

4. BACT ANALYSES

This section of the application includes the analyses for the Best Available Control Technology (BACT). The emission sources at the proposed Princeton Road Station (PRS) are subject to PSD permitting for NO_x, CO, VOC, SO₂, PM, PM₁₀, PM_{2.5}, H₂SO₄, and greenhouse gases (CO₂, CH₄, and N₂O), and thus, the emission sources are subject to BACT for these pollutants. This section summarizes the BACT analyses and the final BACT determinations for the following:

1. Combustion Turbines – the BACT analyses cover the CTs operating on both natural gas and fuel oil and operating in both simple and combined cycle mode. Note, for NO_x, CO, and VOC, the CTs will operate with pollution control devices, and NPPD is proposing both primary BACT determinations that apply during steady state operation of the devices as well as a secondary BACT determinations that apply during the startup and shutdown of the control devices.
2. Reciprocating Internal Combustion Engines EGUs – the BACT analyses cover the RICE operating on both natural gas and fuel oil. Note, for NO_x, CO, and VOC, similar to the CTs, the RICE will operate with pollution control devices, and NPPD is proposing both primary BACT determinations that apply during steady state operation of the devices as well as a secondary BACT determinations that apply during the startup and shutdown of the control devices.
3. Auxiliary Boiler – the BACT analyses cover the natural gas fired boiler.
4. Natural Gas Dew Point Heaters – the BACT analyses cover the natural gas fired heaters.
5. Emergency Equipment – the BACT analyses cover the diesel-fired emergency generators and the fire pump.
6. Fuel Oil Storage Tanks – the BACT analyses cover the fuel storage tanks.

With respect to PM₁₀ and PM_{2.5}, since these pollutants include both filterable and condensable forms of particulate, the BACT analyses for PM₁₀ and PM_{2.5} cover both forms. Ultimately, the BACT limits for PM₁₀ and PM_{2.5} are proposed as limits for total PM₁₀ and total PM_{2.5}, inclusive of both filterable and condensable forms.

The following tables summarize the proposed BACT determinations, including the proposed technology, emission limits, operating practices, averaging periods, and compliance methods, as applicable:

- ▶ Table 4-1. Summary of Proposed BACT – Combustion Turbine (Siemens SGT6-5000F),
- ▶ Table 4-2. Summary of Proposed BACT – RICE (Wartsila 18V50DF),
- ▶ Table 4-3. Summary of Proposed BACT – Auxiliary Boiler,
- ▶ Table 4-4. Summary of Proposed BACT – Natural Gas Heaters,
- ▶ Table 4-5. Summary of Proposed BACT – Emergency Equipment, and
- ▶ Table 4-6. Summary of Proposed BACT – Diesel Storage Tanks.

The full BACT analyses are provided following the BACT summary tables.

Table 4-1. Summary of Proposed BACT Limits – Combustion Turbine (Siemens SGT6-5000F)

Pollutant	Fuel	BACT	Type of Standard	Emission Limit/Operating Practice	Compliance Method
NO_x	NG	SCR, DLN, and Good Combustion, Operation, and Maintenance Practices	Primary Standard - Simple Cycle	3 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	CEMS, See definition of startup in table notes
			Startup - Simple Cycle	SU – 61.0 lb/event	
			Shutdown – Simple Cycle	SD – 18.0 lb/event	
			Primary Standard - Combined Cycle	2.0 ppm _{vd} @15% O ₂ , on a 30-day rolling average basis, excludes periods of SU/SD	
			Startup - Combined Cycle	SU – 123.9 lb/event	
			Shutdown – Combined Cycle	SD – 16.0 lb/event	
CO	ULSD	SCR, water or steam injection, and Good Combustion, Operation, and Maintenance Practices	Primary Standard - Simple Cycle	6.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	CEMS, See definition of startup in table notes
			Startup - Simple Cycle	SU – 147.8 lb/event	
			Shutdown – Simple Cycle	SD – 29.0 lb/event	
			Primary Standard - Combined Cycle	5.0 ppm _{vd} @15% O ₂ , on a 30-day rolling average basis, excludes periods of SU/SD	
			Startup - Combined Cycle	SU – 209.2 lb/event	
			Shutdown – Combined Cycle	SD – 42.0 lb/event	
CO	NG	OC and Good Combustion, Operation, and Maintenance Practices	Primary Standard - Simple Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	CEMS, See definition of startup in table notes
			Startup - Simple Cycle	SU - 843.1 lb/event	
			Shutdown – Simple Cycle	SD – 173.2 lb/event	
			Primary Standard - Combined Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	
			Startup - Combined Cycle	SU – 825.1 lb/event	
			Shutdown – Combined Cycle	SD – 84.65 lb/event	

Pollutant	Fuel	BACT	Type of Standard	Emission Limit/Operating Practice	Compliance Method	
VOC	ULSD	OC and Good Combustion, Operation, and Maintenance Practices	Primary Standard - Simple Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	CEMS, See definition of startup in table notes	
			Startup - Simple Cycle	SU – 2,480.3 lb/event		
			Shutdown – Simple Cycle	SD – 180.7 lb/event		
			Primary Standard - Combined Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD		
			Startup - Combined Cycle	SU - 1,638.4 lb/event		
			Shutdown – Combined Cycle	SD – 180.8 lb/event		
	NG	OC and Good Combustion, Operation, and Maintenance Practices	Primary Standard - Simple Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD	Performance Test / Manufacturer Data	
			Primary Standard - Combined Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD		
			Primary Standard - Simple Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD		
			Primary Standard - Combined Cycle	2.0 ppm _{vd} @15% O ₂ , on a 4-hour rolling average basis, excludes periods of SU/SD		
			Startup - Combined Cycle	SU – 242.4 lb/event		
			Shutdown – Combined Cycle	SD – 68.53 lb/event		
SO ₂	NG	Natural gas (<2 gr S/100 scf NG)	Simple Cycle	Natural gas (< 2 gr S/100 scf NG, annual average)	Fuel records	
			Combined Cycle			
	ULSD	Ultra Low Sulfur Diesel (< 15 ppm S)	Simple Cycle	Ultra Low Sulfur Diesel (< 15 ppm S)	Fuel records	
			Combined Cycle			
	NG			Simple Cycle	100% Load: 0.0055 lb/MMBtu	

Pollutant	Fuel	BACT	Type of Standard	Emission Limit/Operating Practice	Compliance Method
PM, PM ₁₀ , and PM _{2.5}		Natural gas (< 2 gr S/100 scf NG)	Combined Cycle	100% Load: 0.0063 lb/MMBtu	Performance Testing
	ULSD	Ultra Low Sulfur Diesel (< 15 ppm S)	Simple Cycle	100% Load: 0.0320 lb/MMBtu	Performance Testing
			Combined Cycle	100% Load: 0.0314 lb/MMBtu	
H ₂ SO ₄	NG	Natural gas (< 2 gr S/100 scf NG)	Simple Cycle	Natural gas	Fuel records
			Combined Cycle	(< 2 gr S/100 scf NG, annual average)	
GHG (CO ₂)	ULSD	Ultra Low Sulfur Diesel (< 15 ppm S)	Simple Cycle	Ultra Low Sulfur Diesel (< 15 ppm S)	Fuel records
			Combined Cycle		
	NG	Efficient Turbine Design and Operation and Good Combustion, Operation, and Maintenance Practices	Simple Cycle	1,300 lb CO ₂ /MWh gross, on a 12-mo rolling average basis	Part 75, Appendix G
				1000 lb CO ₂ /MWh gross, on a 12-mo rolling average basis	
				1735 lb CO ₂ /MWh gross, on a 12-mo rolling average basis	
				1,250 lb CO ₂ /MWh gross, on a 12-mo rolling average basis	
ULSD	Efficient Turbine Design and Operation and Good Combustion, Operation, and Maintenance Practices	Simple Cycle	1735 lb CO ₂ /MWh gross, on a 12-mo rolling average basis	Part 75, Appendix G	
			1,250 lb CO ₂ /MWh gross, on a 12-mo rolling average basis		
GHG (CH ₄ and N ₂ O)	NG	Efficient Turbine Design and Operation and Good Combustion, Operation, and Maintenance Practices	Simple Cycle	Efficient Turbine Operation and Good Combustion, Operation, and Maintenance Practices	O&M Records
			Combined Cycle		

Pollutant	Fuel	BACT	Type of Standard	Emission Limit/Operating Practice	Compliance Method
	ULSD	Efficient Turbine Design and Operation and Good Combustion, Operation, and Maintenance Practices	Simple Cycle	Efficient Turbine Operation and Good Combustion, Operation, and Maintenance Practices	O&M Records
			Combined Cycle		

For natural gas operation, "startup" shall be defined as the period beginning with the first fire of natural gas in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the unit reaches dry low NO_x mode (pre-mix mode), and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 30 minutes for simple cycle operations or 180 minutes for combined cycle operations. NPPD is contemplating using temperature as a variable for defining the end of startup and would like to discuss this option.

For fuel oil operation, "startup" shall be defined as the period beginning with the first fire of fuel oil in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the water/steam injection is functioning,), and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 30 minutes for simple cycle operations or 180 minutes for combined cycle operations. NPPD is contemplating using temperature as a variable for defining the end of startup and would like to discuss this option.

For natural gas operation and fuel oil operation, shutdown shall be defined as the period beginning when the turbine output is lowered with the intent to shutdown (the unit is no longer in steady state operating mode) and the SCR and oxidation catalysts are not operational and ends with the termination of fuel flow, not to exceed 18 minutes. NPPD is contemplating using temperature as a variable for defining the end of startup and would like to discuss this option.

Table 4-2. Summary of Proposed BACT Limits – RICE (Wartsila 50DF)

Pollutant	Fuel	BACT	Emission Limit/Operating Practice	Compliance Method
NO _x	NG	SCR and Good Combustion, Operation, and Maintenance Practices	100% Load - 6 ppmvd @ 15% O ₂ (Equal to 0.08 g/kWh)	Performance Testing
	ULSD	SCR and Good Combustion, Operation, and Maintenance Practices	100% Load - 35 ppmvd @ 15% O ₂ (Equal to 0.53 g/kWh)	Performance Testing
CO	NG	OC and Good Combustion, Operation, and Maintenance Practices	100% Load - 15 ppmvd @ 15% O ₂ (Equal to 0.12 g/kWh)	Performance Testing
	ULSD	OC and Good Combustion, Operation, and Maintenance Practices	100% Load - 20 ppmvd @ 15% O ₂ (Equal to 0.18 g/kWh)	Performance Testing
VOC	NG	OC and Good Combustion, Operation, and Maintenance Practices	100% Load - 26 ppmvd @ 15% O ₂ (Equal to 0.12 g/kWh)	Performance Testing
	ULSD	OC and Good Combustion, Operation, and Maintenance Practices	100% Load - 40 ppmvd @ 15% O ₂ (Equal to 0.21 g/kWh)	Performance Testing
SO ₂	NG	Natural Gas (<2 gr S/100 scf NG)	Natural Gas (< 2 gr S/100 scf NG, annual average)	Fuel Records
	ULSD	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	Ultra Low Sulfur Diesel (< 15 ppm S)	Fuel Records

Pollutant	Fuel	BACT	Emission Limit/Operating Practice	Compliance Method
PM, PM ₁₀ , and PM _{2.5}	NG	Natural Gas (< 2 gr S/100 scf NG)	100% load: 15 mg/m ³ at 15% O ₂ (equal to 3.9 lb/hr)	Performance Testing
	ULSD	Natural Gas (< 2 gr S/100 scf NG)	100% load: 40 mg/m ³ at 15% O ₂ (equal to 5.6 lb/hr)	Performance Testing
H ₂ SO ₄	NG	Natural Gas (< 2 gr S/100 scf NG)	Natural Gas (< 2 gr S/100 scf NG)	Fuel Records
	ULSD	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	Ultra Low Sulfur Diesel (< 15 ppm S)	Fuel Records
GHG (CO ₂)	NG	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	117 lb CO ₂ /MMBtu	O&M Records
	ULSD	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	163 lb CO ₂ /MMBtu	O&M Records

Pollutant	Fuel	BACT	Emission Limit/Operating Practice	Compliance Method
GHG (CH ₄ and N ₂ O)	NG	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	O&M Records
	ULSD	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	Efficient Engine Operation and Good Combustion, Operation, and Maintenance Practices	O&M Records

Table 4-3. Summary of BACT Emission Limits – Auxiliary Boiler

Pollutant	Fuel	BACT	Operating Practice	Compliance Method
NO _x	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
CO	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
VOC	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
SO ₂	NG	Pipeline Natural Gas (< 2 gr S/100 scf NG)	Pipeline Natural Gas (< 2 gr S/100 scf NG)	Fuel Records
PM, PM ₁₀ , and PM _{2.5}	NG	Pipeline Natural Gas (< 2 gr S/100 scf NG)	Pipeline Natural Gas (< 2 gr S/100 scf NG)	Fuel Records
GHGs (CO ₂ , CH ₄ , and N ₂ O)	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records

Table 4-4. Summary of BACT Emission Limits – Natural Gas Heaters

Pollutant	Fuel	BACT	Emission Limit/Operating Practice	Compliance Method
NO _x	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
CO	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
VOC	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records
SO ₂	NG	Pipeline Natural Gas (<2 gr S/100 scf NG)	Pipeline Natural Gas (< 2 gr S/100 scf NG, annual average)	O&M Records
PM, PM ₁₀ , and PM _{2.5}	NG	Pipeline Natural Gas (< 2 gr S/100 scf NG)	Pipeline Natural Gas (< 2 gr S/100 scf NG, annual average)	O&M Records
GHGs (CO ₂ , CH ₄ , and N ₂ O)	NG	Good Combustion, Operation, and Maintenance Practices	Good Combustion, Operation, and Maintenance Practices	O&M Records

Table 4-5. Summary of BACT Emission Limits – Emergency Equipment

Pollutant	Fuel	BACT	Emission Limit/Operating Practice	Compliance Method
NO _x	ULSD	EPA certified RICE, Good Combustion, Operation, and Maintenance Practices	EPA certified RICE, and Good Combustion, Operation, and Maintenance Practices	O&M Records
CO	ULSD	EPA certified RICE, Good Combustion, Operation, and Maintenance Practices	EPA certified RICE, and Good Combustion, Operation, and Maintenance Practices	O&M Records
VOC	ULSD	EPA certified RICE, Good Combustion, Operation, and Maintenance Practices	EPA certified RICE, and Good Combustion, Operation, and Maintenance Practices	O&M Records
SO ₂	ULSD	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	O&M Records
PM, PM ₁₀ , and PM _{2.5}	ULSD	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	Ultra Low Sulfur Diesel (< 15 ppm Sulfur)	O&M Records
GHGs (CO ₂ , CH ₄ , and N ₂ O)	ULSD	EPA certified RICE, Good Combustion, Operation, and Maintenance Practices	EPA certified RICE, and Good Combustion, Operation, and Maintenance Practices	O&M Records

Table 4-6. Summary of BACT Emission Limits – Diesel Storage Tanks

Pollutant	BACT	Compliance Method
VOC	Fixed-roof tanks with a light paint color	Tank Records

4.1 BACT Requirement

In a memorandum dated December 1, 1987, the U.S. Environmental Protection Agency (EPA) stated its preference for a "top-down" BACT analysis.¹³ The first step in this approach is to determine, for the emission unit and pollutant in question, the most stringent control available for a similar or identical source or source category. If it can be shown that this level of control is technically or economically infeasible for the unit in question, then the next most stringent level of control is determined and similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated for technical or economic reasons. Per EPA guidance, if the most effective control technology is deemed BACT, no further analysis is required for that pollutant. Presented below are the five basic steps of a top-down BACT review procedure according to the *New Source Review Workshop Manual (Draft)*¹⁴:

- ▶ **Step 1. Identify all control technologies.** The first step in the BACT analysis is to identify all control technologies for each pollutant.
- ▶ **Step 2. Eliminate technically infeasible options.** The second step in the BACT analysis is to eliminate any technically infeasible control techniques. Each control technology for each pollutant is considered, and those that are clearly technically infeasible are eliminated. U.S. EPA states the following with regard to technical feasibility:¹⁵

A demonstration of technical infeasibility should be clearly documented and should show, based on physical, chemical and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review.
- ▶ **Step 3. Rank the remaining control technologies by control effectiveness.** The control technologies are then ranked in order of effectiveness.
- ▶ **Step 4. Evaluate most effective controls and document the results.** The remaining control technologies are evaluated based on economic, energy, and environmental considerations.
- ▶ **Step 5. Select BACT.**

The remainder of this section presents the top-down BACT analyses for the CTs, RICE, auxiliary boilers, heater, fuel tanks, and emergency equipment for the following pollutants: NO_x, CO, VOC, SO₂, PM, PM₁₀, PM_{2.5}, H₂SO₄, and greenhouse gases (CO₂, CH₄, and N₂O).

4.2 BACT Analyses for Combustion Turbine

4.2.1 Nitrogen Oxides (NO_x)

This section includes the BACT analysis for NO_x for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.1.1 Overview of NO_x Emissions from CT

There are different ways that NO_x emissions can be formed in a combustion turbine. The literature refers to five (5) primary "types" of NO_x: thermal NO_x, prompt NO_x, NO_x from N₂O intermediate reactions, fuel NO_x,

¹³ U.S. EPA, Office of Air and Radiation, Memorandum from J.C. Potter to the Regional Administrators, Washington, D.C., December 1, 1987.

¹⁴ U.S. EPA, *New Source Review Workshop Manual (Draft): Prevention of Significant Deterioration and Nonattainment Area Permitting*, October 1990.

¹⁵ Ibid, Table B-1

and NO_x formed through reburning. The three most important mechanisms are thermal NO_x, prompt NO_x, and fuel NO_x.¹⁶ For natural gas-fired and diesel-fired units, most NO_x is thermal NO_x.

Thermal NO_x is formed mainly via the Zeldovich mechanism where the nitrogen (N₂) and oxygen (O₂) molecules in the combustion air react to form nitrogen monoxide (NO).¹⁷ Most thermal NO_x is formed in high temperature flame pockets downstream from the fuel injectors.¹⁸ Temperature is the most important factor, and at combustion temperatures above 2,370 °F, thermal NO_x is formed readily.¹⁹ Therefore, reducing combustion temperature is a common approach to reducing NO_x emissions.

Prompt NO_x, a form of thermal NO_x, is formed in the proximity of the flame front as intermediate combustion products such as hydrogen cyanide (HCN), N, and NH are oxidized to form NO_x.²⁰ The contribution of prompt NO_x to overall NO_x is relatively small but increases in low- NO_x combustor designs. Prompt NO_x formation is also largely insensitive to changes in temperature and pressure.²¹

Fuel NO_x forms when fuels containing nitrogen are burned. When these fuels are burned, the nitrogen bonds break and some of the resulting free nitrogen oxidizes to form NO_x. With excess air, the degree of fuel NO_x formation is primarily a function of the nitrogen content of the fuel. Therefore, since natural gas and fuel oil contain little fuel bound nitrogen, fuel NO_x is not a major contributor to NO_x emissions from natural gas- or fuel oil-fired combustion turbines.²²

4.2.1.2 Step 1 - Identification of NO_x Control Technologies - CT

NO_x emissions can be reduced by two general methodologies: combustion control techniques and post-combustion control methods. Combustion control techniques incorporate fuel or air staging that affect the kinetics of NO_x formation (reducing peak flame temperature) or introduce inerts (combustion products, for example) that limit initial NO_x formation, or both. Post-combustion control technologies use various strategies to chemically reduce NO_x to N₂ with or without the use of a catalyst.

Combustion control options include:

- ▶ Dry Low-NO_x (DLN) Combustion Technology,
- ▶ Water or Steam Injection, and
- ▶ Good Combustion Practices (Base Case).

¹⁶ AP-42, Chapter 1, Section 4, *Natural Gas Combustion*, July 1998, and AP-42, Chapter 3, Section 1, *Stationary Gas Turbines*, April 2000.

¹⁷ U.S. EPA, Emission Standards Division, *Alternative Control Techniques Document - NO_x Emissions from Stationary Gas Turbines*, EPA-453/R-93-007. January 1993.

¹⁸ AP-42, Chapter 1, Section 4, *Natural Gas Combustion*, July 1998, and AP-42, Chapter 3, Section 1, *Stationary Gas Turbines*, April 2000.

¹⁹ U.S. EPA, Clean Air Technology Center, *Technical Bulletin: Nitrogen Oxides (NO_x), Why and How They are Controlled*, EPA 456/F-99-006R. November 1999.

²⁰ U.S. EPA, Emission Standards Division, *Alternative Control Techniques Document - NO_x Emissions from Stationary Gas Turbines*, EPA-453/R-93-007. January 1993.

²¹ U.S. EPA, Emission Standards Division, *Alternative Control Techniques Document - NO_x Emissions from Stationary Gas Turbines*, EPA-453/R-93-007. January 1993.

²² Ibid.

Post-combustion control options include:

- ▶ EM_xTM/SCONO_xTM Technology,
- ▶ Selective Catalytic Reduction (SCR),
- ▶ SCR with Ammonia Oxidation Catalyst (Zero-SlipTM),
- ▶ Selective Non-Catalytic Reduction (SNCR), and
- ▶ Multi-Function Catalyst (METEORTM).

4.2.1.2.1 Dry Low-NO_x (DLN) Combustors

Dry low-NO_x combustion is a general term that refers to a burner specially designed to reduce the formation of NO_x by decreasing the overall flame temperature. The reduction in flame temperature can be accomplished in several ways, including using lean mixtures of air and/or fuel staging or by decreasing the residence time of the combustor.²³ In lean combustion systems, excess air is introduced into the combustion zone. This excess air decreases the overall flame temperature because a portion of the energy released from the fuel must be used to heat the excess air to the reaction temperature. Pre-mixing the fuel and air prior to introduction into the combustion zone provides a uniform fuel/air mixture and prevents localized high temperature regions within the combustor area.²⁴ Since NO_x formation rates are an exponential function of temperature, considerable reduction in NO_x can be achieved by the lean pre-mix system.

Dry low-NO_x combustors are often capable of operating in multiple modes, to accommodate turbine load and fuel type. The DLN systems work best when firing natural gas at higher loads. When firing natural gas at low loads, the combustor operates in diffusion mode (rather than DLN mode); the combustor switches to lean premix (DLN) operation at higher loads. When operating using liquid fuels (i.e., fuel oil), the combustor operates in diffusion mode with diluent injection (typically steam or water). The water or steam injection reduces the flame temperature to help minimize NO_x formation.

4.2.1.2.2 Water or Steam Injection

NO_x emissions can be reduced by injecting water or steam into the flame area of the gas turbine combustor. The injected fluid provides a heat sink that absorbs some of the heat of combustion, thereby reducing the peak flame temperature and reducing the formation of thermal NO_x. The water injected into the turbine must be of high purity such that no dissolved solids are injected into the turbine. Dissolved solids in the water may damage the turbine due to erosion and/or the formation of deposits in the hot section of the turbine. Although water/steam injection can reduce NO_x emissions by over 60%, the lower average temperature within the combustor may produce higher levels of CO and VOC as a result of incomplete combustion.²⁵ Additionally, water/steam injection results in a decrease in combustion efficiency, an increase in power (due to increased mass flow), and an increase in maintenance requirements due to wear.²⁶

4.2.1.2.3 Good Combustion Practices

Good combustion practices are operating practices and principles that allow the equipment to operate as efficiently as possible. The air-to-fuel ratio is one of the primary indicators of efficient combustion. Good

²³ Ibid.

²⁴ Ibid.

²⁵ AP-42, Chapter 1, Section 4, *Natural Gas Combustion*, July 1998, and AP-42, Chapter 3, Section 1, *Stationary Gas Turbines*, April 2000.

²⁶ Ibid.

combustion practices involve the monitoring of the air to fuel ratio to ensure the most efficient combustion. Modern turbine control systems implement good combustion practices by using computer-based systems to adjust operating parameters automatically.

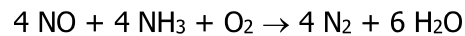
4.2.1.2.4 EM_xTM/SCONO_x

EM_xTM (the second-generation of the SCONO_x NO_x Absorber Technology) is a multi-pollutant control technology that utilizes a coated oxidation catalyst to remove both NO_x and CO without a reagent, such as ammonia (NH₃). The SCONO_x system consists of a platinum-based catalyst coated with potassium carbonate [K₂(CO₃)] to oxidize NO_x (to potassium nitrate [K(NO₃)]) and CO (to CO₂).²⁷ Hydrogen (H₂) is then used as the basis for the catalyst regeneration process where K(NO₃) is reacted to reform the K₂(CO₃) catalyst and release nitrogen gas and water.²⁸ The catalyst is installed in the flue gas with a temperature range between 300°F to 700°F. The SCONO_x catalyst is susceptible to fouling by sulfur if the sulfur content of the flue gas is high.²⁹

Estimates of control efficiency for a SCONO_x system vary depending on the pollutant controlled. California Energy Commission reports a control efficiency of 78% for NO_x reductions down to 2.0 ppm, and even higher NO_x reductions down to 1 ppm for some designs.³⁰

4.2.1.2.5 Selective Catalytic Reduction (SCR)

SCR is a post-combustion gas treatment process in which NH₃ is injected into the exhaust gas upstream of a catalyst bed. On the catalyst surface, NH₃ and NO react to form diatomic N₂ and H₂O vapor. The overall chemical reaction can be expressed as:



When operated within the optimum temperature range, the reaction can result in removal efficiencies between 70 and 90 percent.³¹ Optimal temperatures for SCR units ranges from 480°F to 800°F and typical SCR systems have the ability to function effectively under temperature fluctuations of up to 200°F. SCR can be used to reduce NO_x emissions from combustion of natural gas and light oils (e.g., distillate fuel oil). Combustion of heavier oils can produce high levels of particulate, which may foul the catalyst surface, reducing the NO_x removal efficiency. Other considerations include the possibility for ammonia slip, which refers to emissions of unreacted ammonia escaping with the flue gas and its contribution to secondary particulate formation.

4.2.1.2.6 SCR with Ammonia Oxidation Catalyst (Zero-SlipTM)

SCR with Ammonia Oxidation Catalyst (Zero-SlipTM) is a refinement on standard post-combustion SCR technology developed by Cormetech and Mitsubishi Power Systems to reduce ammonia slip associated with

²⁷ Georgia EPD, *Prevention of Significant Air Quality Deterioration Review Preliminary Determination – Dahlberg Combustion Turbine Electric Generating Facility*, October 2009.

https://epd.georgia.gov/air/sites/epd.georgia.gov/air/files/related_files/document/1570034pd.pdf

²⁸ Ibid.

²⁹ California Energy Commission, *Evaluation of Best Available Control Technology*, Appendix 8.1E, pages 8.1E-9 and 8.1E-10.

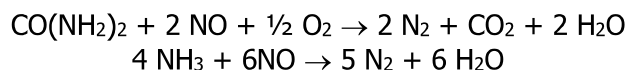
³⁰ California Energy Commission, *Evaluation of Best Available Control Technology*, Appendix 8.1E, page 8.1E-6.

³¹ U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Selective Catalytic Reduction (SCR)*, EPA-452/F-03-032.

traditional SCR systems. The Zero-Slip™ technology consists of a second bed of catalyst that is installed after the main SCR catalyst to further react NO_x with the ammonia. This results in NO_x emissions on par with standard SCR systems and less ammonia slip (less than 2.0 ppm_{vd} at 15% O₂).³²

4.2.1.2.7 Selective Non-Catalytic Reduction (SNCR)

SNCR is a post-combustion NO_x control technology based on the reaction of urea or ammonia with NO_x. In the SNCR chemical reaction, urea [CO(NH₂)₂] or ammonia is injected into the combustion gas path to reduce the NO_x to nitrogen and water. The overall reaction schemes for both urea and ammonia systems can be expressed as follows:



Typical removal efficiencies for SNCR range from 30 to 50 percent and higher when coupled with combustion controls.³³ An important consideration for implementing SNCR is the operating temperature range. The optimum temperature range is approximately 1,600 to 2,000°F. Operation at temperatures below this range results in ammonia slip. Operation above this range results in oxidation of ammonia, forming additional NO_x.

