel and controlling combustion is the only technologically feasible control option.

2. Eliminate Technically Infeasible Control Options

There are no add-on control technologies for controlling SO_2 emissions from a thermal oxidizer. As with the combustion turbines, using low sulfur fuel and controlling combustion is the only technologically feasible control option.

3. Evaluate Technically Feasible Control Options

There are no add-on control technologies for controlling SO_2 emissions from a thermal oxidizer. As with the combustion turbines, using low sulfur fuel and controlling combustion is the only technologically feasible control option.

4. Rank Technically Feasible Options

There are no add-on control technologies for controlling SO_2 emissions from a thermal oxidizer. As with the combustion turbines, using low sulfur fuel and controlling combustion is the only technologically feasible control option.

5. Establish BACT

BACT is use of lower sulfur fuel for the thermal oxidizer pilot and good combustion practices. This will achieve an emission rate of 1.17E-07 lb/hr SO_2 from the thermal oxidizer.

D. VOC BACT Review

1. Identify Available Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for the ethanol load-out thermal oxidizer.

2. Eliminate Technically Infeasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

3. Evaluate Technically Feasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies other than good combustion practices for this thermal oxidizer.

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for VOC for the thermal oxidizer. The thermal oxidizer will be able to achieve 7.95 lb/hr of VOC emissions on an on-going basis.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

The RBLC does not list any control strategies for the thermal oxidizer. The only add-on controls identified for significant removal of these pollutants from the thermal oxidizer's exhaust were utilizing a smokeless design.

2. Eliminate Technically Infeasible Control Options

The only technically feasible control option is smokeless design for $PM/PM_{10}/PM_{2.5}$.

3. Evaluate Technically Feasible Control Options
The only technically feasible control option is smokeless design for $PM/PM_{10}/PM_{2.5}$.

4. Rank Technically Feasible Options

There is nothing to rank since smokeless design is the only technology available.\

5. Establish BACT

Smokeless design was selected as BACT for $PM/PM_{10}/PM_{2.5}$ at an emission rate of 0.0004 lb/hr for the thermal oxidizer.

F. GHG BACT Review

1. Identify Available Control Options

There are two options identified for control of CO_2 emissions from the thermal oxidizer: 1) low-carbon fuel; and 2) energy efficient design. The baseline is fuel type restriction and incorporation of energy efficient construction and operation principles into the thermal oxidizer's design. The baseline is the top performing control options identified. The following discusses each of these control options.

2. Eliminate Technically Infeasible Control Options

There are no effective combustion controls to reduce the GHG emissions from thermal oxidizers, and there are currently no available post-combustion controls. The only achievable technological approach to reducing GHG emissions from the thermal oxidizer is to use the most efficient thermal oxidizer that meets the final design requirements.

3. Evaluate Technically Feasible Control Options

a. Fuel Type Restriction (Low-Carbon Fuel)

The thermal oxidizer will combust ethanol as the primary fuel and natural gas in the pilot. Natural gas has one of the lowest direct GHG emissions of all common fuels.

b. Energy Efficient Design

There are numerous strategies for achieving a highly energy efficient design of a new thermal oxidizer. Design of the thermal oxidizer is dependent on the final process design of the facility. Specifically, the thermal oxidizer will be equipped with an electric igniter and will utilize smoke-less design.

4. Rank Technically Feasible Options

The only achievable technological approach to reducing GHG emissions from the thermal oxidizer is to use the most efficient thermal oxidizer that can perform to the

specification required by the facility's process. There are no effective combustion or post-combustion controls to reduce the GHG emissions from the 12.0 MMBtu/hr thermal oxidizer.

5. Establish BACT

As there are no other control technologies to choose from, no additional steps in the top-down BACT analysis are required for the selection of these control technologies as BACT. Therefore, no further evaluation of this control is needed.

ABBK proposes that GHG BACT for the thermal oxidizer be the use of lower GHG-emitting processes and practices through an energy-efficient design, incorporating a fuel efficient thermal oxidizer pilot. ABBK proposes that the product load-out vapors be inferred based on flow measurements upstream of the thermal oxidizer diverting valve and diverting valve position. ABBK further proposes that the pilot natural gas usage records be based on the vendor engineering calculations for the pilot's natural gas demand. No additional natural gas monitoring at the thermal oxidizer is proposed.

These control options are technically feasible for the thermal oxidizer and are an inherent part of the facility's design.

Total CO_2e emissions from this source (including emissions from natural gas combustion in the thermal oxidizer's pilot) are 1,356 tons per year.

X. BACT ANALYSIS OF EMERGENCY FIRE PUMP DIESEL ENGINE (EP-06001)

A. NO_x BACT Review

NO_x is primarily formed in combustion processes in three ways: 1) the combination of elemental nitrogen with oxygen in the combustion air within the high temperature environment of the combustor (thermal NO_x); 2) reactions of nitrogen with hydrocarbon radicals from the fuel (prompt NO_x); and 3) the oxidation of nitrogen contained in the fuel (fuel NO_x).

The Emergency Diesel Fire Pump for the Project will be a 617 hp diesel engine. The Emergency Diesel Fire Pump will be equipped with turbo chargers which increase the volume of air in the combustion chamber.

Other control methods utilize add-on equipment to remove NO_x from the exhaust gas stream after its formation. The most common control techniques involve the injection of ammonia or urea into the gas stream to reduce the NO_x to molecular nitrogen and water. Ammonia is either injected into the engine combustion chamber (non-selective catalytic reduction [NSCR]) or injected with the use of a catalyst (selective catalytic reduction [SCR]).

1. Identify Available Control Options

For an engine that only operates 100 hours per year for testing and maintenance, there are no controls that are available that would even approach being cost effective. Potential control strategies for engines that are not limited to 100 hours per year of operation are provided in Table B-14 below.

Table B-14 Summary of Potential NO_x Control Technologies.

NO_x Technology	Evaluation Status
Good combustion design	Considered and Applied
Advanced engine design (per NSPS Subpart IIII)	Considered and Applied
Exhaust gas recirculation for NO_x reduction	Considered (Not Feasible)
Lean-NOx catalyst technology	Considered (Not Feasible)
NOx absorber technology	Considered (Not Feasible)
Oxidation catalysts	Considered (Not Feasible)
Selective catalytic reduction (SCR)	Considered (Not Feasible)
Selective non-catalytic reduction (SNCR)	Considered (Not Feasible)

2. Eliminate Technically Infeasible Control Options

The following controls identified in Table B-15 are not feasible for installation on the engine.

Table B-15 Summary of Infeasible NO_x Control Technologies.