4.2.1.2.8 Multi-Function Catalyst (METEOR™)

METEOR™ is a multi-pollutant post-combustion control technology originally developed and patented by Siemens Energy Inc. and optimized by Cormetech. The METEOR™ catalyst uses ammonia, similar to standard SCR systems, to reduce NO_x emissions but is also able to reduce CO, VOC, and ammonia emissions using a single catalyst bed (i.e., eliminate the need for a separate oxidation catalyst system if CO and VOC reductions are required), resulting in reduced pressure drop and parasitic load requirements.³⁴ The ability of the METEOR™ catalyst to reduce NO_x emissions is on par with more traditional SCR designs.³⁵

4.2.1.3 *Step 2 - Elimination of Technically Infeasible NO_x Control Options – CT*

4.2.1.3.1 Dry Low NO_x Combustion Technology Feasibility

Dry low NO_x (DLN) combustion technology is technically feasible for natural gas combustion and the proposed combustion turbines will have DLN combustors. DLN combustion technology is included in the following BACT steps but represents part of the base case for NO_x performance as it is inherent in the operation of the combustion systems.

³² Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of NO_x, Attachment B pages 13-14.

³³ U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Selective Non-Catalytic Reduction (SNCR)*, EPA-452/F-03-031.

³⁴ Siemens Energy and Cormetech, *Capital and O&M Benefits of Advanced Multi-Function Catalyst Technology for Combustion Turbine Power Plants*, Power Gen 2015, page 2.

³⁵ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of NO_x, Attachment B pages 15-16.

As noted above in Section 4.2.1.2.1, DLN cannot be used during fuel oil operation or during gas operation at low loads. Instead, diluent injection, typically water or steam, must be used for NO_x abatement during fuel oil operations. At low loads during gas operation, the combustor operates in diffusion mode. Therefore, DLN burners are considered technically infeasible when combusting fuel oil and when operating at low loads on natural gas.

4.2.1.3.2 Water or Steam Injection Feasibility

Water or steam injection is a NO_x reduction technology that is commonly used to control NO_x emissions when fuel oil is burned, but is not as effective as DLN when firing natural gas.³⁶ Water or steam injection also cannot be used in conjunction with DLN because it leads to unstable combustion and increases CO emissions.³⁷ As the proposed turbines will utilize DLN combustors during natural-gas operation that reduce NO_x emissions further than water or steam injection would, water or steam injection is deemed to be technically infeasible when combusting natural gas.

Water or steam injection is technically feasible for fuel oil combustion and the proposed combustion turbines will have the capability to inject water or steam as part of the combustor design. Water or steam injection technology is included in the following BACT steps but represents part of the base case for NO_x performance as it is inherent in the operation of the combustion system.

4.2.1.3.3 Good Combustion Practices Feasibility

Good combustion practices are technically feasible. The proposed combustion turbines will be equipped with automated computer-based control systems capable of adjusting operating parameters to ensure that all turbine systems, including those intended to minimize pollutant formation, operate as effectively and efficiently as possible.

4.2.1.3.4 EM_xTM/SCONO_xTM Technology Feasibility

The EM_xTM/SCONO_xTM catalyst system is a post-combustion technology that utilizes a proprietary oxidation catalyst and absorption technology using a single catalyst (potassium carbonate) for removal of NO_x, CO, and VOC without the use of ammonia. As summarized by Illinois EPA in their project summary for the Jackson Energy Center PSD permit, the EM_xTM/SCONO_xTM catalyst system has operated successfully on several smaller, natural gas-fired combined-cycle units, but there are engineering challenges with scaling up this technology for use on large gas turbines.^{38,39}

Consequently, it is concluded that EM_xTM/SCONO_xTM is not technically feasible for control of NO_x emissions from the proposed heavy-duty frame-class combustion turbines in any mode of operation.

³⁶ Ibid., Attachment B page 12.

³⁷ Ibid.

³⁸ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of NO_x, Attachment B pages 14.

³⁹ National Energy Technology Laboratory, *8.7. Nitrogen Oxides (NO_x) Emissions*. Available online at <https://www.netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/nitrogen-oxides>. Accessed August 15, 2024.

4.2.1.3.5 SCR Feasibility

The optimal catalyst temperature for the operation of SCR is in the range of 480°F to 800°F, but with recent advances in catalyst materials and design, the temperature can be as high as 1,100°F.⁴⁰ Larger utility-scale combustion turbines, such as the Siemens CTs proposed by NPPD, when operated as simple-cycle units, will have exhaust temperatures above 800°F. Due to the high exhaust temperatures, SCR has historically not been used as frequently on simple cycle units as combined cycle units. However, more recent advancements in the use of cooling air and/or the use of specialty catalysts have increased the use of SCR on these units.

SCR is regularly used on combined-cycle units, since the exhaust from combined cycle operations has had heat removed, and the normal temperature is within the effective range for SCR.

The fuel used in the combustion turbine also impacts the effectiveness of SCR. When operating on fuel oil, rather than natural gas, the emissions profile from the turbine, as well as the performance of the SCR system, are impacted. Namely, the efficiency of the SCR system is reduced, while at the same time, NO_x emissions from the turbine are increased. Nevertheless, properly designed SCR systems are capable of operating during both natural gas and fuel oil operation. Thus, SCR is technically feasible for the proposed combustion turbine during both simple cycle and combined cycle operation.

4.2.1.3.6 SCR with Ammonia Oxidation Catalyst (Zero-Slip™) Feasibility

Based on the review of available control technologies, to date, the Zero-Slip™ catalyst technology has not been demonstrated on large, utility-size units. Full scale operations have only been demonstrated on a 7.5 MW Solar Taurus combustion turbine.⁴¹ In addition, this technology is essentially SCR with a focus on reducing ammonia slip; accordingly, as this technology has not been demonstrated on large, utility size units, and it would not achieve NO_x emission rates lower than that achieved by conventional SCR designs, the Zero-Slip™ technology option is not considered a technically feasible control option for the proposed turbine during any mode of operation.

4.2.1.3.7 SNCR Feasibility

The temperature range required for effective operation of this technology is 1,600 to 2,000°F. This is above the peak exhaust temperature for the proposed turbine units.⁴² SNCR is eliminated as a technically feasible option for control of NO_x emissions from combustion turbines during any mode of operation.

⁴⁰ Mitsubishi Hitachi Power Systems, *Overview of SCR Technology and Retrofitting of SCR's to Comply with Upcoming NO_x BARCT Standards for Electric Power Generating Units*, Robert McGinty, presentation for SCAQMD AWMA Annual Regional Meeting, ca. 2017.

⁴¹ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of NO_x, Attachment B page 14.

⁴² U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Selective Non-Catalytic Reduction (SNCR)*, EPA-452/F-03-031.

4.2.1.3.8 Multi-Function Catalyst (METEOR™) Feasibility

The METEOR™ catalyst technology, developed and patented by Siemens Energy Inc., is currently only in use on one 320 MW Siemens/Westinghouse 501G combustion turbine installed in November 2015.^{43,44} A review of the RBLC database for turbines similar to the proposed units did not return any units that use the METEOR™ catalyst technology. As there is limited commercial operating experience with the METEOR™ catalyst, the METEOR™ technology option is not considered a technically feasible control option for purposes of BACT for any mode of operation.

4.2.1.4 *Step 3 - Summary and Ranking of Remaining NO_x Controls – CT*

The potentially feasible control technologies include SCR, DLN combustors (NG operation), water or steam injection (FO operation) and good combustion practices. Table 4-7 shows the rank for each of these control technologies.

Table 4-7. Remaining NO_x Control Technologies – CT

Control Technology	Technically Feasible	Estimated Efficiency
SCR	Yes	~90%
DLN Combustion Technology	Yes (NG only)	Base Case (NG)
Water or Steam Injection	Yes (FO only)	Base Case (FO)
Good Combustion Practice	Yes	Base Case

4.2.1.5 *Step 4 - Evaluation of Most Stringent NO_x Controls – CT*

SCR is the highest ranking potentially feasible control technology. As summarized in Step 5, NPPD is proposing operation of SCR with DLN and good combustion practices as BACT during NG simple- and combined-cycle operation (as feasible for operating load), and SCR with water or steam injection and good combustion practices as BACT during FO simple- and combined-cycle operation. No additional evaluation of emission control is needed.

4.2.1.6 *Step 5 - Selection of Emission Limits and Controls for NO_x BACT*

4.2.1.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

As summarized in detail Section 3 of this application, the proposed combustion turbines will be subject to either the existing NSPS KKKK or the proposed NSPS KKKKa, depending on whether KKKKa goes into effect. NSPS KKKK does not require SCR and includes a NO_x emission standard for simple cycle operation for natural gas combustion of 15 ppm at 15% O₂ and for fuels other than natural gas of 42 ppm at 15% O₂. The fuel-specific limits apply based on two different averaging periods, a 4-hour rolling average for simple cycle operations and a 30-day rolling average for combined cycle operations.

⁴³ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of NO_x, Attachment B page 16.

⁴⁴ Siemens Energy and Cormetech, *Capital and O&M Benefits of Advanced Multi-Function Catalyst Technology for Combustion Turbine Power Plants*, Power Gen 2015, page 2.

The proposed NSPS KKKKa includes a NO_x limit of 3 ppm at 15% O₂ during natural gas combustion and a limit of 9 ppm at 15% O₂ for fuels other than natural gas average based on the use of SCR. The comment period on the proposed rule ended April 15, 2025, and EPA is currently evaluating the proposed rule. NPPD has provided comments on the rule. NPPD supports an SCR-based limit of 3 ppm during natural gas combustion, as long as the limit does not cover emissions during SUSD and the limit is applied over a long enough period to accommodate the highly transient nature of the CT operation.

NSPS KKKK or KKKKa, whichever is in effect, will serve as the floor for the allowable NO_x BACT limit.

4.2.1.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 15.110 (Simple Cycle >25 MW, Natural Gas-Fired)
 - 15.190 (Simple Cycle >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
 - 15.210 (Combined Cycle & Cogeneration >25 MW, Natural Gas-Fired)
 - 15.290 (Combined Cycle & Cogeneration >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
- ▶ Pollutant Name: Nitrogen Oxides (NO_x)
- ▶ Permit Date: After January 1st, 2014

Trinity reviewed the results of the RBLC search and, for the sake of brevity, removed entries for units less than 850 MMBtu/hr or 100MW. This is because turbines smaller than about 100MW generally fall under the “aeroderivative” category of combustion turbines and are not directly comparable to larger “frame class” combustion turbines. Note that there are no RBLC entries for aeroderivative turbines with emission limits lower than NPPD’s proposed BACT limits.

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-1 and D.1-2). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

The results of the RBLC search for simple-cycle natural gas units are summarized as follows:

- ▶ 2 ppmvd (1 entry),
- ▶ 2.5 ppmvd (2 entries),
- ▶ 9 ppmvd (23 entries), and
- ▶ 15 ppmvd (1 entry).

The large majority of RBLC entries for simple-cycle units operating on natural gas indicate a BACT limit of 9 ppmvd at 15% O₂. These units employ DLN combustors and are not equipped with SCR. The lowest emission limits for simple cycle units on natural gas that require SCR are either 2 ppmvd or 2.5 ppmvd at 15% O₂. In addition to there being some RBLC entries showing 2 to 2.5 ppmvd for simple cycle, it has recently become common for SCR manufacturers to provide short term guarantees on SCR performance at 2.5 ppm for simple cycle units.

As further described below, a NO_x level of 2 ppmvd at 15% O₂ is BACT for combined cycle units operating with SCR. While manufacturers are making similar guarantees for SCR performance on simple cycle units, there is little data to demonstrate the long-term performance of SCR on these units. Further, even if it is possible for simple cycle units to achieve 2.5 ppm, this would only be achievable when operating as a base load unit all the time. It is not possible to consistently achieve this level on a unit that will have a highly

variable dispatch schedule (operating in all three modes – low, intermediate, and baseload) and be subject to frequent starts and stops, which is the schedule anticipated for the new CTs.

Since there is not much history on simple cycle units operating with SCR, Trinity conducted further research related to the RBLC entries at both 2.0 ppmvd and 2.5 ppmvd at 15% O₂. Simply because other simple cycle units have been permitted with NO_x limits of 2 and 2.5 ppm, and SCR vendors are providing short term guarantees on SCR performance does not mean these limits would be BACT for the NPPD CTs.

Alaska LNG Gas Liquefaction Facility (2.0 ppmvd @ 15% O₂)

The Alaska LNG Gas Liquefaction Facility is a proposed natural gas liquefaction plant in Nikiski, Alaska, which would include six simple-cycle natural gas-fired combustion turbines used for gas compression. A permit was issued for this facility on July 7th, 2022, but as of October 2024, construction has not started. BACT for these turbines was determined to be SCR with DLN combustors, with a BACT limit of 2 ppmvd @ 15% O₂.⁴⁵ The technical basis for this limit is not clear from publicly available documents, but based on engineering judgement, it is likely that the use-case for these turbines (refrigerant compression for natural gas liquefaction) results in extended periods of steady-state operation. This is ideal for SCR, which relies on precise injection of ammonia in the correct stoichiometric ratio to reduce NO_x emissions. Conversely, the proposed NPPD combustion turbines will likely be intermediate load units, designed to operate intermittently with potentially frequent starts and stops. While the proposed SCR system may be able to achieve 2 ppmvd NO_x emissions at times, the SCR vendor does not guarantee 2 ppm for simple cycle operation.

Puente Power Project (2.5 ppmvd @ 15% O₂)

The Puente Power Project was a proposed 262-megawatt peaking plant powered by a natural gas combustion turbine. The project was never built, and NPPD was not able to obtain a copy of the issued PSD permit. The BACT limit according to RBLC was 2.5 ppmvd @ 15% O₂ on a 1-hour average basis.

Troutdale Energy Center (2.5 ppmvd @ 15% O₂)

The Troutdale Energy Center was a proposed 653 MW electric generating plant in Troutdale, Oregon. According to the RBLC entry, the plant would have included three natural gas-fired combustion turbines, one of which would have operated in a combined-cycle configuration with a duct burner and heat recovery steam generator. Plans for the plant were abandoned in early 2016.⁴⁶ The two simple-cycle turbines were to be equipped with an SCR system, with a BACT limit of 2.5 ppmvd @ 15% O₂.

The results of the RBLC search for combined-cycle units on natural gas are summarized below:

- ▶ 2 ppmvd (73 entries),
- ▶ 2.5 ppmvd (2 entries),
- ▶ 3 ppmvd (3 entries),
- ▶ 9 ppmvd (1 entry), and
- ▶ 23 ppmvd (1 entry).

A significant number of RBLC entries for combined-cycle units operating on natural gas require SCR, DLN, and good combustion practices to achieve a BACT limit of 2 ppmvd at 15% O₂. NPPD is proposing to use

⁴⁵ *Technical Analysis Report for Construction Permit AQ1539CPT01*, Alaska Department of Environmental Conservation Air Permits Program, July 7, 2022.

⁴⁶ Troutdale Energy Center Facility Fact Page, Oregon Department of Energy. Available online at <https://www.oregon.gov/energy/facilities-safety/facilities/Pages/TEC.aspx>. Accessed July 12, 2024.

these same technologies for the proposed turbines and has received information from Siemens indicating 2 ppmvd is achievable during natural-gas operation.

The RBLC search shows a limited number of simple cycle units with limits applicable during fuel-oil operation. All but one entry, the Troutdale Energy Center, are limited to 42 ppmvd at 15% O₂. The Troutdale Energy Center is discussed in more detail below.

Troutdale Energy Center (3.8 ppmvd @ 15% O₂)

As described above, the Troutdale Energy Center was a proposed 653 MW electric generating plant in Troutdale, Oregon. Plans for the plant were abandoned in early 2016.

During combined cycle fuel-oil operation, Siemens has indicated 5 ppmvd is achievable. Of the 15 RBLC entries for combined-cycle units with ppmvd NO_x limits applicable during fuel-oil operation, 9 entries are limited to 5 ppmvd or less:

The results of the RBLC search for combined-cycle units on fuel oil are summarized below:

- ▶ 5 ppmvd (3 entries),
- ▶ 4 ppmvd (4 entries), and
- ▶ 2 ppmvd (2 entries).

4.2.1.6.3 Summary of NO_x Limits in Air Permits not in RBLC

Trinity conducted additional research outside of the RBLC and identified one permit with a low NO_x limit that was not identified in the RBLC search: Marsh Landing Generating Station ("Marsh Landing") in Antioch, CA. Marsh Landing consists of four Siemens SGT6-5000 F4 simple-cycle combustion turbines operating with tempering air systems, SCR, and oxidation catalyst. These are frame-class combustion turbines which are similar in design to the CTs proposed by NPPD. The facility began commercial operations in 2013 and is subject to a NO_x emission limit of 2.5 ppmvd based on a 1-hour averaging period.⁴⁷ While the CTs are similar, the operating schedules for the CTs may not be similar, and the operating schedule is a factor in the performance of an SCR.

The Oklahoma DEQ recently issued a permit for a simple cycle combustion turbine to Ripley Energy Center. The state BACT determination was 3.5 ppmvd at 15% O₂ for NO_x. In this case, the vendor was "guaranteeing" a NO_x level of 2.5 ppmvd, at 15% O₂ but the terms associated with the guarantee were not clear and Oklahoma believed there was significant uncertainty on the NO_x emissions for simple cycle units with SCR.

4.2.1.6.4 NO_x BACT Limit Selection – Simple-Cycle Operation

Proposed Primary (Steady State) NO_x BACT Limit - Simple-Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable. The NO_x level achievable with a simple cycle SCR has not been well demonstrated. There are vendors that will guarantee 2.5 ppm at 15% O₂, but there is very little data demonstrating units operating at this level, especially units with frequent startups and shutdowns and operating in three different capacity modes (low, intermediate, and baseload). NPPD is proposing a BACT limit for NO_x of 3 ppmvd, corrected to 15% O₂, during simple cycle operation when firing natural gas, based on the use of DLN (as feasible for operating load), dilution air, SCR, and good combustion and operating practices. NPPD is proposing that the limit apply as a 4-hour rolling average, since this is consistent with the averaging period required for the NO_x limits in NSPS Subpart KKKK for

⁴⁷ *Major Facility Review Permit for Facility #B9169*, Bay Area Air Quality Management District, September 9, 2019.

simple cycle operations. NPPD will demonstrate compliance using a continuous emissions monitoring system (CEMS).

Note, while 3 ppmvd corrected to 15% O₂ is BACT, this limit is only achievable when the SCR system is operating at its design efficiency, and it is not achievable during the period immediately following startup of the combustion turbine. The SCR is a catalytic system that requires that the catalyst be hot. When the CT is fired up, there will be a startup period where the CT will need to ramp up to its operating load and the catalyst will need to ramp up to its design operating temperature. The NO_x emissions are naturally higher during this time. Thus, NPPD is proposing that the primary BACT limit of 3 ppmvd corrected to 15% O₂ does not apply during period of SUSD but instead is proposing a separate BACT determination for SUSD.

CT manufacturers provide emissions data for startup events. The data typically include (1) an estimate of the emissions during the period where the catalyst is heating up to the design temperature range and (2) the length of time it takes to reach this temperature. The length of time to get to the catalyst design temperature is longer than the time it takes for the engine to reach the operating load. A CT may take 5 to 10 minutes to reach the operating load but then it takes 10 to 20 minutes longer before the catalyst reaches the design temperature. The "event" refers to the time for the catalyst to reach its desired temperature.

Proposed Primary (Steady State) NO_x BACT Limit - Simple-Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable. The SCR vendors have indicated that a NO_x emission level of 5 ppmvd at 15% O₂ is achievable when combusting fuel oil and when operating a unit that has frequent starts and stops and will operate across a range of operating loads. This is the same NO_x limit that is included in NSPS KKKKa. Thus, NPPD is proposing a BACT limit for NO_x of 5.0 ppmvd, corrected to 15% O₂, during simple cycle operation when firing fuel oil, based on the use of water or steam injection and SCR. NPPD is proposing that the limit apply as a 4-hour rolling average, and exclude periods of startup and shutdown. This averaging period is consistent with both NSPS KKKK and KKKKa. NPPD will demonstrate compliance using a CEMS.

Proposed Secondary (SUSD) NO_x BACT Limits - Simple-Cycle (Natural Gas/Fuel Oil)

NPPD is proposing that BACT for simple cycle SUSD events is to operate in accordance with the manufacturer's recommendations. Siemens has provided estimates of the NO_x emission during SUSD events. The proposed SUSD limits are as follows, based on the SUSD rates provided by Siemens:

- ▶ Startup: 61 lb/event (natural gas), 147.8 lb/event (fuel oil) and
- ▶ Shutdown: 18 lb/event (natural gas), 29 lb/event (fuel oil).

NPPD is proposing the manufacturer's emission estimates for SUSD events as BACT. NPPD will demonstrate compliance with the lb/event rates shown above using a CEMS.

For simple cycle natural gas operation, NPPD is proposing that "startup" be defined as the period beginning with the first fire of natural gas in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the unit reaches dry low NO_x mode (pre-mix mode), and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 30 minutes.

For simple cycle fuel oil operation, "startup" shall be defined as the period beginning with the first fire of fuel oil in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the water/steam injection is functioning, and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 30 minutes.

“Shutdown” shall be defined as the period beginning when the turbine output is lowered with the intent to shutdown (the unit is no longer in steady state operating mode) and the SCR and oxidation catalysts are not operational and ends with the termination of fuel flow, not to exceed 18 minutes.

4.2.1.6.5 NO_x BACT Limit Selection – Combined-Cycle Operation

Proposed Primary (Steady State) NO_x BACT Limit – Combined Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable, which for combined-cycle units firing natural gas, is 2 ppmvd at 15% O₂. Thus, NPPD is proposing a BACT limit for NO_x of 2.0 ppmvd, corrected to 15% O₂, during combined cycle operation when firing natural gas, based on the use of DLN (as feasible for operating load), SCR, and good combustion and operating practices, excluding periods of SUSD. NPPD is proposing that the limit apply as a 30-day rolling average, since a 30-day averaging period is consistent with that required for the NO_x limits in NSPS Subpart KKKK for combined cycle operations. NPPD will demonstrate compliance using a CEMS.

Proposed Primary (Steady State) NO_x BACT Limit – Combined Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable, which for combined-cycle units firing fuel oils, is 5.0 ppmvd, corrected to 15% O₂. Thus, NPPD is proposing a BACT limit for NO_x of 5.0 ppmvd, corrected to 15% O₂, during combined cycle operation when firing fuel oil, based on the use of water or steam injection, SCR, and good combustion and operating practices, excluding periods of SUSD. NPPD is proposing that the limit apply as a 30-day rolling average, since a 30-day averaging period is consistent with that required for the NO_x limits in NSPS Subpart KKKK for combined cycle operations. NPPD will demonstrate compliance using a CEMS.

Proposed Secondary (SUSD) NO_x BACT Limit Selection - Combined-Cycle (Natural Gas/Fuel Oil)

NPPD is proposing that BACT for simple cycle SUSD events is to operate in accordance with the manufacturer’s recommendations. Siemens has provided estimates of the NO_x emission during SUSD events. The proposed SUSD limits are as follows, based on the SUSD rates provided by Siemens:

- ▶ Startup: 123.9 lb/event (natural gas), 209.2 lb/event (fuel oil)
- ▶ Shutdown: 19 lb/event (natural gas), 42 lb/event (fuel oil)

NPPD is proposing the manufacturer’s emission estimates for SUSD events as BACT. NPPD will demonstrate compliance with the lb/event rates shown above using a CEMS.

For combined cycle natural gas operation, NPPD is proposing that "startup" be defined as the period beginning with the first fire of natural gas in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the unit reaches dry low NO_x mode (pre-mix mode), and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 180 minutes.

For combined cycle fuel oil operation, "startup" shall be defined as the period beginning with the first fire of fuel oil in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode), the water/steam injection is functioning, and the SCR and oxidation catalyst are fully operational and controlling emissions, not to exceed 180 minutes.

“Shutdown” shall be defined as the period beginning when the turbine output is lowered with the intent to shutdown (the unit is no longer in steady state operating mode) and the SCR and oxidation catalysts are not operational and ends with the termination of fuel flow, not to exceed 18 minutes.

4.2.2 Carbon Monoxide (CO)

This section includes the BACT analysis for CO for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.2.1 Overview of CO Emissions from CT

CO from combustion turbines is a by-product of incomplete combustion. Conditions leading to incomplete combustion can include insufficient oxygen availability, poor fuel/air mixing, reduced combustion-temperature, reduced combustion gas residence time, and load reduction.

4.2.2.2 Step 1 - Identification of CO Control Technologies – CT

CO emissions can be reduced by two general methodologies: combustion control techniques and post-combustion control methods. Combustion control techniques involve good design of the combustion process and good combustion and operating practices. Post-combustion control can be done with an oxidation catalyst.

4.2.2.2.1 Combustion Process Design and Good Combustion and Operating Practices

To minimize incomplete combustion and the resulting formation of CO, this control technology includes proper equipment design, proper operation, and good combustion practices. Proper equipment design is important in minimizing incomplete combustion by allowing for sufficient residence time at high temperature as well as turbulence to mitigate incomplete mixing. Generally, the effect of combustion zone temperature and residence time on CO emissions is the opposite of their effect on NO_x emissions. Accordingly, it is critical to optimize oxygen availability with input air, while controlling temperature to minimize NO_x formation. Modern turbine control systems implement good combustion practices by using computer-based systems to adjust operating parameters automatically.

4.2.2.2.2 Oxidation Catalyst

An oxidation catalyst is a post-combustion control technology that utilizes a catalyst to oxidize CO. The addition of a catalyst to the basic thermal oxidation process accelerates the rate of oxidation by adsorbing oxygen from the air stream and CO in the waste stream onto the catalyst surface to react to form CO₂ and H₂O.

4.2.2.3 Step 2 - Elimination of Technically Infeasible CO Control Options – CT

The second step in the BACT process is the elimination of technically infeasible control options based on process-specific conditions that prohibit implementation of the control, or the lack of commercial demonstration of achievability.

4.2.2.3.1 Combustion Process Design and Good Combustion and Operating Practices Technical Feasibility

This represents the base case for the combustion turbines.

4.2.2.3.2 Oxidation Catalyst Technical Feasibility

Catalytic oxidizers typically operate within a temperature range between 600 to 800°F.⁴⁸ Larger utility-scale combustion turbines, such as the Siemens CTs proposed by NPPD, when operated as simple-cycle units, will have exhaust temperatures in excess of 1,000°F. Due to the high exhaust temperatures, oxidation catalysts have historically not been used as frequently on simple cycle units. However, more recent advancements in the use of cooling air have increased the use of oxidation catalysts on simple cycle units.

The fuel used in the combustion turbine also impacts the effectiveness of oxidation catalyst. When operating on fuel oil, rather than natural gas, the emissions profile from the turbine, as well as the performance of the oxidation catalyst system, are impacted. Namely, the efficiency of the oxidation catalyst is reduced, while at the same time, CO emissions from the turbine are increased. Nevertheless, properly designed oxidation catalysts are capable of operating during both natural gas and fuel oil operation. Thus, an oxidation catalyst is technically feasible for the proposed combustion turbine during all modes of operation.

4.2.2.4 *Step 3 - Summary and Ranking of Remaining CO Controls – CT*

The only add-on control that is technically feasible to reduce emissions below the base case (Combustion Process Design and Good Combustion Practices) is an oxidation catalyst. As a technically feasible control option, it must be evaluated further in the BACT process.

4.2.2.5 *Step 4 - Evaluation of Most Stringent CO Controls – CT*

Oxidation catalyst is the highest ranking potentially feasible control technology for the proposed turbines. NPPD is proposing installation of oxidation catalyst with good combustion and operating practices as BACT.

4.2.2.6 *Step 5 - Selection of Emission Limits and Controls for CO BACT – CT*

4.2.2.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The combustion turbines will not be subject to any NSPS or NESHAP standard for CO, and thus there is no floor for an allowable CO BACT limit. The units are also not subject to any CO emission limit per the LLCHD rules or Title 129 of the Nebraska Rules and Regulations.