NO_x Technology	Evaluation Status
Exhaust gas recirculation for NO_x reduction	Considered (Not Feasible)
Lean-NOx catalyst technology	Considered (Not Feasible)
NOx absorber technology	Considered (Not Feasible)
Oxidation catalysts	Considered (Not Feasible)
Selective catalytic reduction (SCR)	Considered (Not Feasible)
Selective non-catalytic reduction (SNCR)	Considered (Not Feasible)

3. Evaluate Technically Feasible Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion. Along with the purchase of an NSPS IIII certified engine, it is the only feasible control technology for a small diesel engine.

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for NO_x for the emergency fire pump; add-on controls are not practical on this small unit with limited operation and economic impacts are high. The emergency fire pump will be able to achieve 2.60 g/hp-hr of NO_x emissions on an on-going basis.

B. CO BACT Review

1. Identify Available Control Options

For an engine that only operates 100 hours per year for testing and maintenance, there are no controls that are available that would even approach being cost effective. In addition, the fuel oil that is combusted would quickly poison and/or foul an oxidation catalyst in a short amount of operating time.

2. Eliminate Technically Infeasible Control Options

For the purposes of this BACT analysis, there are no feasible control technologies on this fire pump.

3. Evaluate Technically Feasible Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for a small diesel engine.

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for CO for the emergency fire pump; add-on controls are not practical on this small unit with limited operation and economic impacts are high. The emergency fire pump will be able to achieve 0.50 g/hp-hr of CO emissions on an on-going basis.

C. SO_2 BACT Review

Steps 1-5 Identify, Rank and Select BACT

There are no add-on control technologies for controlling SO_2 emissions from a diesel fire pump. As with the natural gas generators, using low sulfur fuel and controlling combustion is the only technologically feasible control option.

BACT is use of lower sulfur fuel and good combustion practices. This will achieve an emission rate of 0.27 g/hp-hr SO_2 from the fire pump.

D. VOC BACT Review

1. Identify Available Control Options

Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion and is the only feasible control technology for a small diesel engine.

2. Eliminate Technically Infeasible Control Options

For an engine that only operates 100 hours per year for testing and maintenance, there are no controls that are available that would even approach being cost effective.

3. Evaluate Technically Feasible Control Options

For an engine that only operates 100 hours per year for testing and maintenance, there are no controls that are available that would even approach being cost effective.

4. Rank Technically Feasible Options

Combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

Combustion control was selected as BACT for VOC for the emergency fire pump; add-on controls are not practical on this small unit with limited operation and economic impacts are high. The emergency fire pump will be able to achieve 0.10 g/hp-hr of VOC emissions on an on-going basis.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

1. Identify Available Control Options

The RBLC does not list any control strategies other than good combustion practices and low ash fuel (natural gas) for the emergency fire pump. No add-on controls were identified for significant removal of these pollutants from the engine's exhaust.

2. Eliminate Technically Infeasible Control Options

The RBLC does not list any control strategies other than good combustion practices and low ash fuel (natural gas) for the emergency fire pump. No add-on controls were identified for significant removal of these pollutants from the engine's exhaust.

3. Evaluate Technically Feasible Control Options

The only technically feasible control option is combustion control for $PM/PM_{10}/PM_{2.5}$.

4. Rank Technically Feasible Options

There is nothing to rank since no add-on controls are available.

5. Establish BACT

Since no add-on controls were identified, combustion control was selected as BACT for $PM/PM_{10}/PM_{2.5}$ at an emission rate of 0.09 g/hp-hr for the emergency fire pump.

F. GHG BACT Review

1. Identify, Rank and Select BACT

The emergency diesel fire pump is proposed to be used for no more than 100 hours per year. The design of the engine is dictated by the manufacturer, not by the end-user. There are limited commercially available options, which include those engines meeting EPA Tier 3 requirements.

Consistent with its rationale for the BACT determination for greenhouse gas emissions from the combustion turbine, BACT for the emergency fire pump involves selection of the most efficient stationary emergency fire pumps that can meet the facility's needs. Total greenhouse gas emissions from the emergency fire pump are estimated at 34.43 tons CO_2e per year. These greenhouse gas emissions are also de minimis when compared to the turbine greenhouse gas emissions.

A Tier 3-certified engine is the most fuel efficient option for these purposes. Further, because emissions of greenhouse gases are directly correlated to operation of the unit, BACT requires that the engine shall only be operated for maintenance, readiness testing, and during emergencies and other periods authorized by the permitting agency and/or the permit.
Because operation of the emergency diesel fire pump will be limited by permit conditions for reliability-and maintenance related activities and ABBK will be required to keep records of the operation of the emergency fire pump and its fuel usage.

XI. BACT ANALYSIS OF TWO (2) NATURAL GAS FIRED POWER GENERATION ENGINES (EP-20010 and EP-20020)

A. NO_x BACT Review

NO_x is primarily formed in combustion processes in three ways: 1) the combination of elemental nitrogen with oxygen in the combustion air within the high temperature environment of the combustor (thermal NO_x); 2) reactions of nitrogen with hydrocarbon radicals from the fuel (prompt NO_x); and 3) the oxidation of nitrogen contained in the fuel (fuel NO_x). Natural gas contains negligible amounts of fuel-bound nitrogen, although some molecular nitrogen is present. Therefore, it is assumed that essentially all NO_x emissions from the engines originate as thermal NO_x. The rate of formation of thermal NO_x is a function of residence time and free oxygen and is exponential with peak flame temperature. NO_x control techniques are aimed at controlling one or more of these variables during combustion. Controlling the air-to-fuel ratio can reduce the amount of NO_x.[32]

The non-emergency RICE will be lean-burn, 4-stroke engines, which can also be characterized as clean-burn engines. The term "clean-burn" technology refers to engines designed to reduce NO_x by operating at high air-to-fuel ratios. The non-emergency RICE will be equipped with turbo chargers which increase the volume of air in the combustion chamber. Lean-burn engines typically have lower oxides of nitrogen (NO_x) emissions than rich-burn engines.

Other control methods utilize add-on equipment to remove NO_x from the exhaust gas stream after its formation. The most common control techniques involve the injection of ammonia or urea into the gas stream to reduce the NO_x to molecular nitrogen and water. Ammonia is either injected into the engine combustion chamber (non-selective catalytic reduction [NSCR]) or injected with the use of a catalyst (selective catalytic reduction [SCR]). NSCR may be used for rich-burn engines, but is not feasible on lean-burn engines.

1. Identify Available Control Options

a. Non-Selective Catalytic Reduction (NSCR)

NSCR uses the residual hydrocarbons and CO in the rich-burn engine exhaust as a reducing agent for NO_x. In an NSCR, hydrocarbons and CO are oxidized by O_2 and NO_x. The excess hydrocarbons, CO, and NO_x pass over a catalyst that reduces NO_x to N_2.

The NSCR technique is effectively limited to engines with normal exhaust oxygen levels of 4 percent or less. This includes four-stroke rich-burn naturally-aspirated engines and some four-stroke rich- burn turbo-charged engines. Engines operating with NSCR require tight air-to-fuel control to maintain high reduction

[32] EPA. Compilation of Air Pollutant Emission Factors, Fifth Edition. (AP-42), Section 3.2 (7/00).

effectiveness without high hydrocarbon emissions. To achieve effective NO_x reduction performance, the engine may need to be run with a richer fuel adjustment than normal. This exhaust excess oxygen level is usually closer to 1 percent.

b. Selective Catalytic Reduction (SCR)

SCR is a post-combustion technology that employs ammonia in the presence of a catalyst to convert NO_x to nitrogen and water. The function of the catalyst is to lower the activation energy of the NO_x decomposition reaction. Technical factors related to this technology include the catalyst reactor design, optimum operating temperature, sulfur content of the fuel, deactivation due to aging, ammonia slip (ammonia that is left unreacted and exits out the stack) emissions, and the design of the ammonia injection system.

SCR represents state-of-the-art controls for lean-burn four-stroke engine NO_x removal. This technology is also commonly used on natural gas-fired engines.

The temperature of the exhaust in a SCR dictates the type of catalyst that will be used. Typically, for exhaust gases on the higher end of the normal operating range (450 to 850 degrees Fahrenheit), a high-temperature catalyst such as vanadium or zeolite is required. SCRs are commercially available and have been used on engines of this size SCR is technically feasible for application to the non-emergency RICE.

c. Lean-Burn Combustion

The non-emergency RICE will be lean-burn, four-stroke engines. Lean-burn engines may operate up to the lean flame extinction limit, with exhaust oxygen levels of 12 percent or greater. The air-to-fuel ratios of lean-burn engines range from 20:1 to 50:1 and are typically higher than 24:1. The Project's non-emergency RICE lean-burn engines are also characterized as clean-burn engines. Engines operating at high air-to-fuel ratios (greater than 30:1) may require combustion modification to promote stable combustion with the high excess air. The non-emergency RICE are designed with a turbo charger which is used to force more air than non-turbo charged engines into the combustion chamber. Lean-burn engines typically have lower oxides of nitrogen (NO_x) emissions than rich-burn engines.[33]

Steady-state controlled NO_x emissions using no control or only lean-burn combustion range from 0.19 to 20.2 g/bhp-hr according to the RBLC database (Table D-1). The NO_x emissions are highly variable depending on the specific non-emergency RICE and its use. Each vendor that offers non-emergency RICE has different NO_x emission levels, even though they all may use lean-burn technology.

[33] EPA. Compilation of Air Pollutant Emission Factors, Fifth Edition. (AP-42), Section 3.2 (7/00).

Because lean-burn combustion with clean-burn technology is standard on engines like those to be used, it is a technically feasible option for the non-emergency RICE.

2. Eliminate Technically Infeasible Control Options

a. Non-Selective Catalytic Reduction (NSCR)

Lean-burn engines cannot be retrofitted with NSCR control because of the reduced exhaust temperatures. Because lean-burn engines cannot be fitted with NSCR, NSCR is not technically feasible for application to the non-emergency RICE.

3. Evaluate Technically Feasible Control Options

The next step in the top-down BACT analysis is to review each of the technically feasible control options for environmental, energy, and economic impacts. First, all technically feasible controls will be discussed for environmental and energy impacts. Next, if the top control is not chosen, an economic analysis to determine capital and annual control costs in terms of cost-effectiveness (i.e., dollars per ton of pollutant removed) of each control system will be conducted. The top control has been selected. For detailed description of this step which was done for informational purposes only, please see the *Conforming Prevention of Significant Deterioration, Air Quality Construction Permit Modification Application* dated January, 2014. for a more thorough description.

4. Rank Technically Feasible Options

Add-on controls are a technically feasible option on the non-emergency RICE. The non-emergency RICE will come as lean-burn engines, therefore, lean-burn combustion will be considered as baseline. SCR will be added as an add-on control device.

Table B-16 Ranking of Technically Feasible NO_x Control Technologies for the Non-Emergency RICE.

Control Technology	Reduction (%)	Controlled Emission Level (lb/hr)
Lean-burn combustion/ with SCR	94	0.29
Lean-burn combustion	Baseline	4.80

5. Establish BACT

SCR is BACT for natural gas-fired engines. The BACT emission limitation for NO_x is 0.29 lb/hr for steady state loads of 50 percent and higher, based on vendor guarantees. This rate is equivalent to 0.05 g/hp-hr for loads of 50 percent and higher.

B. CO BACT Review

CO results from incomplete combustion. Control of CO is typically accomplished by providing adequate fuel residence time and a high temperature in the combustion zone to ensure complete combustion. CO emissions may indicate early quenching of combustion gases on cylinder walls or valve surfaces. Lean-burn engines typically have higher CO emissions and lower NO_x emissions due to the air-to-fuel ratios at which they both operate.

CO emissions from engines are a function of oxygen availability (excess air), flame temperature, residence time at flame temperature, combustion zone design, and turbulence. Front-end control involves controlling the combustion process to suppress CO formation. Post-combustion control involves the use of catalytic oxidation.

1. Identify Available Control Options

The technologies identified for reducing CO emissions from the engines are an oxidation catalyst (also referred to as a CO catalyst) and combustion controls.

The standard technology for reducing CO emissions is to maintain "good combustion" through proper control and monitoring of the combustion process through the air-to-fuel ratio.

A survey of the RBLC database (Table D-2) indicates that combustion controls is the most prevalent BACT control, with several oxidation catalysts listed as BACT.

2. Eliminate Technically Infeasible Control Options

No control options were found to be infeasible.

3. Evaluate Technically Feasible Control Options

a. Oxidation Catalyst

Oxidation catalysts are a post-combustion technology which does not rely on the introduction of additional chemicals, such as ammonia or urea with SCR, for a reaction to occur. The oxidation of CO to CO_2 utilizes excess air present in the engine exhaust; the activation energy required for the reaction to proceed is lowered in the presence of a catalyst. Products of combustion are introduced into a catalytic bed, with the optimum temperature range for these systems being between 700°F and 1,100°F. At higher temperatures, catalyst sintering may occur, potentially causing permanent damage to the catalyst. The addition of a catalyst bed onto the engine exhaust will create a pressure drop, resulting in back pressure to the engine. This has the effect of reducing the efficiency of the engine and the power generating capabilities.

The use of oxidation catalysts is a technically feasible method for controlling CO emissions from the non-emergency RICE.

b. Combustion Control

"Good combustion practices" include operational and incinerator design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion (controlling the air-to-fuel ratio).