4.2.2.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 15.110 (Simple Cycle >25 MW, Natural Gas-Fired)
 - 15.190 (Simple Cycle >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
 - 15.210 (Combined Cycle & Cogeneration >25 MW, Natural Gas-Fired)
 - 15.290 (Combined Cycle & Cogeneration >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
- ▶ Pollutant Name: Carbon Monoxide (CO)
- ▶ Permit Date: After January 1st, 2014

⁴⁸ U.S. EPA, *CATC Fact Sheet for Catalytic Incineration*, EPA-452/F-03-018. Available at: www.epa.gov/ttn/catc/dir1/fcataly.pdf

Trinity reviewed the results of the RBLC search and, for the sake of brevity, removed entries for units less than 850 MMBtu/hr or 100 MW. This is because turbines smaller than about 100 MW generally fall under the “aeroderivative” category of combustion turbines and are not directly comparable to larger “frame class” combustion turbines. Note that there are no RBLC entries for aeroderivative turbines with emission limits lower than proposed BACT limits.

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-3 and D.1-4). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

The results of the RBLC search for simple-cycle units combusting natural gas are summarized below:

- ▶ 4 ppmvd (2 entries⁴⁹)
- ▶ 5 ppmvd (1 entry)
- ▶ 6 ppmvd (2 entries)
- ▶ 9 ppmvd (16 entries)
- ▶ 15 ppmvd (1 entry)
- ▶ 25 ppmvd (2 entries)
- ▶ 0.00713 lb/MMBtu (1 entry)

Most RBLC entries indicate a BACT limit of 9 ppmvd for simple-cycle units operating on natural gas; however, these units employ good combustion practices as the only control method and are therefore not directly comparable to a combustion turbine with an oxidation catalyst. The two entries with the lowest limit in the database, 4 ppmvd, are for GE 7F.05 turbines with no post-combustion controls. NPPD will operate the CTs with an oxidation catalyst and has received an emission performance guarantee for simple cycle on natural gas of 2 ppmvd at 15% O₂.

The results of the RBLC search for combined-cycle units combusting natural gas are summarized below:

- ▶ 0.9 ppmvd (3 entries)
- ▶ 1 ppmvd (3 entries)
- ▶ 1.5 ppmvd (7 entries)
- ▶ 1.8 ppmvd (1 entry)
- ▶ 2 ppmvd (45 entries⁵⁰)
- ▶ 3 ppmvd (2 entries)
- ▶ 4 ppmvd (8 entries)
- ▶ 4.3 ppmvd (2 entries)
- ▶ 5 ppmvd (1 entry)
- ▶ 25 ppmvd (3 entries)

A significant number of RBLC entries for combined-cycle, heavy-duty frame-class combustion turbines utilize oxidation catalyst and good combustion practices to achieve a BACT limit of 2 ppmvd. The lowest emission limits presented range from 0.9 ppmvd to 1.8 ppmvd. NPPD has received an emission performance guarantee for combined cycle on natural gas of 2 ppmvd at 15% O₂.

⁴⁹ The entry for the Indeck Wharton Energy Center, TX-0694, included separate limits for a GE turbine and Siemens turbine. The Siemens turbine limit was 4 ppmvd, while the GE turbine limit was 9 ppmvd.

⁵⁰ The RBLC entry for Neches Station, TX-0788, includes a 2 ppmvd CO limit on an annual basis during load operations greater than 50%, and a 4 ppmvd CO limit on a 1-hour basis during load operations greater than 50%.

The results of the RBLC search for simple cycle units combusting fuel oil show 3 entries ranging from 6 to 20 ppmvd @ 15% O₂. NPPD has received an emission performance guarantee for simple cycle on fuel oil of 2 ppmvd at 15% O₂.

For combined cycle on fuel oil, a limited number of combined-cycle RBLC entries have CO limits specifically applicable during fuel-oil operation. NPPD has received an emission performance guarantee for combined cycle on fuel oil of 2 ppmvd at 15% O₂. There are 2 RBLC entries that show CO limits lower than 2 ppmvd @ 15% O₂:

- ▶ WI-0300 Nemadji Trail Energy Center
- ▶ CT-0161 Lake Road Energy Center

These facilities are discussed below.

Nemadji Trail Energy Center (Fuel Oil)

This facility is a proposed 625 MW combined-cycle combustion turbine power plant to be built in Superior, Wisconsin. The plant would consist of a single natural gas-fired Siemens SGT6-8000H turbine with fuel-oil backup. As the facility has not been built, the fuel-oil CO emission limit of 1.5 ppmvd @ 15% O₂ has not been demonstrated in practice. The facility's future is also in doubt, as a request to revoke the issued air permit for the site was submitted in October 2024. With this in mind, this facility should not be considered in the BACT analysis for CO from the combined-cycle combustion turbine operating on fuel oil.

Lake Road Energy Center (Fuel Oil)

Upon further review of this facility's operating permit, the unit is subject to a 4.0 ppmvd @ 15% O₂ CO limit at full load and a 5.0 ppmvd @ 15% O₂ during 75%-99% load. The CO limit reflected in the RBLC database, 1.8 ppmvd, was determined to be inaccurate.

4.2.2.6.3 Summary of CO Limits in Air Permits not in RBLC

Trinity conducted additional research outside of the RBLC and identified a permit for the Marsh Landing Generating Station. This permit was discussed under the NO_x BACT. Marsh Landing is subject to a CO emission limit of 2 ppmvd @ 15% O₂ based on a 1-hour averaging period. The facility is not permitted to operate on fuel oil.

4.2.2.6.4 CO BACT Limit Selection – Simple-Cycle Operation

Proposed Primary (Steady-State) CO BACT Limit - Simple-Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a CO emission level of 2 ppmvd at 15% O₂ is achievable when combusting natural gas in simple cycle mode. Thus, NPPD proposes a BACT limit for CO of 2 ppmvd, corrected to 15% O₂, on a 4-hr averaging basis during simple-cycle operation while firing natural gas, excluding periods of startup and shutdown. A four-hour averaging period is proposed to maintain consistency with the NO_x BACT limit. NPPD will demonstrate compliance using a CEMS.

Proposed Primary (Steady-State) CO BACT Limit – Simple-Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a CO emission level of 2 ppmvd at 15% O₂ is achievable when combusting fuel oil in simple cycle mode. Thus, NPPD proposes a BACT limit for CO of 2 ppmvd, corrected to 15% O₂, on a 4-hr averaging basis during simple-cycle operation while firing natural gas, excluding periods of startup and shutdown. A four-hour

averaging period is proposed to maintain consistency with the NO_x BACT limit. NPPD will demonstrate compliance using a CEMS.

Proposed Secondary (SUSD) CO BACT Limits – Simple-Cycle (Natural Gas/Fuel Oil)

NPPD is proposing a separate simple cycle SUSD event emission limit for CO to minimize the CO emissions prior to the oxidation catalyst being at sufficient temperature. The proposed SUSD limits are as follows, based on the worst case estimated SUSD rates provided by Siemens:

- ▶ Startup: 843.14 lb/event (natural gas), 2480.33 lb/event (fuel oil) and
- ▶ Shutdown: 173.16 lb/event (natural gas), 180.73 lb/event (fuel oil).

NPPD will demonstrate compliance using a CEMS.

“Startup” shall be defined as the period beginning with the first fire of fuel in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode) and the oxidation catalyst is fully operational and controlling emissions, not to exceed 30 minutes.

“Shutdown” shall be defined as the period beginning when the turbine output is lowered with the intent to shutdown (the unit is no longer in steady state operating mode) and the SCR and oxidation catalysts are not operational and ends with the termination of fuel flow, not to exceed 18 minutes.

4.2.2.6.5 CO BACT Limit Selection – Combined-Cycle Operation

Proposed Primary (Steady State) CO BACT Limit – Combined-Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a CO emission level of 2 ppmvd at 15% O₂ is achievable when combusting natural gas in combined cycle mode. Thus, NPPD proposes a BACT limit for CO of 2 ppmvd, corrected to 15% O₂, on a 30-day averaging basis during combined-cycle operation while firing natural gas, excluding periods of startup and shutdown. A 30-day averaging period is proposed to maintain consistency with the NO_x BACT limit. NPPD will demonstrate compliance using a CEMS.

Proposed Primary (Steady State) CO BACT Limit – Combined-Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a CO emission level of 2 ppmvd at 15% O₂ is achievable when combusting fuel oil in combined cycle mode. Thus, NPPD proposes a BACT limit for CO of 2 ppmvd, corrected to 15% O₂, on a 30-day averaging basis during combined-cycle operation while firing fuel oil, excluding periods of startup and shutdown. A 30-day averaging period is proposed to maintain consistency with the NO_x BACT limit. NPPD will demonstrate compliance using a CEMS)

Proposed Secondary (SUSD) CO BACT Limit – Combined-Cycle (Natural Gas/Fuel Oil)

NPPD is proposing a separate combined cycle SUSD event emission limit for CO to minimize the CO emissions prior to the oxidation catalyst being at sufficient temperature. The proposed SUSD limits are as follows, based on the worst case estimated SUSD rates provided by Siemens:

- ▶ Startup: 825.1 lb/event (natural gas), 1638.4 lb/event (fuel oil) and
- ▶ Shutdown: 84.65 lb/event (natural gas), 180.78 (fuel oil).

NPPD will demonstrate compliance using a CEMS.

"Startup" shall be defined as the period beginning with the first fire of fuel in the combustion turbine until the unit is operating at a continuous and stable operating level (normal operating mode) and the oxidation catalyst is fully operational and controlling emissions, not to exceed 180 minutes.

"Shutdown" shall be defined as the period beginning when the turbine output is lowered with the intent to shutdown (the unit is no longer in steady state operating mode) and the SCR and oxidation catalysts are not operational and ends with the termination of fuel flow, not to exceed 18 minutes.

4.2.3 Volatile Organic Compounds (VOC)

This section includes the BACT analysis for VOC for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.3.1 Overview of VOC Emissions from CT

VOC emissions result from incomplete combustion. VOCs are released into the atmosphere when some of the fuel remains unburned or is only partially burned during the combustion process. VOC emissions are higher for gas turbines operating at low loads than for similar gas turbines operating at higher loads, as the former has decreased fuel combustion efficiency.

4.2.3.2 Step 1 - Identification of VOC Control Technologies – CT

VOC emissions can be reduced by two general methodologies: combustion control techniques and post-combustion control methods. Combustion control techniques involve good design on the combustion process and good combustion and operating practices. Post-combustion control can be done with an oxidation catalyst.

4.2.3.2.1 Oxidation Catalyst

With respect to VOCs, oxidation catalysts increase the oxidation rate of organic compounds in exhaust gases produced after fuel combustions. When the exhaust passes over the catalyst bed, oxygen and VOCs migrate to the catalyst surface by gas diffusion and are absorbed onto the catalyst's active sites, where oxidation occurs. The oxidation reaction products are then desorbed from the active sites and transferred by diffusion back into gas stream.

4.2.3.2.2 Good Combustion Practices

Good combustion practices allow the equipment to operate as efficiently as possible. The operating parameters most likely to affect emissions include ambient temperature, fuel characteristics, and air-to-fuel ratios. Good combustion practices involve the monitoring and adjustment of these parameters to ensure all turbine systems, including those intended to minimize pollutant formation, are operating as effectively and efficiently as possible. Modern turbine control systems are typically computer-based and can adjust operating parameters automatically, ensuring complete combustion to minimize VOC emission. This is considered the base-case for the proposed combustion turbines.

4.2.3.3 Step 2 - Elimination of Technically Infeasible VOC Control Options – CT

4.2.3.3.1 Oxidation Catalyst

Catalytic oxidizers typically operate within a temperature range between 600 to 800°F.⁵¹ Given the exhaust temperature of utility-scale simple-cycle combustion turbines is typically in excess of 1,000°F, use of oxidation catalyst could be considered technically infeasible, although the possibility of utilizing tempering air to reduce the inlet exhaust temperature exists for turbine units. The exhaust temperature from the combined-cycle turbines falls well within the operating temperature of typical catalytic oxidation systems. Therefore, oxidation catalyst is considered technically feasible for the proposed turbines.

4.2.3.3.2 Good Combustion Practices

This represents the base case for design and operation of the combustion turbines.

4.2.3.4 Step 3 - Summary and Ranking of Remaining VOC Controls – CT

The only add-on control technically feasible to reduce emissions below the base case (Good Combustion Practices) is oxidation catalyst. As a technically feasible control option, it must be evaluated further in the BACT process.

4.2.3.5 Step 4 - Evaluation of Most Stringent VOC Controls – CT

Oxidation catalyst is the highest ranking potentially feasible control technology for the proposed turbines. NPPD is proposing installation of oxidation catalyst with good combustion practices as BACT.

4.2.3.6 Step 5 - Selection of Emission Limits and Controls for VOC BACT – CT

4.2.3.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The combustion turbines will not be subject to any NSPS or NESHAP standard for VOC, and thus there is no floor for an allowable VOC BACT limit. The units are also not subject to any VOC emission limit per the LLCHD rules or Title 129 of the Nebraska Rules and Regulations.

4.2.3.6.2 Summary of RBLC Review

As the selected BACT for VOC emissions relies on an oxidation catalyst, combustion process design and good combustion practices, EPA'S RBLC database was reviewed to determine what has been established as a BACT emission requirement for comparable operations.

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-5 and D.1-6). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

The VOC limits for the RBLC entries are summarized below:

- ▶ <1 ppmvd (7 entries)
- ▶ 1 – 2 ppmvd (41 entries)
- ▶ 2 ppmvd (19 entries)

⁵¹ U.S. EPA, *CATC Fact Sheet for Catalytic Incineration*, EPA-452/F-03-018. Available at: www.epa.gov/ttn/catc/dir1/fcataly.pdf

- ▶ > 2 ppmvd (8 entries)

4.2.3.6.3 Summary of VOC Limits in Air Permits not in RBLC

Marsh Landing Generating Station

Marsh Landing, discussed in Section 4.2.1.6.3, is subject to a VOC emission limit of 2.9 lb/hr and 0.00132 lb/MMBtu. The facility is not permitted to operate on fuel oil.

4.2.3.6.4 VOC BACT Limit Selection – Simple Cycle Operation

Proposed VOC BACT Limit - Simple-Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a VOC emission level of 2 ppmvd at 15% O₂ is achievable when combusting natural gas in simple cycle mode. Thus, NPPD proposes a BACT limit for VOC of 2 ppmvd, corrected to 15% O₂ during simple-cycle operation while firing natural gas, on a 3-hr average basis, as demonstrated using stack testing.

Proposed VOC BACT Limit – Simple-Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a VOC emission level of 2 ppmvd at 15% O₂ is achievable when combusting fuel oil in simple cycle mode. Thus, NPPD proposes a BACT limit for VOC of 2 ppmvd, corrected to 15% O₂, during simple-cycle operation while firing natural gas, on a 3-hr average basis, as demonstrated using stack testing.

4.2.3.6.5 VOC BACT Limit Selection – Combined-Cycle (Natural Gas/Fuel Oil)

Proposed VOC BACT Limit – Combined-Cycle (Natural Gas)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a VOC emission level of 2 ppmvd at 15% O₂ is achievable when combusting natural gas in combined cycle mode. Thus, NPPD proposes a BACT limit for VOC of 2 ppmvd, corrected to 15% O₂, on a 3-hr average basis, as demonstrated using stack testing.

Proposed VOC BACT Limit – Combined-Cycle (Fuel Oil)

BACT is to be set at the lowest level that is achievable. The oxidation catalyst vendors have indicated that a VOC emission level of 2 ppmvd at 15% O₂ is achievable when combusting fuel oil in combined cycle mode. Thus, NPPD proposes a BACT limit for VOC of 2 ppmvd, corrected to 15% O₂, on a 3-hr average basis, as demonstrated using stack testing.

4.2.4 Sulfur Dioxide (SO₂)

This section includes the BACT analysis for SO₂ for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.4.1 Overview of SO₂ Emissions from CT

SO₂ emissions result from the oxidation of fuel bound sulfur, with emissions dependent solely upon the sulfur content of the fuel.

4.2.4.2 Step 1 - Identification of SO₂ Control Technologies – CT

The available control options identified for SO₂ are listed as follows:

Table 4-8. Possible SO₂ Control Technologies for the Combustion Turbines

Pollutant	Control Technologies
SO ₂	Flue Gas Desulfurization (FGD) Scrubber Low-Sulfur Fuel Good Combustion Practices

4.2.4.2.1 Flue Gas Desulfurization (FGD) Scrubber

FGD systems remove SO₂ from exhaust streams by using an alkaline reagent to form sulfite and sulfate salts.⁵² The reaction of SO₂ with the alkaline chemical can be performed using either a wet or dry contact system. FGD wet scrubbers typically employ sodium, calcium, or dual-alkali reagents using packed or spray towers. Wet FGD systems generate wastewater and wet sludge streams requiring treatment and disposal. In dry FGD systems, an alkaline slurry is injected into the combustion process exhaust stream. The liquid sulfite/sulfate salts that form the reaction of the alkaline slurry with SO₂ are dried by heat contained in the exhaust stream and subsequently removed by downstream particulate control equipment.

4.2.4.2.2 Low-Sulfur Fuel

The use of low sulfur fuels in the CTs decreases the amount of sulfur in the system which ultimately decreases emissions of sulfur compounds including SO₂ and SO₃. NPPD will use pipeline quality natural gas containing a maximum sulfur content of 2 gr S/100 scf, and distillate fuel oil containing no more than 15 ppm sulfur to lower the emissions of SO₂.

4.2.4.2.3 Good Combustion Practices

Operation and maintenance of the equipment in accordance with good air pollution control practices and with good combustion practices results in efficient combustion of fuel, which in turn results in reduced usage of fuel and associated emissions of SO₂.

4.2.4.3 *Step 2 - Elimination of Technically Infeasible SO₂ Control Options – CT*

There have been no applications of FGD scrubbers on natural gas-fired or fuel oil fired combustion turbines due to inherently low SO₂ emissions. In addition, combustion turbines have high exhaust gas flow rates. The low SO₂ emissions combined with the large exhaust gas volume results in very low concentrations of SO₂. Due to the low SO₂ concentration in the exhaust gas, an FGD scrubber would not provide any measurable emission reduction and is therefore technically infeasible.

4.2.4.4 *Step 3 - Summary and Ranking of Remaining SO₂ Controls – CT*

The remaining control technologies are the use of low-sulfur fuel and good combustion practices, the base case for BACT.

⁵² U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization – Wet, Spray Dry, and Dry Scrubbers*, EPA-452/F-03-034.

4.2.4.5 Step 4 - Evaluation of Most Stringent SO₂ Controls – CT

NPPD will implement both these options to reduce SO₂ and H₂SO₄ emissions from the combustion turbines.

4.2.4.6 Step 5 - Selection of Emission Limits and Controls for SO₂ BACT – CT

4.2.4.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

As summarized in detail Section 3 of this application, the proposed combustion turbines will be subject to NSPS KKKK. NSPS KKKK provides that either SO₂ emissions from any turbine must not exceed 0.90 lb SO₂/MWh of gross output, or fuels burned in the turbine must have sulfur content that is below the amount which would result in potential sulfur emissions in excess of 0.060 lb SO₂/MMBtu HHV heat input. NSPS KKKK sets the floor of allowable SO₂ BACT limits.

4.2.4.6.2 Summary of RBLC Review

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-7 and D.1-8). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

These entries were generated by searching the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 15.110 (Simple Cycle >25 MW, Natural Gas-Fired)
 - 15.190 (Simple Cycle >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
 - 15.210 (Combined Cycle & Cogeneration >25 MW, Natural Gas-Fired)
 - 15.290 (Combined Cycle & Cogeneration >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
- ▶ Pollutant Name: Nitrogen Oxides (SO₂)
- ▶ Permit Date: After January 1st, 2014

Results were then manually reviewed, and entries with a single-unit capacity less than 850 MMBtu/hr or 100MW were removed. This is because turbines smaller than about 100MW generally fall under the “aeroderivative” category of combustion turbines and have significantly different operating and emissions profiles such that they should not be directly compared to larger “frame class” combustion turbines. NPPD also considered excluding entries for combustion turbines used for refrigeration or gas compression, but ultimately decided against this.

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-7 and D.1-8). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

4.2.4.6.3 SO₂ BACT Limit Selection

Based on review of the RBLC search results and recently issued permits for similar sized simple- and combined-cycle power plants, limits on sulfur content range from 0.25 to 5 gr S/100 scf natural gas, with separate limits for varying averaging periods. In addition, as shown in Appendix D, the RBLC data search shows that no add-on controls are required for either natural gas- or fuel oil-fired CT generating units to control SO₂ emissions.

NPPD proposes the use of low-sulfur fuels and good combustion practices as BACT for SO₂ emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants, and has

seen some variability. NPPD is proposing as BACT that the natural gas combusted in the CT will contain no more than 2 gr S/100 scf, as an annual average based on fuel records, and fuel oil combusted will contain no more than 15 ppm total sulfur, based on fuel records. As NSPS KKKK does not differentiate between simple- and combined-cycle combustion turbines, and the RBLC search indicates no add-on controls are required for either simple- or combined-cycle units to control SO₂ emissions, NPPD is not proposing separate BACT determinations for different modes of operation.

4.2.5 Filterable Particles (PM, PM₁₀, PM_{2.5})

This section includes the BACT analysis for filterable PM, PM₁₀, and PM_{2.5} for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.5.1 Overview of Filterable PM, PM₁₀, and PM_{2.5} Emissions from CT

Filterable PM, PM₁₀ and PM_{2.5} emissions from gas combustion result primarily from incomplete combustion and also ash and sulfur in the fuel.⁵³ Combustion of natural gas and fuel oil generates low PM emissions in comparison to other fuels due to the low ash and sulfur contents of these fuels. Regardless of the type of fuel combusted, filterable PM generally includes airborne particulate matter which passes through the inlet air filters, inert solids in the fuel supply, and metallic rust or oxidation products.⁵⁴

4.2.5.2 Step 1 - Identification of Filterable PM, PM₁₀, and PM_{2.5} Control Technologies – CT

The following are controls that reduce filterable particulate matter:

- ▶ Multicyclone,
- ▶ Wet Scrubber,
- ▶ Electrostatic Precipitator (ESP),
- ▶ Baghouse,
- ▶ Low sulfur fuel (Base Case), and
- ▶ Good combustion and operating practices (Base Case).

4.2.5.3 Multicyclone

Multicyclones consist of several small cyclones operating in parallel. The cyclones create a double vortex inside their shell, conveying centrifugal force on the inlet exhaust stream. The exhaust stream is then forced to move circularly through the cyclone, and the particulate matter in the stream is pushed to the cyclone walls. While this is effective for larger particles, smaller particles tend to be overtaken by the fluid drag force of the air stream and will depart the cyclones with the exiting air stream. The particulate removal in cyclones can be improved by having more complex gas flow patterns.⁵⁵ The control efficiency range for high efficiency single cyclones is 30 - 90% for PM₁₀ and 20 - 70% for PM_{2.5}. The use of multicyclones leads to greater PM control efficiency than from a single cyclone, resulting in control efficiencies in the range of 80-95% for particles greater than 5 microns in diameter (PM₅).⁵⁶ Multicyclones in parallel can typically handle a

⁵³ AP-42, Chapter 3, Section 1, *Stationary Gas Turbines*, April 2000.

⁵⁴ Wien S, Beres J, Richani B, General Electric Company. *Air Emissions Terms, Definitions and General Information*.; 2005. https://www.gevernova.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/resources/reference/ger-4249-air-emissions-terms-definitions-general-information.pdf

⁵⁵ U.S. EPA, *Clean Air Technology Center, Air Pollution Control Technology Fact Sheet: Cyclones*, EPA-452/F-03-005.

⁵⁶ *Ibid.*

higher flowrate when compared to a single cyclone unit, up to approximately 106,000 standard cubic feet per minute (scfm). The allowable inlet gas temperature for a cyclone is limited by the type of construction material but can be as high as 540°C (1,000°F).⁵⁷ Cyclones are generally used as precleaners for final control devices such as fabric filters/baghouses or ESPs due to the lower control efficiency of smaller particles from a cyclone.⁵⁸

4.2.5.4 Wet Scrubber

Wet (in particular, venturi) scrubbers intercept dust particles using droplets of liquid (usually water). The larger, particle-enclosing water droplets are separated from the remaining droplets by gravity. The solid particulates are then separated from the water. The PM collection efficiencies of Venturi scrubbers range from 70% to greater than 99%, depending on the application. Collection efficiencies are generally higher for PM with aerodynamic diameters of approximately 0.5 µm (PM_{0.5}) to 5 µm (PM₅). Inlet gas temperatures for wet scrubbers usually range from 4 to 400°C (40 to 750°F), with typical gas flowrates for single-throat scrubbers ranging from 500 to 100,000 scfm.⁵⁹

4.2.5.5 ESP

An ESP removes particles from an air stream by electrically charging the particles then passing them through a force field that causes them to migrate to an oppositely charged collector plate. After the particles are collected, the plates are knocked ("rapped"), and the accumulated particles fall into a collection hopper at the bottom of the ESP. The collection efficiency of an ESP depends on particle diameter, electrical field strength, gas flow rate, gas temperature, and plate dimensions. An ESP can be designed for either dry or wet applications.⁶⁰ An ESP can generally achieve approximately 99 - 99.9% reduction efficiency for PM emissions. Typical ESPs can handle approximately 1,000 to 100,000 scfm, at high temperatures up to 700°C (1,300°F).⁶¹

4.2.5.6 Baghouse (Fabric Filter)

A baghouse consists of several fabric filters, typically configured in long, vertically suspended sock-like configurations. Particulate laden gas enters from one side, often from the outside of the bag, passing through the filter media and forming a particulate cake. The cake is removed by shaking or pulsing the fabric, which loosens the cake from the filter, allowing it to fall into a bin at the bottom of the baghouse. The air cleaning process stops once the pressure drop across the filter reaches an economically unacceptable level. Typically, the trade-off to frequent cleaning and maintaining lower pressure drops is the wear and tear on the bags suffered in the cleaning process.⁶² Typically, gas temperatures up to 260°C (500°F) can be accommodated routinely in a baghouse. The fabric filters have relatively high maintenance requirements (for example, periodic bag replacement), and elevated temperatures above the designed temperature can shorten the fabric life. Additionally, a baghouse/fabric filter cannot be operated in moist environments where the condensation of moisture could cause the filter to be plugged, reducing efficiency.

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ U.S. EPA, *Clean Air Technology Center, Air Pollution Control Technology Fact Sheet: Venturi Scrubbers*, EPA-452/F-03-017.

⁶⁰ Kitto, J.B. *Air Pollution Control for Industrial Boiler Systems*. Barberton, OH: Babcock & Wilcox. November 1996.

⁶¹ U.S. EPA, *Clean Air Technology Center, Air Pollution Control Technology Fact Sheet: Dry Electrostatic Precipitator (ESP) – Wire-Pipe Type*, EPA-452/F-03-027.

⁶² Kitto, J.B. *Air Pollution Control for Industrial Boiler Systems*. Barberton, OH: Babcock & Wilcox. November 1996.

Under the proper operating conditions, a baghouse can generally achieve approximately 99-99.9% reduction efficiency for PM emissions.⁶³

Depending on the need, baghouses are available as standard units from the factory, or custom baghouses designed for specific applications. Standard baghouses can typically handle 100 to 100,000 scfm; while custom baghouses are generally larger, ranging from 100,000 to over 1,000,000 scfm.⁶⁴

4.2.5.7 Low Sulfur Fuels

Combusting pipeline-quality natural gas with an inherently low sulfur content reduces particulate emissions compared to other available fuels as there is less potential to form solid sulfates and other sulfur byproducts.

4.2.5.8 Good Combustion and Operating Practices

Good combustion and operating practices will minimize the formation of particulate emissions due to incomplete combustion. Good operating practices typically consist of controlling parameters such as fuel feed rates and air/fuel ratios and periodic tuning.

4.2.5.9 Step 2 - Elimination of Technically Infeasible Filterable PM, PM₁₀, and PM_{2.5} Control Options – CT

All four of the add-on control technologies (multicyclones, wet scrubbers, ESPs, and baghouses) are technically infeasible for filterable particulate from natural gas and fuel oil combustion. Although the add-on control technologies identified are utilized in a number of processes to control particulate emissions, none of these add-on control technologies are applicable to natural gas-fired or fuel oil fired combustion turbines. Combustion of these fuels generates relatively low levels of particulate emissions in comparison to other fuels due to the low ash and sulfur content. In addition, turbines operate with a significant amount of excess air, which generates large exhaust flow rates. The low level of particulate emissions combined with the large exhaust gas volume results in very low concentrations of particulate.