Good combustion practices are a technically feasible method of controlling CO emissions from the non-emergency RICE.

4. Rank Technically Feasible Options

The technical feasibility of the CO control options for the non-emergency RICE being considered are summarized in Table B-17. The expected performance has been determined considering the performance of existing systems, vendor guarantees, permitted emission limitations, and the design requirements for the engines.

Table B-17 Summary of Technically Feasible CO Control Technologies for the Non-Emergency RICE.

Control System		Expected Performance (lb/hr)	Feasibility	Comments
Combustion Control		15.69	Feasible	Standard on the RICE. Not an add-on control.
Post Combustion Controls	Oxidation Catalyst	2.73	Feasible	Produces CO_2 emissions. Add-on control device.

5. Establish BACT

Oxidation catalysts represent the highest level of control for CO. Combustion control and oxidation catalysts are BACT for the non-emergency RICE. Recent BACT determinations indicate a level of 0.1 to 4.8 g/bhp-hr for CO emissions from engines firing natural gas. The use of good combustion practices that control the amount of excess air in the flue gas along with the added control of an oxidation catalyst are the practices that can meet a CO emission limitation of 2.73 lb/hr for steady state loads of 50 to 100 percent, based on non-emergency RICE vendors guaranteed emission rate. This BACT emission limitation is equivalent to 0.50 g/hp-hr for loads of 50 percent and higher. This is the lowest-in-class emission rate that can be achieved for these types of natural gas non-emergency RICE engines.

C. SO_2 BACT Review

SO_2 emissions from natural gas combustion sources consist of several components: a) the decomposition of naturally occurring sulfur containing contaminants in natural gas (such as tetrahydrothiophene (THT), tertiary butyl mercaptan (TBM), dimethyl sulfide (DMS), and hydrogen sulfide (H_2S)), and b) mercaptans used as odorants. Therefore, units firing fuels with low sulfur content and high combustion efficiency exhibit correspondingly low SO_2 emissions.

1. Identify Available Control Options

   a. Post-combustion controls, such as wet flue gas desulfurization (FGD), spray dry absorber (SDA), or circulating dry scrubber (CDS) systems, have not been applied to commercial gas-fired engines due to their large costs per pound of SO_2 removal and extremely low sulfur concentrations of natural gas.

   b. "Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion. The use of low sulfur fuel and good combustion practices is the only feasible control technology for the non-emergency RICE.

2. Eliminate Technically Infeasible Control Options

   The use of FGDs, SDAs, or CDSs is technically infeasible and does not represent an available control technology.

3. Evaluate Technically Feasible Control Options

   In the absence of add-on controls, the most effective control method demonstrated for gas engines is the use of low sulfur fuel, such as natural gas, and combustion controls. This was confirmed by a survey of the RBLC database (Table D-4) which disclosed no add-on SO_2 control technologies for the non-emergency RICE to be used for this Project. Because proper combustion control and the firing of fuels with negligible sulfur content (such as natural gas) are the only control methods, they are BACT for the non-emergency RICE. Further control technology is not necessary or appropriate.

4. Rank Technically Feasible Options

   The use of low sulfur fuel and combustion control is the only feasible control technology so there is nothing to rank.

5. Establish BACT

The engines will be natural gas firing lean burn engines. The use of low sulfur fuels and good combustion control will limit steady state SO_2 emissions to 0.01 lb/hr, based on the guarantees from non-emergency RICE engine vendors. Therefore, the BACT emission limitation for SO_2 emissions from the non-emergency RICE is 0.01 lb/hr.

D. VOC BACT Review

VOC results from incomplete combustion. VOC emissions occur when some gas remains unburned or is only partially burned during the combustion process. With natural gas, some organics are unreacted trace constituents of the gas, while others may be products of the heavier hydrocarbon constituents. Partially burned hydrocarbons result from inadequate air-to-fuel mixing before or during combustion or inefficient air-to-fuel ratios in the cylinder during combustion due to maladjustment of the engine fuel system. Lean-burn engines typically have higher VOC emissions than rich-burn engines due to the respective air-to-fuel ratios at which they operate.

VOC emissions from engines are a function of oxygen availability (excess air), flame temperature, residence time at flame temperature, and combustion zone design. Front-end control involves controlling the combustion process to suppress unburned VOC. Post-combustion control involves the use of catalytic oxidation.

1. Identify Available Control Options

The technologies identified for reducing VOC emissions from the non-emergency RICE being considered are the same as those identified for CO control: an oxidation catalyst (also referred to as a CO catalyst) and combustion controls. The standard technology for reducing VOC emissions is to maintain “good combustion” through proper control and monitoring of the combustion process through the air-to-fuel ratio. A survey of the RBLC database (Table D-3) indicates that combustion controls is the most prevalent BACT control with several oxidation catalysts listed as BACT for VOC.

a. Oxidation Catalyst

Oxidation catalyst is a post-combustion technology that does not rely on the introduction of additional chemicals, such as ammonia or urea with SCR, for a reaction to occur. See Section 6.5.2.1 for a discussion oxidation catalyst process.

The use of oxidation catalysts for VOC control is a technically feasible method for controlling VOC emissions from the non-emergency RICE.

b. Combustion Control

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion (controlling the air-to-fuel ratio). Such control practices applied to the Project's non-emergency RICE can achieve VOC emission levels of 2.18 lb/hr without an oxidation catalyst.

Good combustion practices are a technically feasible method of controlling VOC emissions from the non-emergency RICE.
Summary of the Technically Feasible Control Options

2. Eliminate Technically Infeasible Control Options

No control options are infeasible.

3. Evaluate Technically Feasible Control Options

The top control has been selected. For detailed description of this step which was done for informational purposes only, please see the *Conforming Prevention of Significant Deterioration, Air Quality Construction Permit Modification Application* dated January, 2014 for a more thorough description.

The expected performance has been determined considering the performance of existing systems, vendor guarantees, permitted emission limitations, and the design requirements for the engines and is outlined in Table B-18.

Table B-18 Summary of Technically Feasible VOC Control Technologies for the Non-Emergency RICE.

Control System		Expected Performance (lb/hr)	Feasibility	Comments
Combustion Control		2.18	Feasible	Standard on the RICE. Not an add-on control.
Post Combustion Controls	Oxidation Catalyst	1.36	Feasible	Standard on the non-emergency RICE.

4. Rank Technically Feasible Options

The technically feasible VOC control technologies for the non-emergency RICE are ranked by control effectiveness in B-19.

Table B-19 Ranking of Technically Feasible VOC Control Technologies for the Non-Emergency RICE.

Control Technology	Reduction (%)	Controlled Emission Level (lb/hr)
Oxidation Catalyst	37.5	1.36
Combustion Control	Not applicable (baseline)	2.18

5. Establish BACT

With the good combustion controls and oxidation catalysts, these engines will achieve VOC emission rates of 1.36 lb/hr at loads of 50 percent and higher (which is equivalent to 0.25 g/bhp-hr at full load).

The use of good combustion practices that control the amount of excess air in the flue gas along with the added control of an oxidation catalyst will meet a VOC emission limitation of 1.36 lb/hr for steady state operation, based on non-emergency RICE vendors guaranteed emission rate.

This BACT emission limitation is equivalent to 0.25 g/hp-hr for loads of 50 percent and higher. This is the lowest-in-class emission rate that can be achieved for these types of natural gas non-emergency RICE EGUs.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

$PM/PM_{10}/PM_{2.5}$ emissions from natural gas combustion sources consist of several components: a) inert contaminants in natural gas; b) sulfates from fuel sulfur or mercaptans used as odorants, c) dust drawn in from the ambient air, and d) particulate of carbon and hydrocarbons resulting from incomplete combustion.

Therefore, units firing fuels with low ash content and high combustion efficiency exhibit correspondingly low particulate emissions.

1. Identify Available Control Options

Because of their extremely low particulate concentrations and resulting large costs per ton of particulate matter removed, post-combustion controls, such as electrostatic precipitators (ESPs) or baghouses, have not been applied to commercial gas-fired engines.

In the absence of add-on controls, the most effective control method demonstrated for gas engines is the use of low ash fuel, such as natural gas, and combustion controls.

2. Eliminate Technically Infeasible Control Options

The use of ESPs and baghouse filters are both technically infeasible and do not represent an available control technology.

3. Evaluate Technically Feasible Control Options

"Good combustion practices" include operational and design elements to control the amount and distribution of excess air in the flue gas to ensure that there is enough oxygen present for complete combustion. The use of low ash fuel and good combustion practices is the only feasible control technology for the non-emergency RICE. The use of low ash fuels and good combustion control will limit steady state $PM/PM_{10}/PM_{2.5}$ emissions to 0.16 lb/hr, based on the guarantees from non-emergency RICE engine vendors.

4. Rank Technically Feasible Options

The use of low ash fuel and combustion control is the only feasible control technology so there is nothing to rank

5. Establish BACT

Therefore, the use of low ash fuel and combustion control is BACT. The BACT emission limitation for $PM/PM_{10}/PM_{2.5}$ emissions from the non-emergency RICE is 0.16 lb/hr. This limitation includes both filterable and condensable $PM/PM_{10}/PM_{2.5}$ emissions.

F. GHG BACT Review

CO_2 is an inherent product of the chemical reaction between the fuel and oxygen in which it burns. As such, the only way to reduce the amount of CO_2 generated by a fuel-burning power plant is to design and operate it through the use of the most efficient generating technologies for the anticipated load requirement.
Emissions of CO_2 during fossil fueled combustion are strongly correlated to the amount of carbon in the fuel stream. As stated above, a fundamental objective of the Project is to utilize pipeline quality natural gas. Thus, specification of any other fuel would take away a Project objective. That said, in comparison to all other potential fuels, natural gas will achieve the lowest emissions of CO_2 and other GHG. Natural gas combustion produces only about half as much CO_2 as coal and substantially less emissions of both criteria and toxic air pollutants.

1. Identify and Eliminate Technically Infeasible Available Control Options

Table B-20 summarizes the potentially available control technologies for GHG and those that have been eliminated and/or included for consideration as BACT for the project.

Table B-20 Summary of Potential GHG Control Technologies.

GHG Technology	Evaluation Status
Add-on GHG controls	Considered (Not Feasible)
Good combustion design	Considered and Applied
VOLUNTARY CONSIDERATIONS	
Inherently lower-emitting GHG processes, practices, or designs	Considered and Applied
Renewable energy technology (solar or wind)	Considered (Not Feasible)
Alternative generating technologies	Considered (Not Feasible)
Alternative fuels	Considered (Not Feasible)
Energy efficiency	Considered and Applied
Carbon capture and sequestration (CCS)	Considered (Not Feasible)

2. Evaluate Technically Feasible Control Options

At the present time, combined cycle plants utilizing efficient turbines, HRSGs, and clean fuels represent the highest efficiencies with respect to fuel burned versus power produced for large scale, firm base load, and moderate cycling power resources. However, because a 500-700 MW combined cycle plant does not meet the design objectives (quick start and stop, up to 9.4 MW, low water use for cooling, partial and full load operation) and the site space, fuel and electric interconnection limitations, a combined cycle plant does not meet the objectives.

Fast-start capabilities are currently only available for much larger turbines than would be needed to meet the proposed capacity of up to 9.4 MW. Operation of a larger turbine at only a fraction of its capacity would result in significant losses in efficiency, such that the efficiency of the combined-cycle plant would likely be even less than a smaller simple-cycle plant. Further, although once-through steam generators (OTSG) might be used in-lieu-of conventional HSRG technology, the addition of a steam cycle to a plant only intended only for economic dispatch generation likely would provide only marginal-to-no-efficiency gains, in comparison to a simple-cycle operation. Thus, for an economic dispatch plant that will undergo multiple daily start-ups, the steam cycle would likely provide no to marginal benefit while not meeting the objectives regarding fast start and cycling capability.

3. Rank Technically Feasible Options

Table B-21 presents the ranking of the GHG technologies deemed feasible for the Project. While these three technologies are "ranked" in order of their presentation, they are more appropriately considered as a suite of measures that will be implemented to assure that the Project generates and consumes power in the most efficient manner and thereby achieves BACT for GHGs.

Table B-21 GHG Technology Ranking for the Project.

Technology	Ranking	Applied to Project
Reciprocating Engines (employing state-of-the-art design)	1	Yes
Clean Fuels	2	Yes
Energy Efficiency/Operational Design	3	Yes

4. Establish BACT

For the purposes of this BACT analysis, ABBK has determined that a CO_2e emission limitation of 2,489.7 lb/hr is BACT for the non-emergency RICE.

The following is BACT for GHG emissions from the non-emergency RICE:

a. Use of lean-burn, four-stroke, internal combustion engine generating technology to generate up to 9.4 MW while maximizing the greatest amount of "economic dispatch" power from each unit of fuel combusted;

b. Use of natural gas as the only fuel in the non-emergency RICE; and

c. The BACT emissions of CO_2e for each engine are limited to 10,905 tons (2,489.7 lb/hr) per any consecutive 12 month period. This includes the GHG individual BACT limits as follows:

   i. The BACT emissions of CO_2 for each engine are limited to 8,192.64 tons (1,870.47 lb/hr) per any consecutive 12 month period.

   ii. The BACT emissions of CH_4 for each engine are limited to 108 tons (24.7 lb/hr) per any consecutive 12 month period.

   iii. The BACT emissions of N_2O for each engine are limited to 0.015 tons (0.0035 lb/hr) per any consecutive 12 month period.