Due to the low particulate concentration in the exhaust gas, add-on filterable particulate controls would not provide any significant degree of emission reduction for the combustion turbines and are therefore not considered further in this analysis.⁶⁵

4.2.5.10 Step 3 - Summary and Ranking of Remaining Filterable PM, PM₁₀, and PM_{2.5} Controls - CT

Of the control technologies available for PM₁₀/PM_{2.5} emissions, the options technically feasible for the turbines are shown in Table 4-99.

⁶³ U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Fabric Filter – Pulse-Jet Cleaned Type*, EPA-452/F-03-025.

⁶⁴ U.S. EPA, Clean Air Technology Center, *Air Pollution Control Technology Fact Sheet: Fabric Filter – Pulse-Jet Cleaned Type*, EPA-452/F-03-025.

⁶⁵ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of particulates, page 43.

Table 4-9. Remaining Particulate Matter Control Technologies – CT

Control Technology	Technically Feasible for Combustion Turbine
Low Sulfur Fuel	Yes
Good Combustion and Operating Practices	Yes

As shown in Table 4-9, the remaining feasible control technologies include low sulfur fuels and good combustion and operating practices. Good combustion and operating practices in conjunction with low sulfur fuel represent the base case for the combustion turbines. Therefore, as this is the highest-ranking feasible control remaining, it is selected as BACT.

4.2.5.11 Step 4 - Evaluation of Most Stringent Filterable PM, PM₁₀, and PM_{2.5} Controls – CTs

Good combustion and operating practices with natural gas and low sulfur fuel oil is the most stringent filterable PM, PM₁₀, and PM_{2.5} control that is a technically feasible option. NPPD will use pipeline quality natural gas containing a maximum sulfur content of 0.5 gr S/100 scf, and distillate fuel oil containing no more than 15 ppm sulfur to lower the emissions of filterable PM, PM₁₀, and PM_{2.5}.

4.2.5.12 Step 5 - Selection of Emission Limits and Controls for Filterable PM

PM is comprised of only filterable particulate emissions, but PM₁₀ and PM_{2.5} include both filterable particulate emissions, as described above, as well as condensable particulate emissions as described below.

For filterable PM, NPPD proposes the use of low-sulfur fuels and good combustion practices as BACT for SO₂ emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants, and has seen some variability. NPPD is proposing as BACT that the natural gas combusted in the CT will contain no more than 2 gr S/100 scf, as an annual average based on fuel records, and fuel oil combusted will contain no more than 15 ppm total sulfur, based on fuel records.

For filterable PM₁₀ and PM_{2.5}, it is common for permits to include limits on total particulates and to require testing of both the filterable and condensable particles as part of demonstrating compliance with the limits. NPPD is proposing a combined limit for the filterable and condensable PM₁₀ and PM_{2.5} emissions, as further summarized in the section following BACT for condensable PM.

4.2.6 Condensable PM, Including Sulfuric Acid (H₂SO₄)

This section includes the BACT analysis for condensable PM for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.6.1 Overview of Condensable PM Emissions from CT

In contrast to filterable particulate, condensable particulate (PM_{con}) is the portion of PM emissions that exhausts from the stack in gaseous form but condenses to form particulate matter once mixed with the cooler ambient air. Condensable particulate results from sulfur in the fuel and the resultant H₂SO₄, NO_x being oxidized to nitric acid (HNO₃), unburned fuel hydrocarbons, fluids used in the manufacture of the turbine, and other undefined condensables. A combustion turbine operating without an SCR will have lower condensable PM emissions than a similar unit operating with an SCR. The increased condensables result from formation of ammonium sulfates from unreacted ammonia in the control system. Accordingly, emission

estimates for total PM₁₀/PM_{2.5} when utilizing an SCR for NO_x emissions reductions are higher than the total PM₁₀/PM_{2.5} emissions anticipated from turbine systems that do not utilize NO_x controls.

4.2.6.2 Step 1 - Identification of Condensable PM Control Technologies– CT

Based on RBLC search and experience in conducting control technology reviews for similar types of equipment, it is concluded that add-on controls are not available for the control of condensable particulate matter emissions from combustion turbines. Pre-combustion controls must be deployed instead, and include:

- ▶ Wet Scrubbers
- ▶ Wet Electrostatic Precipitators (ESPs)
- ▶ Low-sulfur fuels
- ▶ Good Combustion and Operation Practices

4.2.6.2.1 Wet Scrubber

Wet scrubbers for the control of particulate matter are designed to bring a gas stream into contact with water droplets such that the PM is captured by the droplets and the dirty liquid containing the PM is collected, treated, and either discharged or reused. The cleaned gas exits the scrubber, often passing through a demister to remove moisture.

4.2.6.2.2 Wet ESP

Wet ESPs are designed to remove particulates especially submicron particles, aerosols, and condensable compounds using electrostatic forces in a wet environment. It combines the high-efficiency particle collection of a dry ESP with the benefits of wet scrubbing, making it ideal for applications where the gas is humid, sticky, corrosive, or where ultra-fine PM must be removed.

4.2.6.2.3 Low-Sulfur Fuels

Combusting pipeline-quality natural gas with an inherently low sulfur content reduces particulate emissions compared to other available fuels as there is less potential to form H₂SO₄.

4.2.6.2.4 Good Combustion and Operating Practices

Good combustion and operating practices imply that the unit is operated within parameters that, without significant control technology, allow the equipment to operate as efficiently as possible.

A properly operated combustion unit will minimize the formation of condensable particulate emissions due to incomplete combustion. Good operating practices typically consist of controlling parameters such as fuel feed rates and air/fuel ratios and periodic tuning.

4.2.6.3 Step 2 - Elimination of Technically Infeasible Condensable PM Control Options – CT

Wet scrubbers and wet ESPs are technically infeasible for NG combustion. Although the add-on control technologies are utilized in a number of processes to control particulate emissions, none of these add-on control technologies are applicable to NG or ULSD-fired combustion turbines. Combustion of NG and ULSD generates relatively low levels of particulate emissions in comparison to other fuels due to the low ash and sulfur content. In addition, turbines operate with a significant amount of excess air, which generates large

exhaust flow rates. The low level of particulate emissions combined with the large exhaust gas volume results in very low concentrations of particulate.

Due to the low particulate concentration in the exhaust gas, add-on filterable particulate controls would not provide any significant degree of emission reduction for the combustion turbines and are therefore not considered further in this analysis.⁶⁶

The use of low-sulfur fuels and good combustion and operating practices for the reduction of condensable PM emissions is considered technically feasible for the proposed combustion turbines.

4.2.6.4 Step 3 - Summary and Ranking of Remaining Condensable PM Controls – CT

The options technically feasible for PM_{con} emissions reductions from turbines are shown in Table 4-10-10.

Table 4-10. Remaining Particulate Matter Control Technologies - CT

Control Technology	Technically Feasible for Combustion Turbine
Low Sulfur Fuel	Yes
Good Combustion and Operating Practices	Yes

The remaining feasible control technologies include low sulfur fuels and good combustion and operating practices. Good combustion and operating practices in conjunction with low sulfur fuel represent the base case for the combustion turbines. Therefore, as this is the highest-ranking feasible control remaining, it is selected as BACT.

4.2.6.5 Step 4 - Evaluation of Most Stringent Condensable PM Controls – CT

As stated previously, good combustion and operating practices with low sulfur fuel for the combustion turbines was determined as the most stringent condensable PM control that is a technically feasible option.

4.2.6.6 Step 5 - Selection of Emission Limits and Controls for Filterable PM, PM₁₀, PM_{2.5} BACT – CT

Since it is common for permits to include limits on total particulates and to require testing of both the filterable and condensable particles as part of demonstrating compliance with the limits, NPPD is proposing BACT limits for total particulates, NPPD has completed a Step 5 review to determine BACT for total PM₁₀ and total PM_{2.5}, as further summarized below.

4.2.7 Combined PM Filterable and Condensable - Total PM₁₀, Total PM_{2.5}

NPPD is proposing BACT limits for total PM₁₀ and total PM_{2.5}, as further summarized below.

⁶⁶ Application No. 17040013, *Project Summary for a Construction Permit Application from Jackson Generation, LLC, for an Electrical Generating Facility in Elwood, Illinois*, issued by the Illinois EPA for the public comment period beginning on September 21, 2018. Discussion related to selection of BACT for emissions of particulates, page 43.

4.2.7.1 Step 5 PM BACT Limit Selection – Simple-Cycle Operation

PM is comprised of only filterable particulate emissions, but PM₁₀ and PM_{2.5} include both filterable and condensable particulate emissions.

NPPD is proposing a combined limit for the filterable and condensable PM₁₀ and PM_{2.5} emissions, as further summarized below.

4.2.7.1.1 Summary of RBLC Review

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-9 and D.1-10, D.1-11, and D.1-12). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

A review of the RBLC entries listed in this section provides an indication of what has been established as BACT emission limitations for potentially similar units to those being proposed for installation by NPPD. BACT limits for these entries are typically presented as separate limits on PM and PM₁₀/PM_{2.5}, although some entries include a limit on 'PM', 'PM₁₀', or 'PM_{2.5}' only. Limits on PM_{filt} range from 0.0025 lb/MMBtu to 0.005 lb/MMBtu. Limits on PM₁₀/PM_{2.5} (including limits on only PM₁₀ or PM_{2.5}) range from 0.0036 lb/MMBtu to 0.044 lb/MMBtu. Limits on PM only (including unspecified PM limits) range from 0.0026 lb/MMBtu to 0.01 lb/MMBtu. Note, for most of the RBLC entries, it is not obvious whether the PM limits are for filterable only particulate or if they cover total particulate, inclusive of condensable particulate.

Only three RBLC entries for simple-cycle units of comparable size utilize SCR for NO_x emissions reductions and would therefore be comparable for PM/PM₁₀/PM_{2.5} emission limitations. These entries are listed below in Table 4-11.

Table 4-11. Simple-Cycle Natural-Gas Combustion Turbine PM RBLC Entries for Similar Units with SCR

Facility Name	State	Permit Issuance	System Size	PM/PM ₁₀ /PM _{2.5} Emission Limit ^[1]	Units ^[1]	Averaging Period ^[1]	Notes
Alaska LNG Liquefaction Facility	AK	7/7/2022	1113 MMBtu/hr (each)	0.007	lb/MMBtu	3-hr	BACT noted as GCP and clean fuels (natural gas).
Troutdale Energy Center	OR	3/5/2014	1690 MMBtu/hr (each)	9.1	lb/hr	6-hr	BACT noted as clean fuels (natural gas or ULSD) and limited SUSD time.
Sr. Berton Electric Generating Station	TX	12/19/2014	215-359 MW (each)	Limit not indicated			BACT noted as GCP.

^[1] Please note that the Emission Limit and Averaging Periods for each RBLC entry was cross referenced with the associated air permit for each entry, as available. Corrections were made as necessary, to ensure that emission limits and averaging periods were consistent with the air permits associated with each RBLC entry.

Of the RBLC entries in Table 4-11, only the Alaska LNG facility has a limit based on heat input, in units of lb/MMBtu. Converting the Troutdale Energy Center lb/hr limit to lb/MMBtu, based on the throughput listed on RBLC, yields a limit of 0.0054 lb/MMBtu. No limit was indicated in the RBLC entry for Sr. Berton Electric Generating Station; BACT for this site was determined to be Good Combustion Practices. It should be noted that neither the Alaska LNG facility nor Troutdale Energy Center have been constructed, and thus their emission limits have not been demonstrated in practice.

4.2.7.1.2 Total PM₁₀ and Total PM_{2.5} BACT Limit Selection – Simple-Cycle Operation

NPPD is proposing the use of natural gas and low sulfur fuel oil as BACT for filterable PM, total PM₁₀, PM_{2.5}. The turbine vendors provided total PM₁₀ and total PM_{2.5} emission rates for a variety of operational scenarios and have also provided guaranteed emission rates. The emission rates are based on the use of natural gas and ultra-low sulfur diesel. Consequently, NPPD is proposing the vendor estimates as BACT. The proposed BACT limits are included in Table 4-12 and Table 4-13 below. NPPD is proposing to demonstrate compliance with the proposed limits using performance testing.

Table 4-12. Simple-Cycle Total PM₁₀/Total PM_{2.5} BACT Limits for CT (Siemens, Natural Gas)

Generating Load	BACT Limit (lb/MMBtu)
100%	0.0055

Table 4-13. Simple-Cycle Total PM₁₀/Total PM_{2.5} BACT Limits for CT (Siemens, Fuel Oil)

Generating Load	BACT Limit (lb/MMBtu)
100%	0.011

4.2.7.1.3 Total PM₁₀ and Total PM_{2.5} BACT Limit Selection – Combined-Cycle Operation

The turbine vendors provided total PM₁₀ and total PM_{2.5} emission rates for a variety of operational scenarios. The emission rates are based on the use of natural gas and ultra-low sulfur diesel. Consequently, NPPD is proposing the vendor estimates as BACT. The proposed limits are included in Table 4-14 and Table 4-15. In general, the proposed limits for natural gas operation at full load are within the range expected based on the RBL search, considering that the proposed limits are inclusive of all forms of particulate matter. NPPD is proposing to demonstrate compliance with the proposed limits using performance testing.

Table 4-14. Combined-Cycle Total PM₁₀/Total PM_{2.5} BACT Limits for CT (Siemens, Natural Gas)

Generating Load	BACT Limit (lb/MMBtu)
100%	0.0063

Table 4-15. Combined-Cycle Total PM₁₀/Total PM_{2.5} BACT Limits for CT (Siemens, Fuel Oil)

Generating Load	BACT Limit (lb/MMBtu)
100%	0.0314

4.2.8 Greenhouse Gases (CO₂)

This section includes the BACT analysis for CO₂ for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.8.1 Overview of GHG Emissions (CO₂) from CT

CO₂ production from combustion occurs by a reaction between carbon and oxygen in the air and proceeds stoichiometrically (for every 12 pounds of carbon burned, 44 pounds of CO₂ is emitted).⁶⁷

4.2.8.2 Step 1 - Identification of CO₂ Control Technologies – CT

Trinity reviewed the large body of information on GHG emissions from combustion turbines compiled from various rulemakings, such as the NSPS Subpart TTTTa preamble. The RBLC lists technologies and corresponding emission limits that have been approved by regulatory agencies in permit actions. These results are included in Appendix D, detailing emission levels proposed for similar types of emissions units. Based on the RBLC search, no add-on control methods for GHGs have been deemed BACT for any facility. Many of the RBLC entries list a variant of good combustion practices, efficient operation, state-of-the-art technology, or low emitting fuels (e.g., pipeline-quality natural gas and ULSD).

The following potential CO₂ control strategies were considered as part of this BACT analysis:

- ▶ Carbon Capture and Storage (CCS);
- ▶ Low Carbon Fuels; and
- ▶ Efficient Turbine Operation and Good Combustion, Operating, and Maintenance Practices

These control technologies are discussed in the following sections.

4.2.8.2.1 Carbon Capture and Storage

CCS, also known as CO₂ sequestration, involves cooling, separation and capture of CO₂ emissions from the flue gas prior to being emitted from the stack, compression of the captured CO₂, transportation of the compressed CO₂ via pipeline, and finally injection and long-term geologic storage of the captured CO₂. For CCS to be technically feasible, all three components needed for CCS must be technically feasible; carbon capture and compression, transport, and storage.

The first phase in CCS is to separate and capture the CO₂ gas from the exhaust stream, and then to compress the CO₂ to a supercritical condition.⁶⁸ Since most storage locations for CO₂ are greater than 800 meters deep, where the natural temperatures and pressures are greater than the critical point for CO₂, to inject CO₂ to those depths requires pressurizing the captured CO₂ to a supercritical state.

CO₂ capture can be performed via four main methods: absorption, adsorption, membranes, and cryogenic separation. The choice of the precise process varies with the properties of the exhaust stream. CO₂ separation has been well demonstrated in the oil and gas industries, but the characteristics of those streams are very different from a turbine system exhaust. Most combustion tests and projects have been on exhaust streams from coal combustion, which has more highly concentrated CO₂ than exhaust from natural gas combustion, or on natural gas combined-cycle systems. Existing CO₂ capture technologies have not been demonstrated in the context of capturing CO₂ from simple-cycle combustion turbines, regardless of industry

⁶⁷ *NC Greenhouse Gas (GHG) Inventory Instructions for Voluntary Reporting, November 2009*. Prepared by the North Carolina Division of Air Quality.

https://files.nc.gov/ncdeq/Air%20Quality/inventory/forms/GHG_Emission_Inventory_Instructions_Nov2009_Voluntary.pdf

⁶⁸ Supercritical means that the CO₂ has properties of both a liquid and a gas. Supercritical CO₂ is dense like a liquid but has a viscosity like a gas. For additional details see <https://www.netl.doe.gov/coal/carbon-storage/faqs/carbon-storage-faqs>

use, as they have higher exit gas temperatures, lower exhaust gas CO₂ concentrations, and lower cycle efficiencies, which negatively affects the ability of the CCS systems to control CO₂ emissions.⁶⁹

Once separated, CO₂ must be compressed to supercritical conditions for transport and storage. There are no technical challenges with compressing CO₂ to those levels, but specialized technologies with high operating energy requirements are necessary. The CO₂ could be compressed to supercritical either before or after transport.

For phase two, CO₂ would be transported to a repository. Transport options could include pipeline or truck. Specialized designs may be required for CO₂ pipelines, particularly if supercritical CO₂ is being transported. Transport of CO₂ by pipeline is a demonstrated technology, but currently most CO₂ pipelines are in rural areas. Obtaining right-of-way in developed areas is difficult.

Various CO₂ storage methods have been proposed, though only geologic storage is achievable currently. Geologic storage involves injecting CO₂ into deep subsurface formations for long-term storage. Typical storage locations would be deep saline aquifers as well as depleted or un-mineable coal seams. Captured CO₂ could also potentially be used for enhanced oil recovery via injection into oil fields.

4.2.8.2.2 Efficient Turbine Operation and Good Combustion, Operating, and Maintenance Practices

As the baseline of most analyses, pollutant formation can be most cost-effectively minimized by efficient turbine design and good combustion, operating, and maintenance practices.

Within combustion units, operators can control the localized peak combustion temperature and combustion stoichiometry to achieve efficient fuel combustion. Outside of the unit, energy loss can be minimized by providing sufficient insulation to the combustion units and associated duct work.

For the purposes of this GHG control technology assessment, it is important to note that good operating practices includes periodic maintenance by abiding by an operations and maintenance (O&M) plan. Maintaining the combustion units to the designed combustion efficiency and operating parameters is important for energy efficiency related requirements and efficient operation.

4.2.8.3 Step 2 - Elimination of Technically Infeasible CO₂ Control Options – CT

4.2.8.3.1 Carbon Capture, Transport, and Storage

CCS involves cooling, separation and capture of CO₂ from the flue gas prior to the flue gas being emitted from the stack, compression of the captured CO₂, transportation of the compressed CO₂ via pipeline, and finally injection and long-term geologic storage of the captured CO₂. For CCS to be technically feasible, all three components (carbon capture and compression, transport, and storage) must be technically feasible.

It should be noted that there is little to no research that has been completed on the implementation of CCS systems on simple-cycle turbines. Though the lack of research is due to general industry understanding that it is impossible to utilize a CCS system on a simple-cycle turbine, the technical feasibility is still conservatively examined in this section. However, due to this lack of research on simple-cycle turbines, the

⁶⁹ *Carbon Capture Opportunities for Natural Gas Fired Power Systems*, US Department of Energy, accessed January 2021. https://www.energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%20Opportunities%20for%20Natural%20Gas%20Fired%20Power%20Systems_0.pdf

technical feasibility in this section is completed using data collected on CCS systems installed on combined-cycle turbines.

Carbon Capture

In the Interagency Task Force report on CCS technologies, a number of pre- and post-combustion CCS projects are discussed in detail; however, many of these projects are in formative stages of development and are predominantly power plant demonstration projects (and mainly slip stream projects).⁷⁰ Currently, only two options appear to be feasible for capture of CO₂ from the flue gas from the turbine systems: Post-Combustion Solvent Capture and Stripping and Post-Combustion Membranes. In one 2009 M.I.T. study conducted for the Clean Air Task Force, it was noted that "To date, all commercial post-combustion CO₂ capture plants use chemical absorption processes with monoethanolamine (MEA)-based solvents."⁷¹

A review of the U.S. Department of Energy's (DoE) National Energy Technology Laboratory's (NETL) research and development awards related to post-combustion capture of CO₂ indicates that moving from pilot scale tests at coal-fired power plants to large-scale commercial operations remains a focus; however, the existence of several Front End Engineering Design (FEED) studies indicates that commercial implementation is beginning to move forward.⁷² For example, a FEED study is underway for a commercial-scale carbon capture facility retrofitted at the Delta Energy Center in Pittsburg, CA, capable of capturing 2.4MM tons of CO₂ per year.⁷³ Another FEED study is underway for a 1.7MM ton/yr CO₂ capture project at Louisville Gas And Electric Kentucky Utilities Cane Run #7.⁷⁴

Although FEED studies indicate heightened interest in exploring potential implementation opportunities for CCS, NPPD is aware of only one successful CCS deployment on a combined-cycle combustion turbine facility. The Bellingham Energy Center captured CO₂ from a slipstream (i.e., a portion of the turbine exhaust stream) for use in the food industry and operated from 1991 to 2005.⁷⁵ Additionally, a planned 2,000 MW natural-gas combined-cycle power plant with CCS is expected to come online towards the end of the 2020s, but construction is not expected to start for several years at least.⁷⁶

Presuming carbon capture is feasible, prior to sending the CO₂ stream to the appropriate storage site, it is necessary to compress the CO₂ from near atmospheric pressure to pipeline pressure (around 2,000 psia). The compression of the CO₂ would require a large auxiliary power load, resulting in additional fuel (and CO₂

⁷⁰ *Report of the Interagency Task Force on Carbon Capture and Storage*, August 2010, Section III, pages. 27-52.
https://www.energy.gov/sites/prod/files/2013/04/f0/CCSTaskForceReport2010_0.pdf

⁷¹ Herzog, Meldon, Hatton, *Advanced Post-Combustion CO₂ Capture*, April 2009, page 7.
https://sequestration.mit.edu/pdf/Advanced_Post_Combustion_CO2_Capture.pdf

⁷² Website reviewed June 2024: <https://netl.doe.gov/node/2476?list=Post-Combustion%20Capture>

⁷³ *Front-End Engineering Design for a CO₂ Capture System at Calpine's Delta Energy Center*, U.S. Department of Energy, National Energy Technology Laboratory, Project Review Meeting Presentation for Project Number FE0032149, start date February 1, 2022.

⁷⁴ *CO₂ Capture at Louisville Gas & Electric Cane Run Natural Gas Combined Cycle Power Plant*, U.S. Department of Energy, National Energy Technology Laboratory, Project Review Meeting Presentation for Project Number FE0032223, start date December 22, 2022.

⁷⁵ *Greenhouse Gas Mitigation Measures: Carbon Capture and Storage for Combustion Turbines Technical Support Document*, U.S. Environmental Protection Agency, Office of Air and Radiation, May 23, 2023. (pp. 23)

⁷⁶ *Company Responds as PSC green lights siting for future plant in Doddridge County*, West Virginia Metro News, May 5, 2024.
<https://wvmetronews.com/2024/05/05/psc-green-lights-siting-certificate-for-cpvs-future-plant-in-doddridge-county/>

emissions) to generate the same amount of power.⁷⁷ The auxiliary power load could be handled by installation of a separate system to solely support CO₂ compression, or alternatively be supported by reducing the available energy for sale, relying on the energy generating systems to instead meet the power needs of the compression system. This is often referred to as an “energy penalty” for operation of the CO₂ compression system, and in effect can reduce the net CO₂ reduction of the CCS system.

Carbon Transport

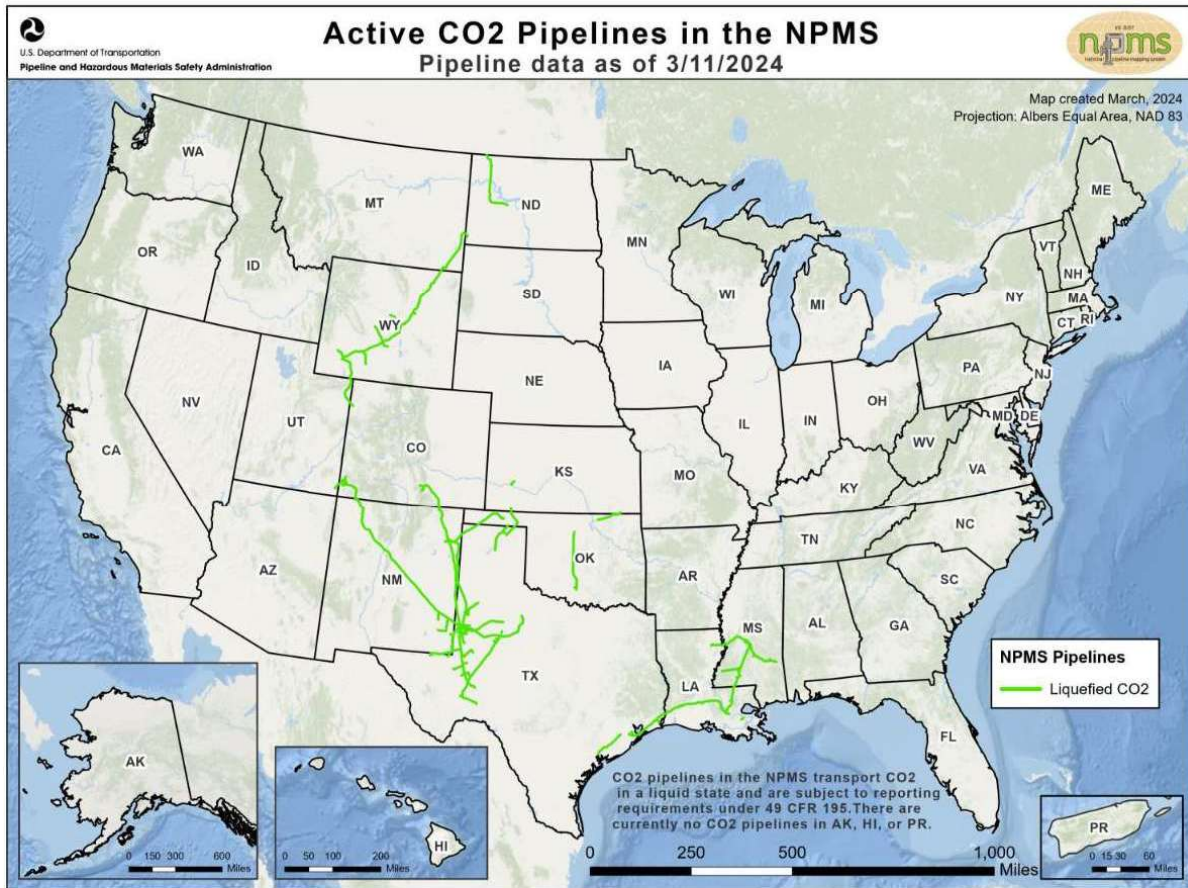
The next step in CCS is the transport of the captured and compressed CO₂ to a suitable location for storage. This would typically be via pipeline. Pipeline transport is an available and demonstrated, although costly, technology. Short CO₂ pipelines have been constructed from power plants to proposed injection wells. However, these pipelines are dedicated use for the power plants and are unavailable for other industrial sites.

Since there are no other CO₂ pipelines in the area, NPPD would need to construct a CO₂ pipeline to a storage location if it were to pursue carbon sequestration as a CO₂ control option.⁷⁸ While it may be technically feasible to construct a CO₂ pipeline, considerations regarding the land use and availability need to be made. For the purposes of this analysis, it is conservatively assumed that a shortest distance pipeline can be built from a potential sequestration site to a potential carbon storage location. Realistically, a longer pipeline would be required to address land use and right-of-way considerations.

⁷⁷ *Report of the Interagency Task Force on Carbon Capture and Storage*, August 2010, page 29.
https://www.energy.gov/sites/prod/files/2013/04/f0/CCSTaskForceReport2010_0.pdf

⁷⁸ *Active CO₂ Pipelines in the NPMS*, U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration National Pipeline Mapping System, March 11, 2024.
https://www.npms.phmsa.dot.gov/Documents/NPMS_CO2_Pipelines_Map.pdf

Figure 4-1. NPMS Active CO₂ Pipelines



Carbon Storage

Capture of the CO₂ stream and transport are not sufficient control technologies by themselves but require the additional step of permanent storage. After separation and transport, storage could involve sequestering the CO₂ through various means such as enhanced oil recovery, injection into saline aquifers, and sequestration in un-mineable coal seams, each of which are discussed as follows:

- ▶ **Enhanced Oil Recovery (EOR):** EOR involves injecting CO₂ into a depleted oil field underground, which increases the reservoir pressure, dissolves the CO₂ in the crude oil (thus reducing its viscosity) and enables the oil to flow more freely through the formation with the decreased viscosity and increased pressure. A portion of the injected CO₂ would flow to the surface with the oil and be captured, separated, and then re-injected. At the end of EOR, the CO₂ would be stored in the depleted oil field.
- ▶ **Saline Aquifers:** Deep saline aquifers have the potential to store post-capture CO₂ deep underground below impermeable cap rock
- ▶ **Un-Mineable Coal Seams:** Additional storage is possible by injecting the CO₂ into un-mineable coal seams. This has been used successfully to recover coal bed methane. Recovering methane is enhanced by injecting CO₂ or nitrogen into the coal bed, which adsorbs onto the coal surface thereby releasing methane.

There are additional methods of sequestration such as direct ocean injection of CO₂ and algae capture and sequestration (and subsequent conversion to fuel); however, these methods are not as widely documented in the literature for industrial scale applications. As such, while capture-only technologies may be

technologically available at a small-scale, the limiting factor is the availability of a mechanism for NPPD to permanently store the captured CO₂.

NETL's Carbon Capture and Storage Database provides a summary of potential storage locations.⁷⁹ According to the database, the nearest potential sequestration sites where test wells were drilled are the Sleepy Hollow Field in southwest-central Nebraska and a site near Madrid, Nebraska, which were investigated as part of the Integrated Midcontinent Stacked Carbon Storage Hub.⁸⁰ Madrid, NE, the closer of the two sites, is about 250 miles from the proposed project location, as the crow flies. It should be noted that these sequestration sites were part of a feasibility study only; NPPD is not aware of plans to develop these sites for commercial use.

Elimination of CCS as Technically Feasible

NPPD has concluded that CCS technology is not technically feasible at this time for simple cycle operations, based on the following key considerations:

- The simple cycle operations will involve frequent starts and stops and will have variable operating loads leading to variable CO₂ emissions;
- Solvent-based carbon capture systems have never been demonstrated for a simple-cycle combustion turbine, and are generally considered infeasible for use in simple-cycle combustion turbines due to the low CO₂ concentration of the exhaust gas;
- There are no existing or planned CO₂ pipelines within a reasonable distance from the proposed project; and
- There are no existing or planned commercially available sequestration sites within a reasonable distance from the proposed project.

Further, NPPD has concluded that CCS technology is not technically feasible at this time for combined cycle operations, based on the following key considerations:

- Solvent-based carbon capture systems have never been demonstrated on the scale of the PRS units due to the low CO₂ concentration of the exhaust gas;
- There are no existing or planned CO₂ pipelines within a reasonable distance from the proposed project; and
- There are no existing or planned commercially available sequestration sites within a reasonable distance from the proposed project.

4.2.8.3.2 Efficient Turbine Operation and Good Combustion, Operating, and Maintenance Practices

Efficient turbine operation coupled with good combustion, operating, and maintenance practices are a potential control option for optimizing the fuel efficiency of the combustion turbines. Combustion turbines typically operate in a lean pre-mix mode to ensure an effective staging of air/fuel ratios in the turbine to maximize fuel efficiency and minimize incomplete combustion. Furthermore, the turbine systems are sufficiently automated to ensure optimal fuel combustion and efficient operation leaving virtually no need for operator tuning of these aspects of operation.

Therefore, efficient turbine operation coupled with good combustion, operating, and maintenance practices is evaluated further for CO₂ BACT purposes.

⁷⁹ Carbon Capture and Storage Database maintained by the NETL, accessed July 2021 at <https://www.netl.doe.gov/coal/carbon-storage/worldwide-ccs-database>

⁸⁰ *Integrated Mid-Continent Stacked Carbon Storage Hub Project Phase II Final Summary Report*, Batelle, December 18, 2020. <https://www.kgs.ku.edu/PRS/IMSCSH/pdfs/IMSCS-HUB%20Final%20Summary%20Report.pdf>

4.2.8.4 Step 3 - Summary and Ranking of Remaining CO₂ Controls – CT

Efficient turbine operation and good combustion, operating, and maintenance practices is the only remaining control method. Reduction efficiency is not applicable for this control method.

4.2.8.5 Step 4 - Evaluation of Most Stringent CO₂ Controls – CT

As efficient turbine operation and good combustion, operating, and maintenance practices is the only remaining control method, no ranking of control methods is required.

4.2.8.6 Step 5 - Selection of Emission Limits and Controls for CO₂ BACT – CT

4.2.8.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

As summarized in detail Section 3 of this application, the proposed combustion turbines will be subject to NSPS Subpart TTTT_a, as finalized by EPA on April 25th, 2024. The NSPS includes CO₂ emission limits for combustion turbines, based on the annual capacity factor of the turbines, where capacity factor in this case means net electric sales as a percentage of potential electric output. The CO₂ emission limits are as follows:

- ▶ Base load combustion turbine
 - Phase 1 (prior to January 2032): 800 to 1,250 lb CO₂/MWh-gross energy output energy output energy⁸¹, based on combined cycle operation;
 - Phase 2 (after December 2031): 100 to 150 lb CO₂/MWh-gross energy output, as determined by 40 CFR 63.5525a, based on carbon capture and sequestration;
- ▶ Intermediate load combustion turbine:
 - 1,170 - 1560 lb CO₂/MWh-gross energy output, as determined by 40 CFR 63.5525a, based on highly efficient generation; and
- ▶ Low Load combustion turbine:
 - 120-160 lb CO₂/MMBtu of heat input, as determined by 40 CFR 63.5525a, based on the use of clean fuels such as natural gas and hydrogen.

4.2.8.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 15.110 (Simple Cycle >25 MW, Natural Gas-Fired)
 - 15.190 (Simple Cycle >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
 - 15.210 (Combined Cycle & Cogeneration >25 MW, Natural Gas-Fired)
 - 15.290 (Combined Cycle & Cogeneration >25 MW, Liquid Fuel & Liquid Fuel Mixtures)
- ▶ Pollutant Name: Nitrogen Oxides (NO_x)
- ▶ Permit Date: After January 1st, 2014

Trinity reviewed the results of the RBLC search and, for the sake of brevity, removed entries for units less than 850 MMBtu/hr or 100MW. This is because turbines smaller than about 100MW generally fall under the "aeroderivative" category of combustion turbines and are not directly comparable to larger "frame class"

⁸¹ In accordance with 40 CFR 60.5520a(c), the emission limits should be based on gross energy output unless the owner or operator of a stationary combustion turbine petitions the Administrator in writing to comply with the alternate applicable net energy output standard. If the Administrator grants the petition, beginning on the date the Administrator grants the petition, the affected EGU must comply with the applicable net energy output-based standard.

combustion turbines. Note that there are no RBLC entries for aeroderivative turbines with emission limits lower than proposed BACT limits.

The detailed RBLC search results tables are provided in Appendix D (Tables D.1-13 and D.1-14). The results are separated based on fuel type – RBLC results for both simple and combined cycle and RBLC results for natural gas and fuel oil.

BACT determinations for similar simple- and combined-cycle generating units, as summarized in the Appendix D tables, denote energy efficiency, good design and good combustion practices as BACT. Post-combustion capture and sequestration of CO₂ is not required. BACT limits for combustion turbines can be found expressed in terms of lb/MMBtu, lb/MWh, Btu/kWh, or tons, typically with a 12-month rolling averaging period.

4.2.8.6.3 Summary of CO₂ Limits in Air Permits not in RBLC

No emission limits that were lower than any limits in the RBLC have been identified.

4.2.8.6.4 CO₂ BACT Limit Selection – Simple-Cycle Operation

Since NSPS TTTTa is currently in effect, NPPD is proposing NSPS TTTTa as the BACT floor and will comply with the applicable requirements. However, NPPD does not believe that the NSPS limits are achievable, and if the NSPS were overturned or the limits were otherwise not in effect at the time this application is being reviewed or when the units are operational, NPPD has proposed BACT limits based on what is really achievable.

NSPS Subpart TTTTa requires carbon-capture implementation for base-load combustion turbines by 2032. Following publication in April 2024, the rule was immediately challenged in the D.C. Circuit court by a coalition of states, utilities, and industry groups. On July 19th, 2024, a three-judge panel of the Court of Appeals for the D.C. Circuit unanimously denied a motion to stay the rule pending the outcome of the litigation, and on July 29th, 2024, the coalition filed an emergency stay application with the Supreme Court (“SCOTUS”). On October 16th, 2024, SCOTUS denied this application, allowing the rule to remain in effect while proceedings play out in lower courts. The Trump EPA filed a motion with the U.S. Court of Appeals, and the litigation over the NSPS is currently held in abeyance while EPA reconsiders the rule.⁸²

NSPS Subpart TTTTa requires highly efficient generation for intermediate-load combustion turbines.

While compliance with the NSPS TTTTa limits would be challenging,

Under NSPS Subpart TTTTa, NPPD plans to operate the proposed turbines as intermediate-load units to avoid the requirement to add carbon capture and sequestration. NPPD does not believe that carbon capture is technically feasible for the reasons described in Step 2 of the CO₂ BACT analysis.

The NSPS Subpart TTTTa CO₂ limit for an intermediate load unit is 1,170 lb CO₂/MWh-gross energy output for natural gas and 1,560 lb CO₂/MWh-gross energy output for fuel oil.

NPPD has reviewed the Siemens simple cycle data – the CO₂ ranges from of 1,124 lb/MWh-gross to 1,553 lb/MWh-gross from base load to the Minimum Emission Complaint Load (MECL) on natural gas, and from 1,529 lb/MWh-gross to 2,041 lb/MWh-gross from base load to MECL on fuel oil. The Siemens CO₂ data are

⁸² *West Virginia v. EPA*, Docket No. 24-1120 (D.C. Cir.)

generally consistent with EPA's review of reported emissions and operating data when evaluating the intermediate load standard. EPA states that "[...] this emissions rate has been demonstrated by a frame simple turbine" (emphasis added).⁸³ EPA did not provide details on the location or model of the turbine in question.

Since the CO₂ at lower loads is above the limits, NPPD will have to consider the impact of operating load on CO₂ as part of demonstrating compliance. That said, since data from the manufacturer of a newer highly efficient frame for a frame-class turbines illustrates a difficulty achieving the intermediate load standard of 1,170 lb CO₂/MWh-gross energy output for natural gas and 1,560 lb CO₂/MWh-gross energy output for fuel oil across the intended operating loads, one cannot reasonably conclude that these limits are technically achievable for frame-class turbines. NPPD does not consider the NSPS Subpart TTTT_a limit of 1,170 lb/MWh-gross as an appropriate BACT limit. In GE's comment to the NSPS TTTT_a rulemaking, GE recommended a rate of 1,300 lb CO₂/MWh for simple cycle units on natural gas.

NPPD understands that a BACT limit must be at least as stringent as the most stringent applicable federal or state regulation. In the event NSPS Subpart TTTT_a is not overturned by SCOTUS or the rule is not repealed by EPA, NPPD will comply with the applicable emission limits under the rule. If NSPS Subpart TTTT_a is stayed or overturned by SCOTUS or repealed by EPA, then NSPS Subpart TTTT_a is no longer the BACT floor.

Proposed CO₂ BACT Limit – Simple-Cycle (Natural Gas)

NPPD proposes efficient turbine design and operation and good combustion, operation, and maintenance practices along with a limit of 1,300 lb/MMBtu applicable as a rolling 12-month average as BACT when combusting natural gas and operating in simple cycle. This is consistent with the emission level recommended by GE for similar units in their comments to EPA. NPPD is proposing to demonstrate compliance using the procedures in 40 CFR Part 75 Appendix G, the procedures for estimating CO₂ mass emissions.

Proposed CO₂ BACT Limit – Simple-Cycle (Fuel Oil)

NPPD proposes efficient turbine design and operation and good combustion, operation, and maintenance practices along with a limit of 1,750 lb/MMBtu applicable as a rolling 12-month average as BACT when combusting fuel oil and operating in simple cycle. This is the BACT rate proposed for natural gas multiplied by the EPA factor 1,560/1,170 to account for the difference in natural gas vs fuel oil. NPPD is proposing to demonstrate compliance using the procedures in 40 CFR Part 75 Appendix G, the procedures for estimating CO₂ mass emissions.

4.2.8.6.5 CO₂ BACT Limit Selection – Combined-Cycle Operation

NSPS TTTT_a requires combined cycle operation as part of the Phase 1 emission limits for baseload units (<800 lb/MWh-gross for natural gas and <1,250 lb/MWh-gross for fuel oil) and requires carbon capture and sequestration as part of Phase 2 emission limits.

NPPD does not believe that carbon capture is technically feasible for the reasons described in Step 2 of the CO₂ BACT analysis. NPPD understands that a BACT limit must be at least as stringent as the most stringent applicable federal or state regulation. In the event NSPS Subpart TTTT_a is not overturned by SCOTUS or repealed by EPA, NPPD will comply with the applicable emission limits under the rule. If NSPS Subpart TTTT_a is stayed or overturned by SCOTUS or repealed by EPA, then NSPS Subpart TTTT_a is no longer the BACT floor.

⁸³ 89 FR 39948, Thursday, May 9, 2024.

NPPD has reviewed the Siemens combined cycle data – the CO₂ ranges from of 745 lb/MWh-gross to 850 lb/MWh-gross from base load to MECL on natural gas, and from 1,060 lb/MWh-gross to 1,120 lb/MWh-gross from base load to MECL on fuel oil.

Proposed Primary (Steady-State) CO₂ BACT Limit – Combined-Cycle (Natural Gas)

NPPD proposes that BACT is a highly efficient combustion turbine with a limit of 1,000 lb/MWh-gross, as a 12-month average during natural gas combustion. This proposed limit is in line with recent BACT determinations for combustion turbines and considers the baseload performance of the CTs as provided by Siemens, which is the expected operating load of the unit in combined cycle. NPPD is proposing to demonstrate compliance using the procedures in 40 CFR Part 75 Appendix G, the procedures for estimating CO₂ mass emissions.

Proposed Primary (Steady-State) CO₂ BACT Limit – Combined-Cycle (Fuel Oil)

NPPD proposes that BACT is a highly efficient combustion turbine with a limit of 1,250 lb/MWh-gross on a 12-month rolling basis during fuel oil combustion. This proposed limit is in line with recent BACT determinations for combustion turbines and considers the baseload performance of the CTs as provided by Siemens, which is the expected operating load of the unit in combined cycle. NPPD is proposing to demonstrate compliance using the procedures in 40 CFR Part 75 Appendix G, the procedures for estimating CO₂ mass emissions.

4.2.9 Greenhouse Gases (CH₄)

This section includes the BACT analysis for CH₄ for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.9.1 Overview of GHG Emissions (CH₄) from CT

CH₄ emissions from the natural gas combustion turbines form as a result of incomplete combustion of hydrocarbons present in the natural gas fuel.

4.2.9.2 Step 1 - Identification of CH₄ Control Technologies – CT

The only available control options for minimizing CH₄ emissions from the combustion turbine systems are efficient turbine operation coupled with good combustion, operating, and maintenance practices to minimize unburned fuel. Oxidation catalysts are not considered available for reducing CH₄ emissions because oxidizing the very low concentrations of CH₄ present in the combustion turbine's exhaust would require much higher temperatures, residence times, and catalyst loadings than those offered commercially for CO oxidation catalysts. For these reasons, catalyst providers do not offer products for reducing CH₄ emissions from gas-fired combustion turbines.

4.2.9.3 Step 2 - Elimination of Technically Infeasible CH₄ Control Options – CT

Efficient turbine operation coupled with good combustion, operating, and maintenance practices are the only technically feasible control options for reducing CH₄ emissions from the combustion turbines.

4.2.9.4 Step 3 - Summary and Ranking of Remaining CH₄ Controls – CT

Since efficient turbine operation coupled with good combustion, operating, and maintenance practices are evaluated in the remaining steps of the BACT analysis, no ranking of control options is required.

4.2.9.5 Step 4 - Evaluation of Most Stringent CH₄ Controls – CT

No adverse energy, environment, or economic impacts are associated with efficient turbine operation and good combustion, operating, and maintenance practices for reducing CH₄ emissions from the combustion turbine.

4.2.9.6 Step 5 - Selection of Emission Limits and Controls for CH₄ BACT – CT

Efficient turbine operation and good combustion, operating, and maintenance practices are the selected control options for minimizing CH₄ emissions from the combustion turbine systems. NPPD has determined that a numerical limit for CH₄ is unnecessary and that the work practices required for CO₂ BACT, and efficient turbine operation coupled with good combustion, operating, and maintenance practices, are sufficient for CH₄ BACT.

4.2.10 Greenhouse Gases (N₂O)

This section includes the BACT analysis for N₂O for the combustion turbines operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.2.10.1 Overview of GHG Emissions (N₂O) Emissions from CT

For the proposed project, the contribution of N₂O to the total CO₂e emissions is trivial and therefore should not warrant a detailed BACT review. Nevertheless, the additional information provided supports the rationale that the proposed project meets BACT for contributions of N₂O to CO₂e.

A tradeoff between NO_x and N₂O emissions from the combustion turbines exists when developing a combustion control strategy which influences the BACT selection process. There are five (5) primary pathways of NO_x production in gas-fired combustion turbine combustion processes: thermal NO_x, prompt NO_x, NO_x from N₂O intermediate reactions, fuel NO_x, and NO_x formed through reburning. For turbines using DLN combustors, the N₂O pathway is an important mechanism of NO_x formation. Flame radicals produced in the high temperature and pressure DLN combustion zone react with the N₂O molecule, creating N₂ and NO.⁸⁴ In premixed gas flames, N₂O is primarily formed in the flame front or oxidation zone. Once formed, the N₂O is readily destroyed due to the relatively high concentration of H radicals, and therefore, the N₂O emissions from premixed gas flames like DLN combustor flames are found experimentally to be very small (generally less than 1 ppm). However, any mechanisms which decrease the H atom concentration in the N₂O formation zone can increase N₂O emissions. These mechanisms include lowering the flame combustion temperature, air-to-fuel staging, and injection of ammonia, urea, or other amine or cyanide species into the exhaust stream which are all common NO_x control measures.⁸⁵ Therefore, there is a tradeoff between NO_x and N₂O emissions when developing a combustion control strategy which influences the BACT selection process.

⁸⁴ Honegger, U., Kansas State University, *Gas Turbine Combustion Modeling for a Parametric Emissions Monitoring System*, 2007.

⁸⁵ American Petroleum Institute, *Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry*, February 2004.

4.2.10.2 Step 1 - Identification of N₂O Control Technologies – CT

N₂O catalysts are a potential control option, as these have been used in nitric/adipic acid plant applications to minimize N₂O emissions.⁸⁶ Through this technology, tail gas from the nitric acid production process is routed to a reactor vessel with a N₂O catalyst followed by ammonia injection and a NO_x catalyst.

4.2.10.3 Step 2 - Elimination of Technically Infeasible N₂O Control Options – CT

N₂O catalyst providers do not offer products to control N₂O emissions from gas-fired combustion turbines due to the very low N₂O concentrations present in exhaust streams (approximately 5 ppm).⁸⁷ In comparison, the application of a catalyst in the nitric acid industry sector has been effective due to the high (1,000-2,000 ppm) N₂O concentration in the exhaust stream.

With N₂O catalysts eliminated, good combustion practice is the only available control option.

Good combustion practices are technically feasible control options for reducing N₂O emissions from the combustion turbines.

4.2.10.4 Step 3 - Summary and Ranking of Remaining N₂O Controls – CT

Since good combustion practices are evaluated in the remaining steps of the BACT analysis, no ranking of control options is required.

4.2.10.5 Step 4 - Evaluation of Most Stringent N₂O Controls – CT

As indicated in EPA's guidance on GHG BACT, GHG control strategies may have the potential to produce higher criteria pollutants as in the case of the competing NO_x and N₂O combustion control strategies for NPPD's combustion turbine systems. In such cases, the guidance suggests that the applicant should consider the effects of increases in emissions of other regulated pollutants that may result from the use of that GHG control strategy, and based on this analysis, the permitting authority can determine whether or not the application of that GHG control strategy is appropriate given the potential increases in other pollutants.⁸⁸

Given the low N₂O emissions relative to NO_x emissions from the combustion turbine systems and EPA's continued concern over adverse impacts from ozone formation due to NO_x and VOC emissions, NPPD does not consider it appropriate to control the combustion processes of the combustion turbine to specifically reduce N₂O emissions due to the counteractive increase in NO_x emissions. Therefore, good combustion practice for the specific purpose of minimizing N₂O formation is eliminated on the basis of adverse criteria pollutant impacts.

4.2.10.6 Step 5 - Selection of Emission Limits and Controls for N₂O BACT – CT

Efficient turbine operation and general good combustion, operating, and maintenance practices are the selected control options for reducing N₂O emissions from the combustion turbines. NPPD has determined

⁸⁶ *N₂O Emissions from Adipic Acid and Nitric Acid Production*, written by Heike Mainhardt (ICF Incorporated) and reviewed by Dina Kruger (U.S. EPA). http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/3_2_Adipic_Acid_Nitric_Acid_Production.pdf

⁸⁷ *Emissions of Nitrous Oxide from Combustion Sources*, in *Progress and Energy and Combustion Science* 18(6): pages 529-552, December 1992, found at: https://www.researchgate.net/publication/223546823_Emissions_of_nitrous_oxide_from_combustion_sources

⁸⁸ PSD and Title V permitting Guidance for Greenhouse Gases. March 2011, page 39.

that a numerical limit for N₂O emissions is unnecessary and that the work practices required for CO₂ BACT, and efficient turbine operation coupled with good combustion, operating, and maintenance practices, are sufficient for N₂O BACT.

4.3 BACT Analyses for RICE EGUs

4.3.1 Nitrogen Oxides (NO_x)

This section includes the BACT analysis for NO_x for the RICE generating units operating on either natural gas or fuel oil.

4.3.1.1 Overview of NO_x Emissions from RICE EGUs

NO_x is formed from RICE units through three main mechanisms: thermal NO_x, prompt NO_x, and fuel NO_x.⁸⁹ Thermal NO_x is the principal mechanism of NO_x formation from gas-fired engines and occurs through the thermal dissociation and subsequent reaction of nitrogen (N₂) and oxygen (O₂) molecules in the combustion air. Most thermal NO_x is formed in high temperature regions in the cylinder where fuel-air mixing occurs sufficiently to produce peak temperature fuel/air interface.

4.3.1.2 Step 1 – Identification of NO_x Control Technologies – RICE EGUs

The NO_x reduction technologies for RICE generating units are as follows:

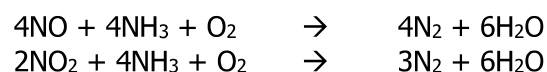
1. Non-Selective Catalytic Reduction (NSCR)
2. Selective Catalytic Reduction (SCR)
3. Lean-Burn and Good Combustion Practices

4.3.1.2.1 Non-Selective Catalytic Reduction (NSCR)

NSCR uses residual hydrocarbons and CO in rich-burn engine exhaust as a reducing agent for NO_x. In an NSCR, hydrocarbons and CO are oxidized by O₂ and NO_x. The excess hydrocarbons, CO, and NO_x pass over a catalyst that reduces NO_x to N₂.

4.3.1.2.2 Selective Catalytic Reduction (SCR)

SCR refers to the process in which NO_x is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. A lean air-fuel mixture is required to supply excess oxygen, which is necessary for the reduction of nitrogen. The overall reactions are as follows:



SCR can be applied as a standalone NO_x control or with other technologies such as combustion controls. The SCR process requires a reactor, a catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_x concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. SCR units typically achieve 70 – 90% NO_x reduction; however, if the upstream NO_x concentration is already low, as is the case with

⁸⁹ AP-42, Chapter 3, Section 4, *Large Stationary Diesel and All Stationary Dual-fuel Engines, October 1996.*

these units, it is difficult to achieve these control efficiencies.⁹⁰ It has been documented that ammonia injection results in the emission of unreacted ammonia in the exhaust; this is referred to as “ammonia slip”. The potential for ammonia slip increases with variability in uncontrolled NO_x; less NO_x entering the system will result in an increase of unreacted ammonia while more NO_x entering the system will result in a decreased NO_x conversion. Dynamic operating conditions or fuel quality will increase system variability and make it more challenging to continuously maintain ammonia injection rates at the stoichiometric level.

4.3.1.2.3 Lean Burn with Good Combustion Practices

Good combustion practices involve controlling the operating parameters of the combustors for temperature, turbulence, excess oxygen levels, and air-fuel mixing to ensure continual operation as close to optimum (i.e., minimum emission) conditions as possible. In addition, NPPD has elected to use lean-burn, four-stroke engines. Although NO_x emissions can be highly variable depending on the specific RICE, typically lean-burn engines will have lower NO_x emissions than rich-burn engines.

4.3.1.3 *Step 2 – Elimination of Technically Infeasible NO_x Control Options – RICE*

4.3.1.3.1 Non-Selective Catalytic Reduction (NSCR)

NSCR systems simultaneously reduce NO_x to N₂, CO to CO₂, and hydrocarbons (HC) to water (H₂O). The reaction stoichiometry to achieve these reductions requires that O₂ concentration levels be kept at or below approximately 0.5 percent.⁹¹ Consequently, RICE units equipped with NSCR systems must run at fuel-rich air/fuel mixture ratios. Because NPPD is proposing to install lean-burn engines, NSCR is not a technically feasible control option for the RICE EGUs.

4.3.1.3.2 Selective Catalytic Reduction (SCR)

SCR is technically feasible for the lean-burn RICE EGUs, as flue gas temperatures and oxygen concentrations are suitable for optimal operation of SCR systems.

4.3.1.3.3 Lean Burn with Good Combustion Practices

This is considered the base case for the proposed RICE EGUs.

4.3.1.4 *Step 3 – Summary and Ranking of Remaining NO_x Controls – RICE*

The technically feasible control technologies for the RICE EGUs include SCR and good combustion practices. Table 4-1616 shows the rank for each of these control technologies.

Table 4-16. Remaining NO_x Control Technologies – RICE

Control Technology	Technically Feasible	Estimated Efficiency
SCR	Yes	~90%
Good Combustion Practice	Yes	Base Case

⁹⁰ OAQPS, *EPA Air Pollution Control Cost Manual*, Sixth Edition, EPA/424/B-02-001 (http://www.epa.gov/ttn/catc/dir1/c_allchs.pdf); January 2002.

⁹¹ *NO_x Emissions from Stationary Internal Combustion Engines*, EPA-453/R-93-032 (<https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=2000IJJ.txt>); September 2000.

4.3.1.5 Step 4 – Evaluation of Most Stringent NO_x Controls – CT

SCR is the highest ranking potentially feasible control technology. As summarized in Step 5, NPPD is proposing operation of SCR with good combustion practices and lean-burn as BACT for the RICE EGUs during all modes of operation (NG and FO). No additional evaluation of emission control is needed.

4.3.1.6 Step 5 – Selection of Emission Limits and Controls for NO_x BACT

4.3.1.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The RICE EGUs will be subject to the following NO_x emission limits:

- ▶ NSPS JJJJ: 1.0 grams per horsepower-hour (g/hp-hr), 82 ppmvd @15% O₂
- ▶ NSPS IIII: between 1.5 g/hp-hr and 2.5 g/hp-hr, depending on the maximum engine speed (130rpm to 2,000 rpm)

4.3.1.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Nitrogen Oxides (NO_x)
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently and are subject to less stringent emission standards under NSPS and NESHAP. Similarly, engines used for purposes other than electric generation, such as gas compression, were excluded, as these units are typically smaller, fire less-clean fuels such as field gas, and are generally operated much differently than engines used for electric generation.