XII. BACT ANALYSIS OF TWO (2) NATURAL GAS FIRED EMERGENCY POWER GENERATION ENGINES (EP-20030 and EP-20040)

A. NO_x BACT Review

NO_x is primarily formed in combustion processes in three ways: 1) the combination of elemental nitrogen with oxygen in the combustion air within the high temperature environment of the combustor (thermal NO_x); 2) reactions of nitrogen with hydrocarbon radicals from the fuel (prompt NO_x); and 3) the oxidation of nitrogen contained in the fuel (fuel NO_x). Natural gas contains negligible amounts of fuel-bound nitrogen, although some molecular nitrogen is present. Therefore, it is assumed that essentially all NO_x emissions from the engines originate as thermal NO_x. The rate of formation of thermal NO_x is a function of residence time and free oxygen and is exponential with peak flame temperature. NO_x control techniques are aimed at controlling one or more of these variables during combustion. Controlling the air-to-fuel ratio can reduce the amount of NO_x.

The emergency RICE will be lean-burn, 4-stroke engines, which can also be characterized as clean-burn engines. The term "clean-burn" technology refers to engines designed to reduce NO_x by operating at high air-to-fuel ratios. The non-emergency RICE will be equipped with turbo chargers which increase the volume of air in the combustion chamber. Lean-burn engines typically have lower oxides of nitrogen (NO_x) emissions than rich-burn engines.

Other control methods utilize add-on equipment to remove NO_x from the exhaust gas stream after its formation. The most common control techniques involve the injection of ammonia or urea into the gas stream to reduce the NO_x to molecular nitrogen and water. Ammonia is either injected into the engine combustion chamber (non-selective catalytic reduction [NSCR]) or injected with the use of a catalyst (selective catalytic reduction [SCR]). NSCR may be used for rich-burn engines, but is not feasible on lean-burn engines.

1. Identify, Eliminate, Evaluate, Rank Available Control Options

Two types of NO_x control techniques have been identified as possible controls to the Cummins Power Generation Engines:

- Selective Catalytic Reduction (SCR)
- Three-Way Catalyst (reduces NO_x, CO and VOCs)

The three-way catalyst is not feasible on the oxygen-rich exhaust from a lean-burn engine.

SCR has been demonstrated in the ABBK BACT analysis to be too expensive for an emergency service engine.

Vendor specifications for the Cummins Power Generation model C1750 N6C Natural Gas Reciprocating Engine have shown that the proposed low-emission lean burn engine will reduce NO_x emissions to 0.29 lb/hr (0.05 g/hp-hr).

2. Establish BACT

Burning only natural gas in a low-emission lean-burn RICE and good combustion practice are BACT for NO_x for the Cummins Power Generation Engines. BACT emission limitation for NO_x per engine is 0.88 g/hp-hr, including periods of startup, shutdown, and malfunction.

B. CO BACT Review

CO results from incomplete combustion. Control of CO is typically accomplished by providing adequate fuel residence time and a high temperature in the combustion zone to ensure complete combustion. CO emissions may indicate early quenching of combustion gases on cylinder walls or valve surfaces. Lean-burn engines typically have higher CO emissions and lower NO_x emissions due to the air-to-fuel ratios at which they both operate.

CO emissions from engines are a function of oxygen availability (excess air), flame temperature, residence time at flame temperature, combustion zone design, and turbulence. Front-end control involves controlling the combustion process to suppress CO formation. Post-combustion control involves the use of catalytic oxidation.

1. Identify, Eliminate, Evaluate, Rank Available Control Options

Two types of CO control techniques have been identified as possible controls to the Cummins Power Generation Engines:

- Three-Way Catalyst (reduces NO_x, CO and VOCs)
- Oxidation Catalyst

The three-way catalyst is not feasible on the oxygen-rich exhaust from a lean-burn engine.

Oxidation catalyst has been demonstrated in the ABBK BACT analysis to be too expensive for an emergency service engine.

2. Establish BACT

Therefore, burning only natural gas and good combustion practice is BACT for CO for the Cummins Power Generation Engines. BACT emission limitation for CO per engine is 2.88 g/bhp-hr, including periods of startup, shutdown, and malfunction.

C. VOC BACT Review

VOC results from incomplete combustion. VOC emissions occur when some gas remains unburned or is only partially burned during the combustion process. With natural gas, some organics are unreacted trace constituents of the gas, while others may be products of the heavier hydrocarbon constituents. Partially burned hydrocarbons result from inadequate air-to-fuel mixing before or during combustion or inefficient air-to-fuel ratios in the cylinder during combustion due to maladjustment of the engine fuel system. Lean-burn engines typically have higher VOC emissions than rich-burn engines due to the respective air-to-fuel ratios at which they operate.

VOC emissions from engines are a function of oxygen availability (excess air), flame temperature, residence time at flame temperature, and combustion zone design. Front-end control involves controlling the combustion process to suppress unburned VOC. Post-combustion control involves the use of catalytic oxidation.

1. Identify, Eliminate, Evaluate, Rank Available Control Options Available Control Options

   One type of VOC control technique has been identified as applicable to the Cummins Power Generation Engines:

   - Three-Way Catalyst (reduces NO_x, CO and VOCs)

   The three-way catalyst is not feasible on the oxygen-rich exhaust from a lean-burn engine.

2. Establish BACT

   Therefore, burning only natural gas and good combustion practices are BACT for VOC for the Cummins Power Generation Engines. BACT emission limitation for VOC per engine is 0.40 g/hp-hr, including periods of startup, shutdown, and malfunction.

D. SO_2 BACT Review

SO_2 emissions from natural gas combustion sources consist of several components: a) the decomposition of naturally occurring sulfur containing contaminants in natural gas (such as tetrahydrothiophene (THT), tertiary butyl mercaptan (TBM), dimethyl sulfide (DMS), and hydrogen sulfide (H_2S)), and b) mercaptans used as odorants. Therefore, units firing fuels with low sulfur content and high combustion efficiency exhibit correspondingly low SO_2 emissions.

1. Identify, Eliminate, Evaluate and Rank Available Control Options Available Control Options

   Inherently low emissions of SO_2 result from natural gas combustion in lean-burn engines.

2. Establish BACT

Therefore, burning only natural gas in a lean-burn RICE and good combustion practice is BACT for SO_2 for the Cummins Power Generation Engines. BACT emission limitation for SO_2 per engine is 0.01 lb/hr including periods of startup, shutdown, and malfunction.