The detailed RBLC search results tables are provided in Appendix D (Table D.2-1 and Table D.2-2). The results are separated based on fuel type - natural gas and fuel oil.

The results of the RBLC search for comparable RICE EGUs are summarized below.

Natural Gas-Fired ICE

The RBLC entry most similar to the proposed RICE EGUs, AK-0084, is subject to a NO_x limit of 0.08 g/kW-hr when firing natural gas. MI-0440, another similar facility, is subject to a limit of 0.5 g/hp-hr (excluding SUSD). The two other facilities identified in the RBLC search are subject to NO_x limits on a lb/hr basis, making them difficult to consider when determining BACT, as the limits are not normalized to engine output.

Fuel Oil-Fired ICE

Of the RBLC entries included in this analysis, only AK-0084 includes a fuel oil-specific NO_x emission limit: 0.53 g/kW-hr.

4.3.1.6.3 Summary of NO_x Limits in Air Permits not in RBLC

In addition to the RBLC search, NPPD conducted additional research to identify air permits issued for sources similar to the RICE EGUs which were not entered into the RBLC database. These units may not have undergone a BACT analysis and are included here for reference purposes only.

Montana-Dakota Utilities Company – Lewis & Clark Station

Lewis & Clark Station, located in Richland County, MT, is subject to an emission limit of 2.6 lb/hr during normal operation (i.e., excluding SUSD). The RICE units at this facility are permitted for natural gas operation only, and are equipped with SCR.

Wisconsin Public Service Corporation – Weston Generating Station

Weston Generating Station, located in Rothschild, WI, operates seven 18MW RICE units. The RICE units are subject to an emission limit of 2.9 lb/hr per engine during normal operation (i.e., excluding SUSD).

City of Tallahassee – Arvah Hopkins

The Arvah B. Hopkins Generating Station, located in Leon County, FL, operates five Wartsila 18V50SG 18.82 MW natural gas-fired RICE units. The units are equipped with SCR. Each RICE is subject to emission limits of 5 ppmvd @ 15% O₂ and 2.44 lb/hr.

Matanuska Electric – Eklutna Generation Station

Eklutna Generation Station, located near Palmer, AK, operates ten Wartsila 18V50DF RICE units, each rated for 17.1MW and authorized to fire both natural gas and fuel oil. The RICE units are subject only to NSPS Subpart JJJJ emission standards for NO_x: 1.0 g/hp-hr (82 ppmv @ 15% O₂).

4.3.1.6.4 NO_x BACT Limit Selection – Natural-Gas Operation

SCR with combustion controls is the most effective system for controlling NO_x emissions during natural gas combustion. Wartsila has guaranteed a level of 6 ppmvd @ 15% O₂ at base load during natural gas operation, based on the use of these controls. Based on this, NPPD is proposing a BACT limit of 6 ppmvd @ 15% O₂ at base load (equivalent to 0.060 g/hp-hr), excluding startup and shutdown emissions.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.1.6.5 NO_x BACT Limit Selection – Fuel-Oil Operation

SCR with combustion controls is the most effective system for controlling NO_x emissions during fuel oil combustion. Wartsila has guaranteed a level of 35 ppmv @ 15% O₂ at base load during fuel oil operation, based on the use of these controls. Thus, NPPD is proposing a BACT limit for NO_x of 35 ppmv @ 15% O₂ at base load (equivalent to 0.380 g/hp-hr), excluding startup and shutdown emissions. This is less than the

NSPS IIII limit for compression ignition RICE, which ranges from 1.5 to 2.5 g/hp-hr depending on the engine speed, and it is less than the NSPS JJJJ limit of 1.0 g/hp-hr for dual fuel RICE.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.2 Carbon Monoxide (CO)

This section includes the BACT analysis for CO for the RICE generating units operating on either natural gas or fuel oil.

4.3.2.1 Overview of CO Emissions from RICE EGUs

CO is an intermediate combustion product that appears in the exhaust from RICE units when the reaction of CO to CO₂ cannot proceed to completion.⁹² This occurs when there is insufficient oxygen near the fuel molecule during combustion, if the combustion gas temperature is too low, or if the residence time in the cylinder is too short.

4.3.2.2 Step 1 – Identification of CO Control Technologies – RICE EGUs

The CO reduction technologies for non-emergency RICE are as follows:

1. Oxidation Catalyst
2. Lean Burn with Good Combustion Practices

4.3.2.2.1 Oxidation Catalyst

An oxidation catalyst is a post-combustion control technology that utilizes a catalyst to oxidize CO. The addition of a catalyst to the basic thermal oxidation process accelerates the rate of oxidation by adsorbing oxygen from the air stream and CO in the waste stream onto the catalyst surface to react to form CO₂.

4.3.2.2.2 Lean Burn and Good Combustion Practices

Good combustion practices include controlling engine operating parameters, such as fuel injection rate and combustion air-to-fuel ratios to encourage complete combustion. In addition, NPPD has elected to use lean-burn, four-stroke engines. Although CO emissions can be highly variable depending on the specific RICE, typically lean-burn engines will have lower CO emissions than rich-burn engines.

4.3.2.3 Step 2 – Elimination of Technically Infeasible CO Control Options – RICE

Both control options listed above (Oxidation Catalyst and Lean Burn with Good Combustion Practices) are considered technically feasible.

⁹² AP-42, Chapter 3, Section 4, *Large Stationary Diesel and All Stationary Dual-fuel Engines*, April 2000.

4.3.2.4 Step 3 – Summary and Ranking of Remaining CO Controls – RICE

The only add-on control that is technically feasible to reduce emissions below the base case (Good Combustion Practices and Lean-Burn) is an oxidation catalyst. As a technically feasible control option, it must be evaluated further in the BACT process.

4.3.2.5 Step 4 – Evaluation of Most Stringent CO Controls – CT

NPPD is proposing the use of oxidation catalyst coupled with good combustion practices and lean-burn as BACT for the reduction of CO from the RICE EGUs. As there are no other technically feasible control options identified, no further evaluation is required.

4.3.2.6 Step 5 – Selection of Emission Limits and Controls for CO BACT

4.3.2.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The RICE EGUs will be subject to the following emission limits:

- ▶ NESHAP ZZZZ: Reduce CO emissions by 70% or more or limit the exhaust formaldehyde concentration to 580 ppbvd, or less (15% O₂) and
- ▶ NSPS JJJJ (for dual-fuel): 2g/hp-hr.

There are no CO limits in NSPS IIII (for diesel).

4.3.2.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Carbon Monoxide (CO)
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently, serve a fundamentally different operational purpose, and are subject to less stringent emission standards under NSPS and NESHAP.

The detailed RBLC search results tables are provided in Appendix D (Table D.2-3 and Table D.2-4). The results are separated based on fuel type - natural gas and fuel oil.

The results of the RBLC search for comparable RICE EGUs are summarized below.

Natural Gas-Fired ICE

AK-0084, the RBLC entry most similar to the proposed RICE EGUs, is subject to a CO emission limit of 0.12 g/kW-hr when firing natural gas. MI-0440 is subject to a limit of 0.3 g/hp-hr (0.4 g/kW-hr). The two other facilities identified in the RBLC search are subject to CO limits on a lb/hr basis, making them difficult to consider when determining BACT as the limits are not normalized to engine output.

Fuel Oil-Fired ICE

AK-0084 is the only site identified in the RBLC search with a fuel oil-specific emission limit. It is limited to 0.18 g/kW-hr when firing fuel oil.

4.3.2.6.3 Summary of CO Limits in Air Permits not in RBLC

In addition to the RBLC search, NPPD conducted additional research to identify air permits issued for sources similar to the RICE EGUs which were not entered into the RBLC database. These units may not have undergone a BACT analysis and are included here for reference purposes only.

Montana-Dakota Utilities Company – Lewis & Clark Station

Lewis & Clark Station is subject to an emission limit of 2.4 lb/hr during normal operation (i.e., excluding SUSD). The engines are equipped with oxidation catalysts for the control of CO emissions.

Wisconsin Public Service Corporation – Weston Generating Station

Each RICE unit at Weston Generating Station is subject to an emission limit of 4.43 lb/hr and 14 ppmvd at 15% O₂, on a 1-hour average basis. The RICE are equipped with an oxidation catalyst.

City of Tallahassee – Arvah Hopkins

Each RICE unit at Arvah Hopkins power plant is equipped with oxidation catalyst and subject to CO emission limits of 15 ppmvd at 15% O₂, on a 3-hour average basis, and 2.44 lb/hr. The engines must also demonstrate 93% or greater reduction in CO across the oxidation catalyst at 100 percent load, plus or minus 10 percent.

Matanuska Electric – Eklutna Generation Station

The RICE EGUs at Eklutna Generation Station are subject only to CO emission limits under NSPS JJJJ: 2.0 g/hp-hr (270 ppmvd at 15% O₂).

4.3.2.6.4 CO BACT Limit Selection – Natural-Gas Operation

Oxidation catalyst with combustion controls is the most effective system for controlling CO emissions during natural gas combustion. Wartsila has guaranteed a level of 15 ppmvd @ 15% O₂ at base load during natural gas operation, based on the use of these controls. Based on this, NPPD is proposing a BACT limit of 15 ppmvd @ 15% O₂ at base load (equivalent to 0.090 g/hp-hr), excluding startup and shutdown emissions.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.2.6.5 CO BACT Limit Selection – Fuel-Oil Operation

Oxidation catalyst with combustion controls is the most effective system for controlling CO emissions during fuel oil combustion. Wartsila has guaranteed a level of 20 ppmv @ 15% O₂ at base load during fuel oil operation, based on the use of these controls. Thus, NPPD is proposing a BACT limit for CO of 20 ppmv @ 15% O₂ at base load (equivalent to 0.133 g/hp-hr), excluding startup and shutdown emissions.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.3 Volatile Organic Compounds (VOC)

This section includes the BACT analysis for VOC for the RICE generating units operating on either natural gas or fuel oil.

4.3.3.1 *Overview of VOC Emissions from RICE EGUs*

VOC emissions from the RICE EGUs consist of a wide variety of organic compounds and are generated when some of the fuel remains uncombusted or is only partially combusted.

4.3.3.2 *Step 1 – Identification of VOC Control Technologies – RICE EGUs*

The VOC reduction technologies for non-emergency RICE are as follows:

1. Oxidation Catalyst
2. Good Combustion Practices and Lean-Burn

4.3.3.2.1 Oxidation Catalyst

An oxidation catalyst is a post-combustion control technology that utilizes a catalyst to oxidize unburned hydrocarbons in the exhaust stream (i.e., VOCs). The addition of a catalyst to the basic thermal oxidation process accelerates the rate of oxidation by adsorbing oxygen from the air stream and VOCs in the waste stream onto the catalyst surface to react to form CO₂ and H₂O.

4.3.3.2.2 Lean Burn with Good Combustion Practices

Good combustion practices include controlling engine operating parameters, such as fuel injection rate and combustion air-to-fuel ratios to encourage complete combustion. In addition, NPPD has elected to use lean-burn, four-stroke engines. Although VOC emissions can be highly variable depending on the specific RICE, typically lean-burn engines will have lower VOC emissions than rich-burn engines, as the excess combustion air allows for more complete combustion to occur.

4.3.3.3 *Step 2 – Elimination of Technically Infeasible VOC Control Options – RICE*

Both control options listed above (Oxidation Catalyst and Lean Burn with Good Combustion Practices) are considered technically feasible

4.3.3.4 Step 3 – Summary and Ranking of Remaining VOC Controls – RICE

The only add-on control that is technically feasible to reduce emissions below the base case (Good Combustion Practices and Lean-Burn) is an oxidation catalyst. As a technically feasible control option, it must be evaluated further in the BACT process.

4.3.3.5 Step 4 – Evaluation of Most Stringent VOC Controls – RICE

NPPD is proposing the use of oxidation catalyst coupled with good combustion practices and lean-burn as BACT for the reduction of VOCs from the RICE EGUs. As there are no other technically feasible control options identified, no further evaluation is required.

4.3.3.6 Step 5 – Selection of Emission Limits and Controls for VOC BACT

4.3.3.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The RICE EGUs will be subject to the following emission limits:

- ▶ NSPS JJJJ (for dual-fuel): 0.7 g/hp-hr (excluding formaldehyde).

There are no VOC limits in NSPS IIII (for diesel).

4.3.3.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Sulfur Dioxide
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently, serve a fundamentally different operational purpose, and are subject to less stringent emission standards under NSPS and NESHAP.

The detailed RBLC search results tables are provided in Appendix D (Table D.2-5 and Table D.2-6). The results are separated based on fuel type - natural gas and fuel oil.

The results of the RBLC search for comparable RICE EGUs are summarized below.

Natural Gas-Fired ICE

AK-0084, the RBLC entry most similar to the proposed RICE EGUs, is subject to a VOC emission limit of 0.09 g/kW-hr when firing natural gas. MI-0440 is subject to a limit of 0.7 g/hp-hr (0.94 g/kW-hr). LA-0295 is

subject to a limit of 29 ppmvd @ 5% O₂. The other facility identified in the RBLC search is subject to VOC limits on a lb/hr basis, making it difficult to consider when determining BACT as the limits are not normalized to engine output.

Fuel Oil-Fired ICE

AK-0084 is the only site identified in the RBLC search with a fuel oil-specific emission limit. It is limited to 0.21 g/kW-hr when firing fuel oil.

4.3.3.6.3 VOC BACT Limit Selection – Natural-Gas Operation

Oxidation catalyst with combustion controls is the most effective system for controlling VOC emissions during natural gas combustion. Wartsila has guaranteed a level of 26 ppmvd @ 15% O₂ at base load during natural gas operation, based on the use of these controls. Based on this, NPPD is proposing a BACT limit of 26 ppmvd @ 15% O₂ at base load (equivalent to 0.090 g/hp-hr), excluding startup and shutdown emissions.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.3.6.4 VOC BACT Limit Selection – Fuel-Oil Operation

SCR with combustion controls is the most effective system for controlling VOC emissions during fuel oil combustion. Wartsila has guaranteed a level of 40 ppmv @ 15% O₂ at base load during fuel oil operation, based on the use of these controls. Thus, NPPD is proposing a BACT limit for VOC of 40 ppmv @ 15% O₂ at base load (equivalent to 0.14 g/hp-hr), excluding startup and shutdown emissions.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions. NPPD is proposing that the BACT limits not apply during startup and shutdown. However, different from the combustion turbines, NPPD is not proposing separate emission limits during startup and shutdown. Since it is difficult to measure NO_x emissions over the short duration and highly transient period of a RICE startup event, NPPD is proposing to rely on vendor estimates to understand emission during startup and shutdown events. Further, NPPD is proposing that BACT for startup and shutdown is to follow the manufacturer's recommendations, including limiting the duration of startups and shutdowns in accordance with manufacturers recommendations.

4.3.4 Sulfur Dioxide (SO₂)

This section includes the BACT analysis for SO₂ for the RICE generating units operating on either natural gas or fuel oil.

4.3.4.1 *Overview of SO₂ Emissions from RICE EGUs*

SO₂ emissions from RICE are a function of only the sulfur content in the fuel rather than any combustion variables.⁹³ During the combustion process, virtually all fuel-bound sulfur is oxidized to SO₂. The oxidizing

⁹³ AP-42, Chapter 3, Section 4, *Large Stationary Diesel and All Stationary Dual-fuel Engines, October 1996.*

environment in the stack may convert some of this SO₂ to SO₃. The SO₃ may react with water vapors in the stack to form sulfuric acid. The best way to limit emissions of sulfuric acid is to minimize the initial formation of SO₂.

4.3.4.2 Step 1 – Identification of SO₂ and H₂SO₄ Control Technologies – RICE EGUs

The SO₂ reduction technologies for non-emergency RICE are as follows:

1. Wet Scrubber
2. Semi-Dry Scrubber (Spray Dryer Type)
3. Dry Scrubber (Injection System)
4. Low Sulfur Fuels
5. Good Combustion Practices

4.3.4.2.1 Wet Scrubber

Wet scrubber systems remove SO₂ from exhaust streams by utilizing an alkaline reagent to form aqueous sulfite and sulfate salts. The reaction of SO₂ with the alkaline chemical can be performed using sodium, calcium, or dual-alkali reagents using packed bed scrubbers or spray towers. Waste treatment and disposal are required as this process generates wastewater and waste sludge when the unreacted reagents in the scrubbing liquid precipitate out during the scrubbing process. The control efficiency of wet scrubbers range from 95% to 99%.⁹⁴

4.3.4.2.2 Semi-Dry Scrubber (Spray Dryer Type)

In a spray dryer type dry scrubbing system, a slurry of alkaline reagent, typically lime or another sodium-based reagent, is atomized into the hot flue gas to absorb SO₂. The resulting dry material is collected in a downstream particulate matter control device, typically an electrostatic precipitator or fabric filter. Lime is usually preferred as the sorbent because it is more reactive than limestone and cheaper than sodium-based reagents. These systems are designed for SO₂ removal efficiencies of about 80%.⁹⁵

4.3.4.2.3 Dry Scrubber (Injection System)

Dry injection-based scrubbing systems involve the direct injection of a powdered sorbent (generally lime or limestone) into the flue gas. Sulfur oxides react directly with the reagent, and the dry waste is removed by particulate control equipment. Dry injection systems typically achieve control efficiencies of about 50% for SO₂ and are usually applied when lower control efficiencies are acceptable or for smaller installations.⁹⁶

4.3.4.2.4 Low Sulfur Fuels

Firing low-sulfur fuels in the RICE EGUs decreases the amount of sulfur available for oxidation during the combustion process, which in turn decreases emissions of sulfur compounds including SO₂ and SO₃. NPPD will use pipeline quality natural gas containing a maximum sulfur content of 2 gr S/100 scf, and distillate fuel oil containing no more than 15 ppm sulfur to lower emissions of SO₂.

⁹⁴ *Air Pollution Control Technology Fact Sheet: Packed Bed/Packed-Tower Wet Scrubber*, U.S. EPA, May 1999.

⁹⁵ *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization (FGD) – Wet, Spray Dry, and Dry Scrubbers*, U.S. EPA, n.d.

⁹⁶ *Ibid.*

4.3.4.2.5 Good Combustion Practices

The operation and maintenance of the RICE EGUs in accordance with good air pollution control practices and with good combustion practices results in efficient combustion of fuel, which in turn results in reduced usage of fuel and associated emissions of SO₂.

4.3.4.3 *Step 2 – Elimination of Technically Infeasible SO₂ Control Options – RICE*

As is the case for combustion turbines, NPPD was unable to identify any application of wet, semi-dry, or dry scrubbers on natural gas- or fuel oil-fired internal combustion engines, even on engines firing field gas with relatively high sulfur contents. This is likely because the high exhaust flowrates from the engines and low SO₂ emissions result in low SO₂ concentrations in the flue gas. Due to the low SO₂ concentration, scrubbers would not provide any measurable reduction and are therefore technically infeasible.

4.3.4.4 *Step 3 – Summary and Ranking of Remaining SO₂ Controls – RICE*

The remaining control technologies are the use of low-sulfur fuel and good combustion practices, the base case for BACT.

4.3.4.5 *Step 4 – Evaluation of Most Stringent SO₂ Controls – CT*

NPPD will implement both these options to reduce SO₂ emissions from the RICE EGUs.

4.3.4.6 *Step 5 – Selection of Emission Limits and Controls for SO₂ BACT*

4.3.4.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

None of the applicable rules for RICE include SO₂ emission limits.

4.3.4.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Sulfur Dioxide
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently, serve a fundamentally different operational purpose, and are subject to less stringent emission standards under NSPS and NESHAP.

None of the RBLC entries identified contained SO₂ emission limits.

4.3.4.6.3 SO₂ BACT Limit Selection – Natural-Gas Operation

NPPD proposes the use of low-sulfur fuels and good combustion practices as BACT for SO₂ emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants, and has seen some variability. NPPD is proposing as BACT that the natural gas combusted will contain no more than 2 gr S/100 scf, as an annual average based on fuel records, and fuel oil combusted will contain no more than 15 ppm total sulfur, as an annual average, based on fuel records.

4.3.4.6.4 SO₂ BACT Limit Selection – Fuel-Oil Operation

NPPD proposes the use of low-sulfur fuels and good combustion practices as BACT for SO₂ emissions. NPPD is proposing a BACT limit based on the use of fuel oil with 15 ppm sulfur or less and good combustion practices. This is the contract limit for the ULSD currently used at Sheldon Station.

4.3.5 Filterable Particles (PM, PM₁₀, PM_{2.5})

This section includes the BACT analysis for filterable PM, PM₁₀, and PM_{2.5} for the RICE generating units operating on either natural gas or fuel oil and operating in either simple cycle or combined cycle mode.

4.3.5.1 Overview of Filterable PM Emissions from RICE EGUs

Similar to combustion turbines, filterable particulate emissions from internal combustion engines result primarily from airborne particulate matter in the combustion air, inert solids in the fuel supply, and metallic rust or oxidation products.

4.3.5.2 Step 1 – Identification of PM_{filt} Control Technologies – RICE EGUs

Control technologies potentially available for the reduction of filterable particulate matter from the RICE EGUs are as follows:

- ▶ Multicyclone,
- ▶ Wet Scrubber,
- ▶ Electrostatic Precipitator (ESP),
- ▶ Baghouse,
- ▶ Diesel particulate filter
- ▶ Low sulfur fuel (Base Case), and
- ▶ Good combustion and operating practices (Base Case).

These technologies are discussed in detail in other sections.

4.3.5.3 Step 2 – Elimination of Technically Infeasible PM_{filt} Control Options – RICE EGUs

All four add-on control technologies (multicyclones, wet scrubbers, ESPs, and baghouses) are technically infeasible for the reduction of filterable particulate matter emissions from the RICE EGUs. PM_{filt} emissions from the RICE units exist in low concentrations in the exhaust gas; as a result, add-on PM_{filt} controls would not provide any significant degree of emission reduction for the RICE units and are therefore not considered further in this analysis. It should be noted that no RICE RBLC entries require add-on controls for reduction of particulate matter emissions.

4.3.5.4 Step 3 – Summary and Ranking of Remaining PM_{filt} Control Options – RICE EGUs

The remaining technically feasible PM_{filt} control options are the use of low sulfur fuels and good combustion and operating practices. NPPD is proposing the use of low sulfur fuels in conjunction with good combustion and operating practices as BACT for PM_{filt} for the RICE EGUs.

4.3.5.5 Step 4 – Evaluation of Most Stringent PM_{filt} Controls – RICE EGUs

As the use of low sulfur fuels and good combustion and operating practices are the only remaining technically feasible control options, and NPPD is proposing these as BACT, no further evaluation is required.

4.3.5.6 Step 5 - Selection of Emission Limits and Controls for Filterable PM – RICE

PM is comprised of only filterable particulate emissions, but PM_{10} and $PM_{2.5}$ include both filterable particulate emissions, as described above, as well as condensable particulate emissions as described below. For filterable PM_{10} and $PM_{2.5}$, it is common for permits to include limits on total particulates and to require testing of both the filterable and condensable particles as part of demonstrating compliance with the limits. NPPD is proposing a combined limit for the filterable and condensable PM_{10} and $PM_{2.5}$ emissions, as further summarized in the section following BACT for condensable PM.

For filterable PM, NPPD proposes the use of low-sulfur fuels and good combustion practices as BACT for SO_2 emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants, and has seen some variability. NPPD is proposing as BACT that the natural gas combusted in the CT will contain no more than 2 gr S/100 scf, as an annual average based on fuel records, and fuel oil combusted will contain no more than 15 ppm total sulfur, based on fuel records. As NSPS KKKK does not differentiate between simple- and combined-cycle combustion turbines, and the RBLC search indicates no add-on controls are required for either simple- or combined-cycle units to control SO_2 emissions, NPPD is not proposing separate BACT determinations for different modes of operation.

4.3.6 Condensable PM, Including Sulfuric Acid (H_2SO_4)

4.3.6.1 Overview of Condensable PM Emissions from RICE EGUs

Condensable PM emissions from the RICE EGUs primarily result from products of incomplete combustion, especially during startups, idling, or low load operation.⁹⁷ Condensable particulate matter can also be formed when SO_2 emitted from the RICE reacts to form sulfuric acid mist (H_2SO_4).

4.3.6.2 Step 1 – Identification of PM_{con} Control Technologies – RICE EGUs

Based on the RBLC search and experience in conducting control technology reviews for similar types of equipment, it is concluded that add-on controls are not available for the reduction of condensable particulate matter emissions from the RICE EGUs. Pre-combustion controls must be deployed instead, and include:

- ▶ Low-Sulfur Fuels
- ▶ Good Combustion and Operating Practices

⁹⁷ AP-42 Chapter 3, *Large Stationary Diesel And All Stationary Dual-fuel Engines*, Section 3.4.3.4, October 1996.

4.3.6.2.1 Wet Scrubber

Wet scrubbers for the control of particulate matter are designed to bring a gas stream into contact with water droplets such that the PM is captured by the droplets and the dirty liquid containing the PM is collected, treated, and either discharged or reused. The cleaned gas exits the scrubber, often passing through a demister to remove moisture.

4.3.6.2.2 Wet ESP

Wet ESPs are designed to remove particulates especially submicron particles, aerosols, and condensable compounds using electrostatic forces in a wet environment. It combines the high-efficiency particle collection of a dry ESP with the benefits of wet scrubbing, making it ideal for applications where the gas is humid, sticky, corrosive, or where ultra-fine PM must be removed.

4.3.6.2.3 Low-Sulfur Fuels

The use of low sulfur fuels in the RICE units, such as natural gas containing no more than 2 gr S/100 scf or ULSD diesel containing less than 15ppm total sulfur, reduces condensable particulate matter emissions as there is less SO₂ present to potentially form H₂SO₄.

4.3.6.2.4 Good Combustion and Operating Practices

Good combustion and operating practices include controlling engine operating parameters, such as fuel feed rates, air/fuel ratios, and routine maintenance and tuning to ensure the engine operates as efficiently as possible. Proper operation will minimize the formation of condensable particulate emissions due to incomplete combustion.

4.3.6.3 Step 2 – Elimination of Technically Infeasible PM_{con} Control Options – RICE EGUs

Wet scrubbers and wet ESPs are technically infeasible for NG combustion. Although the add-on control technologies are utilized in a number of processes to control particulate emissions, none of these add-on control technologies are applicable to NG or ULSD-fired RICE. Combustion of NG and ULSD generates relatively low levels of particulate emissions in comparison to other fuels due to the low ash and sulfur content.

The use of low-sulfur fuels and good combustion and operating practices for the reduction of condensable PM emissions is considered technically feasible for the proposed combustion turbines.

4.3.6.4 Step 3 – Summary and Ranking of Remaining PM_{con} Control Options – RICE EGUs

The remaining feasible control technologies include low sulfur fuels and good combustion and operating practices. Good combustion and operating practices in conjunction with low sulfur fuel represent the base case for the RICE. Therefore, as this is the highest-ranking feasible control remaining, it is selected as BACT.

4.3.6.5 Step 4 – Evaluation of Most Stringent PM_{con} Controls – RICE EGUs

As NPPD is proposing the most stringent condensable particulate matter emissions reduction measures, further evaluation is not necessary.

4.3.6.6 Step 5 - Selection of Emission Limits and Controls for PM_{con} – RICE EGUs

Since it is common for permits to include limits on total particulates and to require testing of both the filterable and condensable particles as part of demonstrating compliance with the limits, NPPD is proposing BACT limits for total particulates, NPPD has completed a Step 5 review below to determine BACT for total PM_{10} and total $PM_{2.5}$, as further summarized below.

4.3.7 Total PM_{10} and Total $PM_{2.5}$

Particulate matter emissions from the proposed RICE EGUs will consist of both filterable and condensable PM. BACT for both filterable and condensable PM is determined to be the use of low-sulfur fuels and good combustion practices.

4.3.7.1 Step 5 - Selection of Emission Limits and Controls for PM_{10} and $PM_{2.5}$

4.3.7.1.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

There are no regulations that apply to the RICE that include limits for total PM_{10} and $PM_{2.5}$.

4.3.7.1.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Particulate Matter⁹⁸
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently, serve a fundamentally different operational purpose, and are subject to less stringent emission standards under NSPS and NESHAP.

The detailed RBLC search results tables are provided in Appendix D (Table D.2-7 and Table D.2-8). The results are separated based on fuel type - natural gas and fuel oil.