E. $PM/PM_{10}/PM_{2.5}$ BACT Review

$PM/PM_{10}/PM_{2.5}$ emissions from natural gas combustion sources consist of several components: a) inert contaminants in natural gas; b) sulfates from fuel sulfur or mercaptans used as odorants, c) dust drawn in from the ambient air, and d) particulate of carbon and hydrocarbons resulting from incomplete combustion.

Therefore, units firing fuels with low ash content and high combustion efficiency exhibit correspondingly low particulate emissions.

1. Identify, Eliminate, Evaluate, and Rank Available Control Options

Inherently low emissions of $PM/PM_{10}/PM_{2.5}$ result from natural gas combustion due to high combustion efficiencies and the clean-burning nature of natural gas.

2. Establish BACT

Therefore, burning only natural gas in a lean-burn RICE and good combustion practice is BACT for $PM/PM_{10}/PM_{2.5}$ for the Cummins Power Generation Engines. BACT emission limitation for $PM/PM_{10}/PM_{2.5}$ per engine is 0.16 lb/hr including periods of startup, shutdown, and malfunction.

F. GHG BACT Review

CO_2 is an inherent product of the chemical reaction between the fuel and oxygen in which it burns. As such, the only way to reduce the amount of CO_2 generated by a fuel-burning power plant is to design and operate it through the use of the most efficient generating technologies for the anticipated load requirement.
Emissions of CO_2 during fossil fueled combustion are strongly correlated to the amount of carbon in the fuel stream. As stated above, a fundamental objective of the Project is to utilize pipeline quality natural gas. Thus, specification of any other fuel would take away a Project objective. That said, in comparison to all other potential fuels, natural gas will achieve the lowest emissions of CO_2 and other GHG. Natural gas combustion produces only about half as much CO_2 as coal and substantially less emissions of both criteria and toxic air pollutants.

1. Identify Available Control Options

Four types of control techniques have been identified as applicable to the combustion reciprocating engines:

- Carbon Capture and Sequestration/Storage (CCS)
- Selecting higher energy efficient engine generators
- Efficient process controls and practices
- Low carbon fuel selection

2. Eliminate, Evaluate and Rank Available Control Options

a. CCS

Carbon Capture and Sequestration/Storage (CCS) is the only potential add-on technology available and incorporates capturing CO_2 emissions, transporting the CO_2, generally via pipeline, and injecting the CO_2 into subsurface geological formations.

A cost analysis was performed for the September 16, 2011 PSD construction permit and the total capital cost for capture technology was cost prohibitive and therefore CCS was economically infeasible for use at the ABBK facility.

b. Selecting higher energy efficient engine generators; Efficient process controls and practices; and Low carbon fuel selection

ABBK is proposing to install two (2) Cummins Power Generation model C1750 N6C reciprocating IC engines for emergency electricity generation. These units were chosen for their generator efficiency, output power and reliability. These units will be maintained using good combustion practices and manufacturer recommended maintenance in order to promote combustion efficiency and engine life and will burn only pipeline quality natural gas to minimize the combustion of hydrocarbons. Therefore, firing pipeline quality natural gas, good combustion practices and efficient process controls and practices is BACT for the Cummins Power Generation engines.

3. Establish BACT

The BACT GHG Emission rates for each Cummins Power Generation Natural Gas Reciprocating Engine Generator Set are:

The BACT emissions of CO_2e for each engine are limited to 124.48 tons (2,489.7 lb/hr) per any consecutive 12 month period. This includes the GHG individual BACT limits as follows:

a. The BACT emissions of CO_2 for each engine are limited to 93.52 tons (1,870 lb/hr) per any consecutive 12 month period.

b. The BACT emissions of CH_4 for each engine are limited to 1.2 tons (24.73 lb/hr) per any consecutive 12 month period.

c. The BACT emissions of N_2O for each engine are limited to 0.0002 tons (0.0035 lb/hr) per any consecutive 12 month period.

XIII. BACT ANALYSIS OF PLANT HAUL ROADS (EP-01000FUG AND EP-01050FUG)

Abengoa Bioenergy will construct paved in-plant haul roads for delivery of biomass and other raw materials such as denaturant and process chemicals; as well as for shipment of products and by-products.

Abengoa Bioenergy plans to pave all in-plant haul roads associated with the ethanol production plant; therefore, only mitigation control measures applicable to paved roads are addressed in this BACT.

A. $PM/PM_{10}/PM_{2.5}$ BACT Review

Particulate emissions occur whenever vehicles travel over a paved surface, such as public and industrial roads and parking lots.

1. Identify Available Control Options

The following control options are best management practices (BMPs) that have been identified and considered in determining BACT for the in-plant haul roads:

a. Posting and limiting vehicle speeds;

b. Use of wind fences or other wind breaks;

c. Water spray/road washing;

d. Chemical stabilization;

e. Sweeping; and

f. Combination of the controls identified above.

2. Eliminate Technically Infeasible Control Options

The above listed BMPs are all technically feasible and can be implemented at the site to mitigate particulate emissions.

3. Evaluate and Rank Technically Feasible Control Options

The combination of paved roads with wet suppression followed by vacuuming and/or sweeping represents the most effective control option for fugitive emissions. Control efficiencies of up to 95% can be achieved with frequent application. The second most effective control option is the combination of paved roads and either wet suppression or sweeping.

Control efficiencies for water flushing and sweeping are highly variable and dependent on application rates and frequency. In general, reported control efficiencies for both approaches fall into a range of 25% to 58% compared to a baseline of paved roads without mitigative controls. The control efficiency of water flushing with a high application rate and frequency may be higher than with sweeping alone. However, in comparison to sweeping, water flushing has several potential drawbacks, including high water usage, potential water pollution and the frequent need for the water truck to return to a water source, generating increased vehicle tailpipe emissions.

EPA's RBLC database was reviewed to identify PM/PM_{10} control technologies that were potentially applicable to paved in-plant haul roads.

According to EPA's RBLC database, paved in-plant haul roads with fugitive dust controls such as daily sweeping and/or washing is ranked as the top control and has been established as BACT technology for in-plant haul roads.

4. Establish BACT

Abengoa Bioenergy proposes that BACT for the in-plant haul roads consist of the following:

a. Paving of all in-plant haul roads;
b. Post and enforce a maximum speed limit of 15 mph;
c. Develop, maintain and implement a fugitive control strategy and monitoring plan;
d. No visible emissions beyond property boundary.

ABBK proposes that the paved in-plant haul road BACT limit be based on a truck traffic limit calculated using a 7-day rolling average and visibility monitored to ensure there are no visible emissions beyond the property boundary. Further, a Fugitive Dust Control Plan will be developed and will detail the work practices to be implemented to reduce fugitive emissions from the unpaved biomass laydown roads and unpaved staging area. ABBK will also provide a copy of the Fugitive Dust Control Plan and associated documentation to KDHE upon request to demonstrate compliance with BACT.

XIV. BACT ANALYSIS OF FACILITY BERM (EP-10002)

A berm is proposed to be built around the existing facility with by products from the biomass-to-ethanol and biomass-to-energy production facility.

A. $PM/PM_{10}/PM_{2.5}$ BACT Review

The dirt and sand removed from the biomass before it is processed along with a small amount of fly ash will be used to construct the berm. Wind erosion will be the cause of potential particulate matter emissions.

1. Identify Available Control Options

The RBLC database was queried for fugitive dust sources, which includes agriculture activities, ash storage/handling/disposal, construction activities, paved roads, unpaved roads, and other fugitive dust sources. A second query was run for biomass to ensure that all possible control strategies were identified.

Possible control strategies are as follows:

- Fabric filter/bin vent filter
- Best operating practices
- Enclosure/wind screens
- Water spray/ wet suppression

2. Eliminate Technically Infeasible Control Options

Due to the nature of the berm, it will be a fugitive source. The berm will be constructed around the perimeter of the facility with only a small portion open to wind erosion at any given time. As such, it is not possible to capture emissions and route them to a fabric filter or bin vent filter. Likewise, the large and mobile nature of the berm construction will not allow enclosure or wind screens to be constructed since the open portion of the berm will be continuously moving around the perimeter of the facility. Therefore, fabric filter/bin vent filter and enclosure/wind screens are not technically feasible control options. All other options will be evaluated further.

3. Evaluate Technically Feasible Control Options

Both wet suppression and best operating practices are technically feasible and considered to be equally effective for purposes of this BACT analysis. A moisture content of at least 20% will be maintained in the berm during its construction. Additional moisture will be added as needed to reduce fugitive dust. The developed portions of the berm will be permanently sealed through compaction and planting of grasses to reduce particulate emissions to a negligible amount. A Fugitive Dust Management Plan, similar to that already required for the in-plant haul roads, will be developed for the berm and serve as best operating practices for the control of fugitive dust.

4. Rank Technically Feasible Options

The degree of control for water spray/wet suppression is dependent on the level of moisture maintained in the berm construction material. The RBLC entries do not specify the level of moisture maintained in the comparable facilities' operations. Likewise, the RBLC entries do not specify a control percentage from the implementation of best operating practices.

5. Establish BACT

Therefore, both wet suppression and best operating practices will be considered equally effective for purposes of this BACT analysis.

XV. BACT ANALYSIS OF SYNTHETIC ORGANIC CHEMICAL MANUFACTURING INDUSTRY EQUIPMENT (EP-02000) AND LOADING LOSSES (EP-02100FUG)

A. VOC BACT Review

The facility design will incorporate the loading and transport of ethanol within the plant. VOC emissions will be the result of fugitive leaks (EP-02000) and loading losses (EP-02100FUG) not captured by the Vapor Recovery System.

1. Identify Available Control Options

The potential strategies for control of VOC emissions from fugitives are best management practices and the development of a leak detection and repair (LDAR) program. The results of the database search from January 1, 2003 to present further show that the development and implementation of an LDAR program is considered BACT in many cases, as shown in Table D-13 (Appendix D). Because of the fugitive nature of this emission source and the sheer numbers of components (pumps, valves, flanges, etc.) in VOC service in a biomass to ethanol production facility, it would not be practical or cost effective to capture and control these emissions.

2. Evaluate Technically Feasible Control Options

The most practical method of controlling VOC emissions is to promptly repair any leaking components. Therefore, the development of an LDAR program is the only feasible control technology.

3. Eliminate Infeasible Control Options and Rank Technically Feasible Options

The development of an LDAR program along with the use of best management practices is the only feasible control technology, so there is nothing to rank.

4. Establish BACT

Therefore, the development and implementation of an LDAR program similar to NSPS, Subpart VVa (40 CFR Section 60.480a through Section 60.489a), and modified to be source- and pollutant-type specific and use of best management practices were selected as BACT for VOC for both the fugitive leaks and loading losses.

XVI. BACT ANALYSIS OF ORGANIC LIQUID AND CHEMICAL STORAGE TANKS (T-02101, T-02108, T-02109, T-02102, T-02105, T-02112)

The facility will include two ethanol product shift tanks (T-02101 and T-02108), two ethanol product storage tanks (T-02102 and T-02112), and one denaturant storage tank (T-02105) that will emit VOC as a result of changes in the liquid level and the outside temperature/pressure.

A. VOC BACT Review

Emissions resulting from changes to the liquid level are known as working losses and emissions resulting from the evaporation of the stored liquid are known as standing loses.

Working losses will occur during filling and emptying of the tanks. The rising liquid level during filling forces air saturated with VOC vapors to be expelled from the tank to maintain the tank pressure. During emptying of the tank, outside air replaces the liquid in the tank. As this air becomes saturated with VOC vapors, it expands and a portion of the air is expelled to maintain constant pressure in the tank. Standing losses are due to changes in the outside temperature and pressure, which create a pressure differential between the atmosphere and the tank vapor space, forcing VOC saturated vapors to be expelled from the tank.

- Ethanol product shift tank (T-02101) 41,000 gallons
- Ethanol product shift tank (T-02108) 41,000 gallons
- Ethanol product storage tank (T-02102) 528,600 gallons
- Ethanol product storage tank (T-02112) 528,600 gallons
- Denaturant storage tank (T-02105) 22,500 gallons

1. Identify Available Control Options

Based on fixed and floating roof tank information and the results of the RBLC database search from January 1, 2003 to present shown in Table D-11 (Appendix D of the January 2014), the most common BACT control is use of an internal floating roof. The two viable options for controlling tank emissions are fixed roof and internal floating roof tanks (an external floating roof could also be used, but generally this is not done). Both options are technically feasible.

2. Rank and Evaluate Technically Feasible Control Options

The most effective option is an internal floating roof, which can achieve 68 – 98% control. An internal floating roof would reduce emissions to an estimated 301 lb/year of VOC for each shift tank, 431 lb/year of VOC for each storage tank, and 2,534 lb/year of VOC for the denaturant tank. Thus, the internal floating roof is the most effective option. There is no NSPS to establish a BACT floor above the fixed roof level of control, but ABBK has selected the floating roof to achieve the highest level of VOC emissions control.

3. Establish BACT

BACT will be the use of an internal floating roof which will control emissions to the following levels:

- Ethanol product shift tank T-02101: 301 lb/hr
- Ethanol product shift tank T-02108: 301 lb/hr
- Ethanol product storage tank T-02102: 431 lb/hr
- Ethanol product storage tank T-02112: 431 lb/hr
- Denaturant storage tank T-02105: 3,534 lb/hr