Natural Gas-Fired ICE

AK-0084 is subject to a total PM limit, which applies to PM, PM_{10} , and $PM_{2.5}$, of 0.13 g/kW-hr when firing natural gas. The other limits identified in the RBLC search are all on a lb/hr basis, making them difficult to consider when determining BACT as the limits are not normalized to engine output and engine output was not readily available.

⁹⁸ All forms of particulate matter were included in the search criteria.

Fuel Oil-Fired ICE

AK-0084 is the only site identified in the RBLC search with a fuel-oil specific emission limit. During fuel oil operation, each engine is subject to a filterable PM limit of 0.15 g/kW-hr, which applies to PM, PM₁₀, and PM_{2.5}. The engines are also subject to a total PM limit, which also applies to PM/PM₁₀/PM_{2.5}, of 0.29 g/kW-hr.

4.3.7.1.3 Summary of PM Limits in Air Permits not in RBLC

In addition to the RBLC search, NPPD conducted additional research to identify air permits issued for sources similar to the RICE EGUs which were not entered into the RBLC database. These units may not have undergone a BACT analysis and are included here for reference purposes only.

Montana-Dakota Utilities Company – Lewis & Clark Station

The RICE EGUs at Lewis & Clark station are each subject to a PM/PM₁₀/PM_{2.5} limit of 2.27 lb/hr during normal operation (i.e., excluding SUSL).

Wisconsin Public Service Corporation – Weston Generating Station

Each RICE EGU at Weston Generating Station is subject to an PM/PM₁₀/PM_{2.5} emission limit of 2.37 lb/hr, excluding SUSL.

City of Tallahassee – Arvah Hopkins

The RICE EGUs at Arvah Hopkins are not subject to a numerical PM/PM₁₀/PM_{2.5} limit. Instead, good combustion practices and the use of pipeline-quality natural gas must be used to minimize PM/PM₁₀/PM_{2.5} emissions.

Matanuska Electric – Eklutna Generation Station

The RICE EGUs at Eklutna Generation Station are subject to a PM emission limit of 0.05 grains per cubic foot of exhaust gas, corrected to standard conditions and averaged over three hours.

4.3.7.1.4 Total PM₁₀ and Total PM_{2.5} BACT Limit Selection – Natural Gas Operation

NPPD is proposing a BACT limit for PM₁₀ and PM_{2.5} of 15 mg/m³ at 15% O₂ at 100% load (equal to 3.9 lb/hr) during natural gas operation, based on the use of good combustion practices and the use of low-sulfur fuel. The limit includes both filterable and condensable PM and is based on the emission rates provided by Wartsila.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions.

4.3.7.1.5 Total PM₁₀ and Total PM_{2.5} BACT Limit Selection – Fuel Oil Operation

NPPD is proposing a BACT limit for PM₁₀ and PM_{2.5} of 30 mg/m³ at 15% O₂ at 100% load (equal to 8.1 lb/hr) during fuel oil operation, based on the use of good combustion practices and the use of low-sulfur fuel. The limit includes both filterable and condensable PM and is based on the emission rates provided by Wartsila.

NPPD is proposing to demonstrate compliance with the proposed BACT limits using stack testing conducted at steady state 100% load conditions.

4.3.8 Greenhouse Gases (CO₂)

This section includes the BACT analysis for CO₂ for the RICE generating units operating on either natural gas or fuel oil.

4.3.8.1 Overview of CO₂ Emissions from RICE EGUs

CO₂ is produced from the RICE units as a product of combustion and proceeds stoichiometrically (for every 12 pounds of carbon burned, 44 pounds of CO₂ is emitted).⁹⁹

4.3.8.2 Step 1 – Identification of CO₂ Control Technologies – RICE

Available CO₂ control technologies are presented in the following sections for the RICE EGUs. There are no NSPS or NESHAPs applicable to the RICE that regulate CO₂ emissions. Likewise, no RBLC entries were identified that are similar to the proposed RICE EGUs and using any type of add-on control device for the control of CO₂ emissions. This suggests that BACT for CO₂ for the RICE EGUs should be represented by emission limits that do not account for the implementation of an add-on control device.

Based on a review of technical literature, past control technology determinations, and generally available technologies and practices, the following options are potentially available to control CO₂ from the RICE EGUs:

- ▶ Good Design and Operating Practices

4.3.8.2.1 Good Design and Operating Practices

Good design and operating practices for controlling GHG emissions from the RICE consists of minimizing startup and idling time, in addition to having good air to fuel mixing to promote complete combustion. By operating a combustion unit as efficiently as possible, GHG emissions are minimized. This is achieved in normal practice for RICE units that are equipped with computerized control systems that optimize operating parameters automatically.

4.3.8.3 Step 2 – Elimination of Technically Infeasible CO₂ Control Options – RICE

NPPD will implement good combustion design and operating practices on each RICE EGU. The RICE vendors have implemented design elements that promote complete combustion and efficiency, and NPPD will operate the units as efficiently as possible.

4.3.8.4 Step 3 – Summary and Ranking of Remaining CO₂ Controls – RICE

Good combustion design and operating practices are the only remaining CO₂ control option for the RICE units. As such, ranking of control technologies is not necessary.

4.3.8.5 Step 4 – Evaluation of Most Stringent CO₂ Controls – CT

There are no adverse economic, environmental, or energy impacts associated with good combustion design and operating practices for the RICE EGUs.

⁹⁹ NC Greenhouse Gas (GHG) Inventory Instructions for Voluntary Reporting, November 2009. Prepared by the North Carolina Division of Air Quality.

https://files.nc.gov/ncdeq/Air%20Quality/inventory/forms/GHG_Emission_Inventory_Instructions_Nov2009_Voluntary.pdf

4.3.8.6 Step 5 – Selection of Emission Limits and Controls for CO₂ BACT

4.3.8.6.1 Summary of Applicable Limits from NSPS/NESHAPs/State Rules

The RICE EGUs will not be subject to any NSPS, NESHAP, or state-level CO₂ emission limits.

4.3.8.6.2 Summary of RBLC Review

Trinity queried the RBLC database using the following criteria:

- ▶ Process Type Code:
 - 17.110 (Large Internal Combustion Engines (>500HP) firing Fuel Oil
 - 17.120 (Large Internal Combustion Engines (>500HP) firing Other Liquid Fuel & Liquid Fuel Mixtures
 - 17.130 (Large Internal Combustion Engines (>500HP) firing Natural Gas
 - 17.140 (Large Internal Combustion Engines (>500HP) firing Landfill/Digester/Bio-Gas
 - 17.150 (Large Internal Combustion Engines (>500HP) firing Other Gaseous Fuel & Gaseous Fuel Mixtures
 - 17.190 (Large Internal Combustion Engines (>500HP) firing Other/Unknown Fuel
- ▶ Pollutant Name: Carbon Dioxide (CO₂) and Carbon Dioxide Equivalent (CO₂e)
- ▶ Permit Date: After January 1st, 2014

Process codes for all fuel types for large RICE units were included in the search to avoid excluding any mischaracterized units. Trinity reviewed the results of the RBLC search and removed any entries which were clearly for emergency- or standby-engines only. This is because BACT requirements for emergency engines differ from prime engines, as they are used much less frequently and are subject to less stringent emission standards under NSPS and NESHAP. Similarly, engines used for purposes other than electric generation, such as gas compression, were excluded, as these units are typically smaller, fire less-clean fuels such as field gas, and are generally operated much differently than engines used for electric generation.

The detailed RBLC search results tables are provided in Appendix D (Table D.2-9 and Table D.2-10). The results are separated based on fuel type - natural gas and fuel oil.

Natural Gas-Fired ICE

AK-0084 is subject to a CO₂ emission limit of 869,621 tons per year when operating on natural gas. MI-0440 is subject to an emission limit of 48,724 tons per year on a rolling 12-month basis. Finally, KS-0030 is subject to a CO₂ emission limit of 1.25 lb/kWh on a 12-month rolling average basis.

Fuel Oil-Fired ICE

Of the RBLC entries included in this analysis, only AK-0084 includes a fuel oil-specific CO₂ emission limit, 1,299,630 tons per year as CO₂e. It is not clear if this limit includes any amount of natural gas operation.

4.3.8.6.3 Summary of CO₂ Limits in Air Permits not in RBLC

In addition to the RBLC search, NPPD conducted additional research to identify air permits issued for sources similar to the RICE EGUs which were not entered into the RBLC database. These units may not have undergone a BACT analysis and are included here for reference purposes only.

Montana-Dakota Utilities Company – Lewis & Clark Station

The RICE EGUs at Lewis & Clark Station are not subject to a CO₂ emission limit. The units are subject to a maximum fuel throughput limit which may indirectly serve as a limit on CO₂ emissions.

Tucson Electric Power – Irvington Generating Station

Wisconsin Public Service Corporation – Weston Generating Station

Each RICE EGU at Weston Generating Station is subject to a CO₂ emission limit of 1,100 lb/MWh-gross on a 12-month rolling average basis. The units are also restricted to fire only pipeline quality natural gas.

City of Tallahassee – Arvah Hopkins

The RICE EGUs at Arvah Hopkins are each subject to a CO₂ emission limit of 1,110 lb/MWh-gross, demonstrated initially via performance testing and subsequently via fuel usage recordkeeping. The limit applies on a 12-month rolling average basis.

Marquette Board of Light and Power

Matanuska Electric – Eklutna Generating Station

The RICE EGUs at Eklutna Generating Station are not subject to a CO₂ emission limit.

4.3.8.6.4 CO₂ BACT Limit Selection – Natural-Gas Operation

is proposing a CO₂ BACT limit for natural gas combustion of 117 lb/MMBtu heat input (HHV), based on the use of good combustion design and operating practices. This limit is the CO₂ factor in 40 CFR Part 98 Subpart C – the GHG Emissions Reporting Rule (converted from 53.06 kg/MMBtu). NPPD is proposing to rely on O&M records for demonstrating compliance.

4.3.8.6.5 CO₂ BACT Limit Selection – Fuel-Oil Operation

is proposing a CO₂ BACT limit for fuel oil combustion of 163 lb/MMBtu heat input (HHV), based on the use of good combustion design and operating practices. This limit is the CO₂ factor in 40 CFR Part 98 Subpart C – the GHG Emissions Reporting Rule (converted from 73.96 kg/MMBtu). NPPD is proposing to rely on O&M records for demonstrating compliance.

4.3.9 Greenhouse Gases (CH₄)

This section includes the BACT analysis for CH₄ for the RICE generating units operating on either natural gas or fuel oil.

4.3.9.1 Overview of CH₄ Emissions from RICE EGUs

CH₄ emissions from the natural gas combustion turbines form as a result of incomplete combustion of hydrocarbons present in the fuel.

4.3.9.2 Step 1 – Identification of CH₄ Control Technologies – RICE

The only available control options for minimizing CH₄ emissions from the RICE EGUs are good combustion design and operation to minimize unburned fuel. Oxidation catalysts are not considered available for reducing CH₄ emissions because oxidizing the very low concentrations of CH₄ present in the RICE exhaust would require much higher temperatures, residence times, and catalyst loadings than those offered commercially for CO oxidation catalysts. For these reasons, catalyst providers do not offer products for reducing CH₄ emissions from internal combustion engines.

4.3.9.3 Step 2 – Elimination of Technically Infeasible CH₄ Control Options – RICE

Good combustion design and operation is the only technically feasible control option for reducing CH₄ emissions from the RICE units.

4.3.9.4 Step 3 – Summary and Ranking of Remaining CH₄ Controls – RICE

Ranking of control technologies is not required, as good combustion design and operation is the only remaining option and is evaluated in the remaining steps of the BACT analysis.

4.3.9.5 Step 4 – Evaluation of Most Stringent CH₄ Controls – CT

No adverse energy, environment, or economic impacts are associated with good combustion design and operation for reducing CH₄ emissions from the RICE EGUs.

4.3.9.6 Step 5 – Selection of Emission Limits and Controls for CH₄ BACT

In lieu of a numerical BACT limit for CH₄ from the RICE EGUs, NPPD is proposing the use of good combustion design and operation as BACT for the reduction of CH₄ emissions. A numerical limit is not necessary given the insignificant contribution of CH₄ to the total GHG emissions from the RICE EGUs, and the inherent difficulty in measuring CH₄ emissions from the units.

4.3.10 Greenhouse Gases (N₂O)

This section includes the BACT analysis for N₂O for the RICE generating units operating on either natural gas or fuel oil.

4.3.10.1 Overview of N₂O Emissions from RICE EGUs

N₂O emissions from internal combustion engines form solely as a byproduct of combustion, through many of the same processes by which N₂O is formed in combustion turbines.

4.3.10.2 Step 1 – Identification of N₂O Control Technologies – RICE

NPPD is not aware of any available add-on controls designed specifically to reduce N₂O emissions from natural-gas or diesel-fired engines. N₂O catalysts are an available technology for reducing N₂O emissions, but as discussed in Section 4.2.10.2, these systems require high inlet N₂O concentrations in the exhaust stream to provide any meaningful reduction in N₂O emissions and are not considered an available control technology for the emergency engines. Thus, good combustion practices are the only available control option for reducing N₂O emissions from the RICE EGUs.

4.3.10.3 Step 2 – Elimination of Technically Infeasible N₂O Control Options – RICE

Good combustion practices is a technically feasible option for reducing N₂O emissions from the RICE EGUs.

4.3.10.4 Step 3 – Summary and Ranking of Remaining N₂O Controls – RICE

Since good combustion practices is the only available control option, ranking of controls is not necessary.

4.3.10.5 Step 4 – Evaluation of Most Stringent N₂O Controls – CT

No adverse energy, environmental, or economic impacts are associated with good combustion practices for reducing N₂O emissions from the RICE EGUs.

4.3.10.6 Step 5 – Selection of Emission Limits and Controls for N₂O BACT

In lieu of a numerical BACT limit for N₂O from the RICE EGUs, NPPD is proposing the use of good combustion design and operation as BACT for the reduction of N₂O emissions. A numerical limit is not necessary given the insignificant contribution of N₂O to the total GHG emissions from the RICE EGUs, and the inherent difficulty in measuring CH₄ emissions from the units.

4.4 BACT Analyses for Auxiliary Boiler

The proposed 99.6 MMBtu/hr Auxiliary Boiler will be fired with NG. The control technologies listed in the following subsections were obtained from the RBLC database for gas-fired boilers in the size range of the Auxiliary Boiler at Cooper Station and from research of emerging technologies. The RBLC search conducted for this analysis was based on RBLC Process Code 12.310 – Industrial Size Boilers/Furnaces >100 MMBtu/hr and 13.310 – Commercial/Institutional Size Boilers/Furnaces <100 MMBtu/hr over a ten-year period. The RBLC results are summarized in Appendix D.

4.4.1 NO_x BACT

4.4.1.1 Step 1 - Identification of Potential Control Techniques

Using the RBLC search and permit review results, as well as review of technical literature, potentially applicable NO_x control technologies were identified based on the principles of the control technology and engineering experience for general combustion units. These technologies are listed as follows:

- ▶ EM_x/SCONO_x
- ▶ SCR
- ▶ Selective Non-Catalytic Reduction
- ▶ Low-NO_x Combustors
- ▶ Good Combustion Practices

EM_x/SCONO_x, SCR and SNCR were discussed in detail in Section 4.2.1.

Low NO_x combustors use internal flue gas recirculation, or staged combustion. The purpose of the staging is to lower the flame temperature and reduce oxygen concentration at the flame front. This will limit the formation of thermal NO_x. Ultra-low NO_x burners can incorporate more advanced combustion techniques, such as enhanced staged combustion, lean premix combustion, and advanced burner geometry and controls to create larger and more branched flames. This further lowers the flame temperature which results in a further reduction in thermal NO_x formation.

4.4.1.2 Step 2 - Elimination of Technically Infeasible Control Options

Since EM_x technology has not been demonstrated on NG-fired boilers, this technology is determined to be technically infeasible. All other options identified in Step 1 are technically feasible.

4.4.1.3 Step 3 - Rank of Remaining Control Technologies

The remaining control technologies are presented in Table 4-1717.

Table 4-17. Remaining NO_x Control Technologies – Auxiliary Boiler

Rank	Control Technology	Potential Control Efficiency (%)¹⁰⁰
1	SCR	50-90
2	SNCR	40-60
3	Low-NO _x Combustors	Base Case

4.4.1.4 Step 4 - Evaluation of Most Stringent Controls

After ranking the technically feasible control technologies, the fourth step of the analysis is to evaluate the control options on the basis of economic, energy, and environmental considerations, and document the results.

4.4.1.4.1 SCR

NPPD evaluated the environmental, energy, and economic impacts of using SCR. No significant environmental impacts are expected from operation of an SCR. Energy impacts include the consumption of electricity to operate the system. Economic impacts for the installation of SCR are significant. The proposed boiler with a low NO_x combustor has a baseline emission rate of 0.037 lb/MMBtu. Assuming 100% utilization and assuming that an SCR is capable of achieving 90 percent control, this equates to 14.6 tons of NO_x emissions removed with the control device.

NPPD prepared a cost estimate using the U.S. EPA’s Air Pollution Control Cost Estimation Spreadsheet for SCR (June 2019), which is based on Chapter 2 – Selective Catalytic Reduction Cost Manual that was last updated in June 2019.¹⁰¹ Standard factors were used for a NG-fired boiler using the design specifications of the proposed auxiliary boiler. As shown in the complete cost analysis, provided in Appendix E, the estimated annualized total cost for an SCR would be \$363,285 per year in 2024 dollars. The cost of purchasing, installing, and operating an SCR is approximately \$24,957 per ton of NO_x removed. This cost is well beyond the range of cost effectiveness for BACT.

Moreover, with the exception of one RBLC entry (LA-0364), which has not been constructed, no NG-fired boilers listed in the RBLC with a heat input capacity less than 100 MMBtu/hr have installed SCR. Therefore, based on the environmental, energy, and economic analysis and a review of similar boilers in the RBLC database, SCR is not selected as BACT for control of NO_x emissions from the auxiliary boiler.

4.4.1.4.2 SNCR

NPPD evaluated the environmental, energy, and economic impacts of using SNCR. No significant environmental impacts are expected from the operation of SNCR. Energy impacts are attributed to only the electricity usage associated with operation of the SNCR itself, which is lower than that of SCR. Similar to SCR, economic impacts for the installation of SNCR are significant. The proposed boiler with a low NO_x combustor has a baseline emission rate of 0.037 lb/MMBtu. Assuming 100% utilization and assuming that an SNCR is capable of achieving 60 percent control, this equates to 9.7 tons of NO_x emissions removed with the control device.

¹⁰⁰ The control efficiencies identified in the table for SCR and SNCR represent typical control efficiency ranges for these control technologies and were used for ranking purposes only. The control efficiencies are not intended to reflect the emission reductions that would occur from the baseline emission rate of 9 ppmvd at 3% O₂.

¹⁰¹ https://www.epa.gov/sites/default/files/2019-06/scrcostmanualspreadsheet_june-2019vf.xlsx

NPPD prepared a cost estimate using the U.S. EPA's Air Pollution Control Cost Estimation Spreadsheet for SCR (June 2019), which is based on Chapter 1 – Selective Noncatalytic Reduction Cost Manual that was last updated in April 2019.¹⁰² Standard factors were used for a NG-fired boiler using the design specifications of the proposed auxiliary boiler. As shown in the complete cost analysis, provided in Appendix E the estimated annualized total cost for an SNCR would be \$126,365 in 2024 dollars. The cost of purchasing, installing, and operating an SNCR is approximately \$13,022 per ton NO_x removed. This cost is well not cost effective for BACT.

NPPD has determined that SNCR is not BACT based on the environmental, energy, and economic analysis. This determination is consistent with the RBLC database, as no facilities in the database have installed SNCR for control of NO_x emissions from a NG-fired boiler less than 100 MMBtu/hr.

4.4.1.4.3 Low-NO_x Combustors

The proposed auxiliary boiler will be equipped with low-NO_x burners. Based on the insignificant environmental and energy impact associated with this technology and the feasibility from an economic standpoint, NPPD has determined that low-NO_x combustors are the BACT for the Auxiliary Boiler.

4.4.1.5 *Step 5 - Selection of BACT*

4.4.1.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.3-1).

4.4.1.5.2 NO_x BACT Limit Selection

NPPD has determined that low-NO_x burners are BACT for the auxiliary boiler. NPPD proposes a BACT emission limit of 0.037 lb/MMBtu, demonstrated on a 3-hour average basis via stack testing. This is consistent with the vendor data for a low NO_x system. Emission limits in the RBLC database range from 0.006 lb/MMBtu to 0.1 lb/MMBtu, with several recent BACT determinations approved at values of 0.011 lb/MMBtu and greater, including several units with similar heat input capacity at 0.035 to 0.04 lb/MMBtu in 2022 and 2023. The proposed emission limit is consistent with the emission limits provided in the RBLC database. Compliance with the proposed NO_x BACT limit will be demonstrated based on an initial performance test.

4.4.2 CO and VOC BACT

4.4.2.1 *Step 1 - Identification of Potential Control Techniques*

Using the RBLC search and permit review results, as well as review of technical literature, potentially applicable CO and VOC control technologies were identified based on the principles of the control technology and engineering experience for general combustion units. These technologies are listed as follows:

- ▶ Oxidation Catalyst
- ▶ Good Combustion Practices

¹⁰² https://www.epa.gov/sites/default/files/2019-06/snrcrcostmanualspreadsheet_june2019vf.xlsx

Oxidation catalyst and good combustion controls were discussed in detail in Section 4.3. of this application.

4.4.2.2 Step 2 - Technical Feasibility Analysis

All options are technically feasible, no option will be eliminated in this step.

4.4.2.3 Step 3 - Ranking of Remaining Control Technologies by Effectiveness

The third of the five steps in the top-down BACT assessment procedure is to rank technically feasible control technologies by control effectiveness. The remaining control technologies are presented in Table 4-18.

Table 4-18. Remaining CO and VOC Control Technologies – Auxiliary Boiler

Rank	Control Technology	Potential Control Efficiency (%)
1	Oxidation Catalyst	50-90 for CO, 50-60 for VOC
2	Good Combustion Controls	Base Case

4.4.2.4 Step 4 - Top-Down Evaluation of Control Options

After ranking the technically feasible control technologies, the fourth step of the analysis is to evaluate the control options on the basis of economic, energy, and environmental considerations, and document the results.

4.4.2.4.1 Oxidation Catalyst

No NG-fired boilers listed in the RBLIC with a heat input capacity less than 100 MMBtu/hr have installed oxidation catalyst. Therefore, based on the economic analysis and a review of similar boilers in the RBLIC database, oxidation catalyst is not selected as BACT for control of CO or VOC emissions from the Auxiliary Boiler. Thus, NPPD proceeded with evaluating the next most efficient control option presented in Section 4.4.2.1.

4.4.2.4.2 Good Design and Operating Practices

The only remaining technology is good design and operating practices. A properly designed and operated boiler minimizes CO and VOC formation by ensuring that the boiler temperature and oxygen availability are adequate for complete combustion. Additionally, tune-ups will be performed as required under 40 CFR 63 Subpart DDDDD. Good design and operating practices is considered BACT for CO and VOC emissions for the proposed boiler.

4.4.2.5 Step 5 – Select BACT for Auxiliary Boiler

4.4.2.5.1 Summary of RBLIC review

The detailed RBLIC search results tables for CO and VOC are provided in Appendix D (Table D.3-2 and Table D.3-3).

4.4.2.5.2 CO and VOC BACT Limit Selection

Based on the control technology evaluation, good design and operation to achieve minimum emissions of CO and VOC is determined as the BACT for the Auxiliary Boiler. NPPD proposes a CO BACT emission limit of 0.037 lb/MMBtu, demonstrated on a 3-hour average basis via stack testing and a VOC BACT emission limit

of 0.0054 lb/MMBtu, demonstrated on a 3-hour average basis via stack testing. These are consistent with the vendor data for a low NO_x burner system.

There is one RBLC database entry for CO for a unit without oxidation catalyst that is significantly lower than the proposed emission limit, which is 0.0075 lb/MMBtu for a 40.4 MMBtu/hr NG-fired boiler at Seminole Generating Station. A detailed review of the PSD permit and associated documentation associated with the project reveals that no stack testing or continuous emissions monitoring was required to demonstrate compliance with this emission limit. Therefore, operation at this level of emissions has not been demonstrated and is not considered further in this analysis. The proposed CO emission limit is consistent with all other emission limits provided in the RBLC database for similar sized NG-fired units without oxidation catalyst. Compliance with the Auxiliary Boiler CO BACT limit will be based on an initial performance test conducted in accordance with U.S. EPA Method 10.

RBLC database entries for VOC emissions from boilers without oxidation catalyst range from 0.0015 lb/MMBtu to 0.008 lb/MMBtu, with 0.0054 lb/MMBtu being the most prevalent. The two most recent RBLC database entries included in Appendix D for the 2023 calendar year were approved at an emission rate of 0.0054. Therefore, NPPD is proposing an emission limit of 0.0054 lb/MMBtu consistent with the most recently approved PSD permits listed in the RBLC search.

4.4.3 PM/PM₁₀/PM_{2.5} BACT

4.4.3.1 Step 1 – Identify Available Control Options

Using the RBLC search and permit review results, potentially applicable PM/PM₁₀/PM_{2.5} control technologies for a gas-fired boiler were identified. The only available control options are low sulfur fuels and combustion design controls.

4.4.3.2 Step 2 – Eliminate Technically Infeasible Control Options

Low sulfur fuels and combustion design controls are a technically feasible control option for reducing PM emissions from the auxiliary boiler.

4.4.3.3 Step 3 – Rank Remaining Control Options by Effectiveness

Implementing combustion design controls provides the most effective means for reducing emissions of PM/PM₁₀/PM_{2.5} from the auxiliary boiler.

4.4.3.4 Step 4 – Top-Down Evaluation of Control Options

Both low sulfur fuels and combustion design controls are proposed as BACT.

4.4.3.5 Step 5 – Select BACT for Auxiliary Boiler

4.4.3.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.3-4 and Table D.3-5).

4.4.3.5.2 PM BACT Limit Selection

NPPD proposes that BACT is the use of low sulfur fuels and good combustion practices. NPPD proposes a PM, PM₁₀, and PM_{2.5} BACT emission limit of 0.0075 lb/MMBtu (filterable plus condensable) on a 3-hour average basis, as demonstrated using stack testing. Emission limits in the RBLC database range from 0.0007

lb/MMBtu to 0.01 lb/MMBtu, with several recent BACT determinations approved at values of 0.0075 lb/MMBtu and greater, including several units with similar heat input capacity at 0.0075 to 0.008 lb/MMBtu in 2022 and 2023. Based on review of the RBLC database, NPPD believes that the proposed PM, PM₁₀, and PM_{2.5} BACT limit is consistent with established limits for comparable boilers.

4.4.4 H₂SO₄ BACT

4.4.4.1 Step 1 – Identify Available Control Options

Emissions of H₂SO₄ emissions depend upon the sulfur content of the fuel and oxidation of SO₂ to SO₃, followed by immediate conversion of SO₃ to H₂SO₄ when water vapor is present. H₂SO₄ emissions are generally controlled with add-on control equipment designed to capture the emissions prior to the time they are exhausted to the atmosphere.

- ▶ FGD System;
- ▶ DSI; and
- ▶ Fuel Specification.

4.4.4.2 Step 2 – Eliminate Technically Infeasible Control Options

4.4.4.2.1 FGD System

FGD systems are not listed in the RBLC as BACT for the control of H₂SO₄ emissions for auxiliary boilers. This technology has not been applied to NG auxiliary boilers due to very low H₂SO₄ emissions. Controls would not provide any measurable emission reduction.

Based on the information reviewed for this BACT determination, NPPD has determined that the use of an FGD system is not a technically feasible option for the auxiliary boiler.

4.4.4.2.2 Dry Sorbent Injection

Dry sorbent injection is not listed in the RBLC as BACT for the control of H₂SO₄ emissions for auxiliary boilers. This technology has not been applied to NG auxiliary boilers due to very low SO₂ and H₂SO₄ emissions. Controls would not provide any measurable emission reduction.

Based on the information reviewed for this BACT determination, NPPD has determined that the use of dry sorbent injection is not a technically feasible option for the Auxiliary Boiler at this source.

4.4.4.2.3 Fuel Specifications

Combusting NG, which has an inherently low sulfur content, has a very low potential for generating H₂SO₄ emissions. Fuel specifications are included in RBLC for the control of H₂SO₄ emissions from auxiliary boilers. Based on the information reviewed for this BACT determination, NPPD has determined that the use of Fuel Specifications is a technically feasible option for the Auxiliary Boiler at this source.

4.4.4.3 Step 3 – Rank Remaining Control Options by Effectiveness

The only remaining control measure identified for control of H₂SO₄ resulting from the operation of the Auxiliary Boiler is fuel specifications.

4.4.4.4 Step 4 – Top-Down Evaluation of Control Options

The top and only available and technically feasible H₂SO₄ control option will be applied to achieve compliance with the proposed BACT limit.

4.4.4.5 Step 5 – Select BACT for Auxiliary Boiler

NPPD proposes the use of natural gas and good combustion practices as BACT for SO₂ emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants, and has seen some variability. NPPD is proposing as BACT that the natural gas combusted will contain no more than 2 gr S/100 scf, as an annual average based on fuel records.

4.4.5 GHG BACT

4.4.5.1 Step 1 – Identify Available Control Options

CO₂ is by far the dominant GHG from this source. CH₄ and N₂O are present only in very small amounts, are incidental to combustion, and trend with the CO₂ emissions. There are no known supplemental controls for N₂O or methane emissions from gas-fired units. Therefore, this BACT analysis focused on CO₂ as a surrogate for all GHG emissions. The CO₂ control technologies are as follows:

- ▶ Low Carbon Fuel Source;
- ▶ Good Operation and Maintenance, and
- ▶ Good Combustion Practices/Tune-ups.

4.4.5.2 Step 2 – Eliminate Technically Infeasible Control Options

4.4.5.2.1 Low Carbon Fuel Use

It is technically feasible to burn a low carbon fuel such as natural gas in the boilers.

4.4.5.2.2 O&M Practices

Boiler efficiency decreases over time; however, the rate of deterioration can be curbed by proper O&M practices. A well operated and maintained plant will experience less deterioration of boiler efficiency. Operation and maintenance according to the manufacturer's emission-related instructions will prevent generation of additional GHG emissions due to efficiency losses over the lifetime of each piece of combustion equipment.

Based on the information reviewed for this BACT determination, NPPD has determined that the use of O&M practices is a technically feasible option for the auxiliary boiler.

4.4.5.2.3 Good Combustion Practices/Tune-ups

Good combustion practices require a visual check by an experienced boiler engineer to ensure that everything is in good working condition and set according to the manufacturer's recommendations or the optimum settings developed for the particular boiler. Simple parametric testing may be required, which may involve changes in the key control variables of the combustion system and observation of key parameters such as CO emissions, steam outlet conditions, flue gas outlet (stack) temperature, and NO_x emissions. Up to a 3% reduction in CO₂ emissions is possible through tuning.

As part of the O&M practices, combustion tuning of boilers will be conducted on an as-needed basis to address any decreases in boiler efficiency over time.

Based on the information reviewed for this BACT determination, NPPD has determined that the use of Improved Combustion Measures: Combustion Tuning is a technically feasible option for the Auxiliary Boiler at this source.

4.4.5.3 Step 3 – Rank Remaining Control Options by Effectiveness

The third of the five steps in the top-down BACT assessment procedure is to rank technically feasible control technologies by control effectiveness. NPPD will operate a boiler using the only available control options, so there is nothing to rank as part of the selection.

4.4.5.4 Step 4 – Top-Down Evaluation of Control Options

All of the control measures that are technically feasible will be used.

4.4.5.5 Step 5 – Select BACT for Auxiliary Boiler

4.4.5.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.3-6).

4.4.5.5.2 CO₂ BACT Limit Selection

NPPD proposes a CO₂ BACT emission limit of 117.1 lb/MMBtu with compliance demonstrated by combusting pipeline NG. CO₂e emissions from the Auxiliary Boiler shall be controlled through the use of good combustion practices and efficient boiler design using the measures listed in Section 4.4.5.2.3.

4.5 BACT Analyses for Natural Gas Dew Point Heaters

4.5.1 NO_x BACT

4.5.1.1 Step 1 – Identify All Control Technologies

The following control options have been identified to reduce NO_x emissions:

- ▶ SCR
- ▶ SNCR
- ▶ Low-NO_x Combustors
- ▶ Good Combustion Practices

These control technologies have been previously described in Sections 4.2.1 and 4.4.1.

4.5.1.2 Step 2 – Eliminate Technically Infeasible Options

4.5.1.2.1 SCR

As previously stated, the ideal flue gas temperature range for optimal SCR operation is 700°F to 750°F. However, the exhaust temperature for each heater is approximately 300°F. Therefore, additional exhaust gas preheaters would be required to raise the temperature by approximately 535°F for the boilers and

300°F for the oil heaters. Since the temperature is not within the required operating range, SCR is technically infeasible.

4.5.1.2.2 Low-NO_x and Ultra-Low-NO_x Burners

Low-NO_x burners are considered technically feasible. Ultra low-NO_x burners are not a listed control for fuel gas preheaters or space heaters in the RBLC database. Therefore, ultra-low-NO_x burners are removed from consideration.

4.5.1.2.3 Good Combustion Practices

Good combustion practices are included in NPPD's baseline design and are therefore technically feasible.

4.5.1.3 *Step 3 – Rank Remaining Control Technologies by Control Effectiveness*

Table 4-19 ranks the NO_x control technologies in descending order of maximum CE.

Table 4-19. Ranked NO_x Control Options – Natural Gas Heaters

Rank	Control Option	Control Efficiency (%)
1	Low-NO _x burners	38%-63%
2	Good combustion practices	0%

4.5.1.4 *Step 4 – Evaluate the Most Effective Controls and Document Results*

4.5.1.4.1 Low-NO_x Burners

Low-NO_x burners are proposed for the fuel gas preheaters based on availability for sources in the proposed size range.

4.5.1.4.2 Good Combustion Practices

Good combustion practices are included in NPPD's baseline design and do not pose any adverse energy, environmental, or economic impacts.

4.5.1.5 *Step 5 – Select BACT*

4.5.1.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.4-1).

4.5.1.5.2 NO_x BACT Limit Selection

NPPD has determined that low-NO_x burners are BACT for the heaters. NPPD proposes a BACT emission limit of 0.037 lb/MMBtu. Compliance will be demonstrated through the combustion of natural gas and maintaining and operating combustion sources in accordance with manufacturer's recommendations. Although the RBLC database contains entries with lower emission limits for similar small, NG-fired combustion units, these units are not required to demonstrate compliance through source testing, and in most cases are not designed to allow for direct measurement of emissions. Therefore, little data is available to prove that the units comply with these limits. Given the relatively low emissions from small, NG-fired

combustion units, and the uncertainty with respect to the performance of these units, NPPD’s proposed emission limits represent BACT-level control.

4.5.2 CO and VOC BACT

4.5.2.1 Step 1 – Identify All Control Technologies

The following control options have been identified as possible techniques to achieve more complete combustion of the exhaust gas from small heaters.

- ▶ Oxidation Catalyst
- ▶ Good Combustion Practices

Oxidation catalyst and good combustion practices were discussed in Section 4.4.2 of this application.

4.5.2.2 Step 2 – Eliminate Technically Infeasible Options

The next step in the process is to evaluate all possible options and determine if any of them are technically infeasible for the proposed project.

4.5.2.2.1 Oxidation Catalyst

The results from the RBLC database search do not include oxidation catalyst. NPPD is not aware of any heaters of this size that have demonstrated the use of such a system and therefore does not consider this technology to be technically feasible.

4.5.2.2.2 Good Combustion Practices

Good combustion practices, such as controlling the air/oxygen supply and maintaining an appropriate temperature in the combustion chambers, is included in the baseline design for the heaters. Therefore, this control method is technically feasible.

4.5.2.3 Step 3 – Rank Remaining Control Technologies by Control Effectiveness

Table 4-20 ranks the control technologies in descending order of maximum CE.

Table 4-20. Ranked Control Options – CO and VOC – Natural Gas Heaters

Rank	Control Option	Control Efficiency (%)
1	Good Combustion Practices	Base Case

4.5.2.4 Step 4 – Evaluate the Most Effective Controls and Document Results

NPPD has chosen to apply good combustion practices for selecting a BACT emission limit.

4.5.2.5 Step 5 – Select BACT

4.5.2.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.4-2).

4.5.2.5.2 CO and VOC BACT Limit Selection

NPPD will reduce CO and VOC emissions through the use of good combustion controls, according to the requirements of BACT. For each heater, NPPD is proposing a CO BACT limit of 0.037 lb/MMBtu and a VOC BACT limit of 0.005 lb/MMBtu. The proposed limits are consistent with the most prevalent emission limits included in the RBLC database, including emission limits from the 2022 and 2023 calendar years. Compliance will be demonstrated through the combustion of pipeline quality NG, maintaining and operating combustion sources in accordance with manufacturer's recommendations. Given the size and intermittent operation of these units, it is NPPD's position that no source testing is needed.

4.5.3 PM/PM₁₀/PM_{2.5} BACT

4.5.3.1 Step 1 – Identify Available Control Options

Using the RBLC search and permit review results, potentially applicable PM/PM₁₀/PM_{2.5} control technologies for NG-fired heaters were identified. The only available control option is combustion design controls.

4.5.3.2 Step 2 – Eliminate Technically Infeasible Control Options

Combustion design controls are a technically feasible control option for reducing PM emissions from the heaters.

4.5.3.3 Step 3 – Rank Remaining Control Options by Effectiveness

Implementing combustion design controls provides the most effective means for reducing emissions of PM/PM₁₀/PM_{2.5} from the heaters.

4.5.3.4 Step 4 – Top-Down Evaluation of Control Options

The top and only available and technically feasible PM control option will be applied to achieve compliance with the proposed BACT limit.

4.5.3.5 Step 5 – Select BACT for the Heaters

4.5.3.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.4-4 and Table D.4-5).

4.5.3.5.2 PM/PM₁₀/PM_{2.5} BACT Limit Selection

NPPD proposes a PM, PM₁₀, and PM_{2.5} BACT emission limit of 0.0075 lb/MMBtu, based on manufacturer data. Based on review of the RBLC database, NPPD believes that the proposed PM, PM₁₀, and PM_{2.5} BACT limit is consistent with established limits for comparable NG heaters. Given the size and intermittent operation of these units, it is NPPD's position that no source testing is needed.

4.5.4 H₂SO₄ BACT

4.5.4.1 Step 1 – Identify Available Control Options

H₂SO₄ emissions are generally controlled with add-on control equipment designed to capture the emissions prior to the time they are exhausted to the atmosphere. Add-on control equipment for reduction of H₂SO₄ emissions from small, NG-fired combustion sources has not been demonstrated, and is therefore not an

available control. The only available control option for reduction of H₂SO₄ emissions is the combustion of low sulfur fuels.

4.5.4.2 Step 2 – Eliminate Technically Infeasible Control Options

Combusting only clean NG, which has an inherently low sulfur content, rather than higher sulfur content fuels alone or in combination with NG has a very low potential for generating H₂SO₄ emissions. Based on the information reviewed for this BACT determination, NPPD has determined that the use of low sulfur fuel is a technically feasible option for the heaters at this source.

4.5.4.3 Step 3 – Rank Remaining Control Options by Effectiveness

The only measure identified for control of H₂SO₄ resulting from the operation of the heaters is the use of low sulfur fuel.

4.5.4.4 Step 4 – Top-Down Evaluation of Control Options

The top and only available and technically feasible H₂SO₄ control option will be applied to achieve compliance with the proposed BACT limit.

4.5.4.5 Step 5 – Select BACT for Heaters

4.5.4.5.1 Summary of RBLC review

The detailed RBLC search results tables for sulfuric acid are provided in Appendix D (Table D.4-7).

4.5.4.5.2 H₂SO₄ BACT Limit Selection

NPPD proposes the use of natural gas and good combustion practices as BACT for H₂SO₄ emissions. NPPD has conducted a review of the sulfur levels in natural gas received at their power plants and has seen some variability. NPPD is proposing as BACT that the natural gas combusted will contain no more than 2 gr S/100 scf, as an annual average based on fuel records.

4.5.5 GHGs BACT

4.5.5.1 Step 1 – Identify Available Control Options

The CO₂ is by far the dominant GHG from this source. CH₄ and N₂O are present only in very small amounts, are incidental to combustion, and trend with the CO₂ emissions. This BACT analysis focused on CO₂ as a surrogate for all GHG emissions.

- ▶ O&M Practices;
- ▶ Efficient Burner Design; and
- ▶ Good Combustion Practices

4.5.5.2 Step 2 – Eliminate Technically Infeasible Control Options

All of the control techniques identified for small, NG-fired heaters are technically feasible.

4.5.5.3 Step 3 – Rank Remaining Control Options by Effectiveness

The third of the five steps in the top-down BACT assessment procedure is to rank technically feasible control technologies by control effectiveness. The remaining control technologies are presented in Tabel 4-21.

Table 4-21. Remaining GHG Control Technologies – Natural Gas Heaters

Rank	Control Technology	Potential Control Efficiency (%)
1	Efficient Burner Design	Base Case
2	O&M Practices	Base Case
3	Good Combustion Practices	Base Case

4.5.5.4 Step 4 – Top-Down Evaluation of Control Options

NPPD has chosen to apply Efficient Burner Design, O&M Practices, and Good Combustion Practices for selecting a BACT limit. Therefore, no further evaluation under Step 4 is required.

4.5.5.5 Step 5 – Select BACT for the Heaters

4.5.5.5.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.4-8).

4.5.5.5.2 CO₂ BACT Limit Selection

NPPD proposes a CO₂e BACT emission limit for all heaters of 117.1 lb/MMBtu with compliance demonstrated by combusting natural gas. CO₂e emissions from the heaters shall be controlled through the use of good combustion practices.

4.6 BACT Analyses for Emergency Equipment

Alongside the new generation capacity, NPPD is planning to construct five (5) emergency RICE units:

- ▶ Emergency Diesel Generator #1 (to serve the East bank of RICE): 880 kWe (1,183 hp) (EPA Tier 2 certified)
- ▶ Emergency Diesel Generator #2 (to serve the West bank of RICE): 880 kWe (1,183 hp) (EPA Tier 2 certified)
- ▶ Emergency Diesel Generator #3 (to serve the CTs): 2,516 kWe (3,374 hp) (EPA Tier 2 certified)
- ▶ Emergency Diesel Generator #4 (to provide backup power for the electric, fuel oil tank farm heaters): 2,516 kWe (3,374 hp) (EPA Tier 2 certified)
- ▶ Fire Pump: 235 kW (315 hp) Clarke Model UFAD98 (EPA Tier 3 certified)

BACT analyses for this equipment will be combined for the sake of brevity, given the similarities between the units.

4.6.1 Nitrogen Oxides (NO₂)

4.6.1.1 Overview of NO_x Emissions from Emergency Equipment

Refer to Section 4.3.1.1 for background on pollutant formation from internal combustion engines.

4.6.1.2 Step 1 – Identification of NO_x Control Technologies – Emergency Equipment

Potentially available control options for reducing NO_x emissions from the emergency engines are listed below:

- ▶ Non-Selective Catalytic Reduction (NSCR)
- ▶ Selective Catalytic Reduction (SCR)
- ▶ Good Combustion Practices and Lean-Burn

These technologies are discussed at length in the above sections of this application.

4.6.1.3 Step 2 – Elimination of Technically Infeasible NO_x Control Options – Emergency Equipment

4.6.1.3.1 Non-Selective Catalytic Reduction (SNCR)

As explained in Section 4.3.1.3, SNCR systems are technically infeasible for lean-burn internal combustion engines. As the emergency engines proposed by NPPD are all lean-burn, SNCR is therefore technically infeasible.

4.6.1.3.2 Selective Catalytic Reduction (SCR)

SCR systems require fairly constant exhaust gas temperatures, and operation outside of the ideal range can result in increased emissions of NO_x and NH₃ due to ammonia slip. Further, SCR is difficult to use for sources which operate infrequently and for short durations, as it takes time for the exhaust stream to reach the required operating temperature range. For these reasons, SCR is determined to be technically infeasible for the emergency engines.

4.6.1.3.3 Good Combustion Practices and Lean-Burn

This is considered the base case for the proposed emergency engines.

4.6.1.4 Step 3 – Summary and Ranking of Remaining NO_x Controls – Emergency Equipment

Good Combustion Practices and Lean-Burn is the only remaining control option for reducing NO_x emissions from the emergency engines. Ranking of control options is not necessary.

4.6.1.5 Step 4 – Evaluation of Most Stringent NO_x Controls - Emergency Equipment

Good Combustion Practices and Lean-Burn is the only remaining control option and will be applied to achieve compliance with the proposed BACT limits. Further evaluation is not needed.

4.6.1.6 Step 5 – Selection of Emission Limits and Controls for NO_x BACT

4.6.1.6.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-1).

4.6.1.6.2 NO_x BACT Limit Selection

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.2 Carbon Monoxide (CO)

4.6.2.1 Overview of CO Emissions from Emergency Equipment

Section 4.3 contains information on the generation of CO emissions from internal combustion engines.

4.6.2.2 Step 1 – Identification of CO Control Technologies – Emergency Equipment

Potentially available control options for reducing CO emissions from the emergency engines are listed below:

- ▶ Oxidation Catalyst
- ▶ Good Combustion Practices and Lean-Burn

These technologies are discussed at length in Section 4.3.

4.6.2.3 Step 2 – Elimination of Technically Infeasible CO Control Options – Emergency Equipment

Although catalytic oxidation are technically feasible, these technologies may not provide consistent CO control efficiencies and may be difficult to operate when used to reduce CO emissions from sources that operate for short periods of time and that experience frequent starts/stops. Since it can take time for the exhaust stream to reach the required operating temperature range for efficient oxidation, the CO and control efficiency of catalytic oxidation systems for an emergency engine is lower than for a unit that runs continuously. Except for emergencies, the engines will normally only run monthly for readiness testing.

Good Combustion Practices and Lean-Burn is a technically feasible control option for reducing CO and VOC emissions from ICEs.

4.6.2.4 Step 3 – Summary and Ranking of Remaining CO Controls – Emergency Equipment

Good Combustion Practices and Lean-Burn is the only remaining control option for reducing CO emissions from the emergency engines. Ranking of control options is not necessary.

4.6.2.5 Step 4 – Evaluation of Most Stringent CO Controls - Emergency Equipment

Good Combustion Practices and Lean-Burn is the only remaining control option and will be applied to achieve compliance with the proposed BACT limits. Further evaluation is not needed.

4.6.2.6 Step 5 – Selection of Emission Limits and Controls for CO BACT

4.6.2.6.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-2).

4.6.2.6.2 CO BACT Limit Selection

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.3 Volatile Organic Compounds (VOC)

4.6.3.1 *Overview of VOC Emissions from Emergency Equipment*

Section 4.3.3.1 contains information on the generation of VOC emissions from internal combustion engines.

4.6.3.2 *Step 1 – Identification of VOC Control Technologies – Emergency Equipment*

Potentially available control options for reducing VOC emissions from the emergency engines are listed below:

- ▶ Oxidation Catalyst
- ▶ Good Combustion Practices and Lean-Burn

These technologies are discussed at length in Section 4.3.3.2.

4.6.3.3 *Step 2 – Elimination of Technically Infeasible VOC Control Options – Emergency Equipment*

As detailed in Section 4.3, catalytic oxidation is not technically feasible for the proposed emergency engines.

4.6.3.4 *Step 3 – Summary and Ranking of Remaining VOC Controls – Emergency Equipment*

Good Combustion Practices and Lean-Burn is the only remaining control option for reducing VOC emissions from the emergency engines. Ranking of control options is not necessary.

4.6.3.5 *Step 4 – Evaluation of Most Stringent VOC Controls - Emergency Equipment*

Good Combustion Practices and Lean-Burn is the only remaining control option and will be applied to achieve compliance with the proposed BACT limits. Further evaluation is not needed.

4.6.3.6 *Step 5 – Selection of Emission Limits and Controls for VOC BACT*

4.6.3.6.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-3).

4.6.3.6.2 VOC BACT Limit Selection

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.4 Sulfur Dioxide (SO₂)

4.6.4.1 Overview of SO₂ Emissions from Emergency Equipment

Refer to Section 4.3.4.1 for information on SO₂ formation from internal combustion engines.

4.6.4.2 Step 1 – Identification of SO₂ Control Technologies – Emergency Equipment

The available SO₂ control options for the emergency engines are listed below:

- ▶ Wet Scrubber
- ▶ Semi-Dry Scrubber (Spray Dryer Type)
- ▶ Dry Scrubber (Injection System)
- ▶ Low Sulfur Fuels
- ▶ Good Combustion Practices

To NPPD's knowledge, add-on controls have never been deployed on an emergency-use internal combustion engine, due to the inherently low SO₂ concentrations in the exhaust gas and the infrequency of operation. Thus, wet scrubber, semi-dry scrubber, and dry-scrubber technology will not be evaluated further in this BACT analysis.

4.6.4.3 Step 2 – Elimination of Technically Infeasible SO₂ Control Options – Emergency Equipment

4.6.4.3.1 Low Sulfur Fuels

Firing low-sulfur fuels in the emergency engines decreases the amount of sulfur available for oxidation during the combustion process, which in turn decreases emissions of sulfur compounds including SO₂ and SO₃. NPPD will use only Ultra Low Sulfur Diesel (ULSD) containing no more than 15 ppm sulfur to lower emissions of SO₂.

4.6.4.3.2 Good Combustion Practices

Good combustion practices are a technically feasible option for reducing SO₂ emissions from the emergency engines.

4.6.4.4 Step 3 – Summary and Ranking of Remaining SO₂ Controls – Emergency Equipment

The use of low sulfur fuels and good combustion practices are both technically feasible SO₂ control options for the emergency engines and will be used to achieve the proposed BACT limits.

4.6.4.5 Step 4 – Evaluation of Most Stringent SO₂ Controls - Emergency Equipment

There are no adverse energy, environmental, or economic impacts associated with the use of low sulfur fuels and good combustion practices.

4.6.4.6 Step 5 – Selection of Emission Limits and Controls for SO₂ BACT

4.6.4.6.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-4).

4.6.4.6.2 SO₂ BACT Limit Selection

NPPD proposes BACT for SO₂ for the emergency engines as the use of low sulfur fuels and good combustion practices.

4.6.5 Filterable Particles (PM, PM₁₀, PM_{2.5})

4.6.5.1 *Overview of PM_{filt} Emissions from Emergency Equipment*

PM_{filt} emissions from internal combustion engines are described in detail in Section 4.3.

4.6.5.2 *Step 1 – Identification of PM_{filt} Control Technologies – Emergency Equipment*

Potentially available control options for reducing PM_{filt} emissions from emergency engines are listed below:

- ▶ Catalyzed Diesel Particulate Filter (CDPF)
- ▶ Good Combustion Practices and Lean-Burn

4.6.5.3 *Step 2 – Elimination of Technically Infeasible PM_{filt} Control Options – Emergency Equipment*

Both CDPF and Good Combustion Practices and Lean-Burn are technically feasible control options for reducing PM_{filt} emissions from the emergency engines. Therefore, no control options are eliminated in this step of the analysis.

4.6.5.4 *Step 3 – Summary and Ranking of Remaining PM_{filt} Controls – Emergency Equipment*

Particulate filters are an effective means of reducing PM_{filt} emissions from internal combustion engines, with a control efficiency of up to 94% depending on the size of the engine.¹⁰³ Implementing Good Combustion Practices and Lean-Burn is the second most effective control option for reducing PM_{filt} emissions.

4.6.5.5 *Step 4 – Evaluation of Most Stringent PM_{filt} Controls - Emergency Equipment*

During the development of NSPS Subpart IIII, EPA determined that add-on controls are economically infeasible for emergency-use internal combustion engines. Based on EPA's economic analysis, NPPD has determined that CDPF is not BACT for PM_{filt} emissions from the emergency engines.

With CDPF eliminated, Good Combustion Practices with Lean-Burn is the top and only remaining available and technically feasible PM_{filt} control option and will be applied to achieve compliance with the proposed BACT limit.

4.6.6 PM, Total PM₁₀, Total PM_{2.5}

4.6.6.1.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-5 and Table D.5-6).

¹⁰³ Memo from Ms, Tanya Parise, Alpha Gamma Technologies, Inc. to Mr. Sims Roy, U.S. EPA OAQPS ESD Combustion Group. *Cost per Ton for NSPS for Stationary CI ICE*. June 9, 2005.

4.6.6.1.2 PM BACT Limit Selection

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.7 Greenhouse Gases (CO₂)

4.6.7.1 *Overview of GHG Emissions (CO₂) from Emergency Equipment*

Refer to Section 4.3.8.1 for information on the formation of CO₂ emissions from internal combustion engines.

4.6.7.2 *Step 1 – Identification of CO₂ Control Technologies – Emergency Equipment*

Available GHG control technologies are presented in the following sections for diesel-driven engines. There are no NSPS or NESHAPs that can be used to establish a floor for GHG emission rates from these combustion sources. Likewise, no similar facilities or facilities with similar process types were identified in the RBLC as using any type of add-on control device. This finding is important and bolsters the conclusion that BACT should be represented by emission limits that do not account for the implementation of an add-on control device.

Based on a review of technical literature, past control technology determinations, and generally available technologies and practices, the following options could potentially be applied to control GHG emissions:

- ▶ Fuel Selection
- ▶ Good Design and Operating Practices

4.6.7.2.1 Fuel Selection

The carbon intensity of fuels can vary significantly across available fossil fuels commonly used in industry. Fuels with low carbon intensity have lower GHG emissions than fuels with high carbon intensity. Therefore, GHG (including CO₂) BACT considerations involve the evaluation of low carbon intensity fuel options. By selecting a low carbon fuel, GHG emissions are minimized. Diesel is the standard fuel type for this equipment, given its ease of handling and storage, its suitability for use in emergency equipment with highly variable operations, and its prevalence of use in engine technology.

4.6.7.2.2 Good Combustion Practices

Good combustion practices for reducing CO₂ emissions from diesel-fired engines consist of minimizing startup and idling time, in addition to good air the fuel mixing to promote complete combustion. By operating a combustion unit as efficiently as possible, GHG emissions are minimized. This is achieved in normal practice for emergency-use engines that, by design, only operate for maintenance purposes, readiness testing and during emergency events.

4.6.7.3 *Step 2 – Elimination of Technically Infeasible CO₂ Control Options - Emergency Equipment*

Both the use of diesel fuel and good combustion practices are technically feasible control options for reducing CO₂ emissions from the emergency engines.

4.6.7.4 Step 3 – Summary and Ranking of Remaining CO₂ Controls - Emergency Equipment

Good combustion practices and use of diesel fuel are proposed as BACT for CO₂ for the emergency engines. Ranking is not required.

4.6.7.5 Step 4 – Evaluation of Most Stringent CO₂ Controls - Emergency Equipment

For emergency equipment, CO₂ BACT considerations will include good combustion practices and the use of diesel fuel. There are no significant economic, environmental, or energy impacts associated with the selected control methods.

4.6.7.6 Step 5 – Selection of Emission Limits and Controls for CO₂ BACT – Emergency Equipment

4.6.7.6.1 Summary of RBLC review

The detailed RBLC search results tables are provided in Appendix D (Table D.5-7).

4.6.7.6.2 CO₂ BACT Limit Selection

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.8 Greenhouse Gases (CH₄)

For the sake of brevity, NPPD is proposing that BACT for CO₂ for the emergency engines be applied as BACT for CH₄ as well. Control options for the reduction of CO₂ are also effective at reducing CH₄ emissions from emergency engines.

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.6.9 Greenhouse Gases (N₂O)

NPPD is proposing that BACT for CO₂ for the emergency engines be applied as BACT for N₂O as well. Control options for the reduction of CO₂ are also effective at reducing N₂O emissions from emergency engines.

NPPD is subject to NSPS IIII for the emergency engines and is required to purchase engines meeting EPA certification criteria. To satisfy BACT, NPPD will purchase emergency engines certified by the manufacturers and will operate the engines using good combustion practices.

4.7 BACT Analyses for Fuel Oil Storage Tank

4.7.1 Volatile Organic Compounds (VOC)

In lieu of a complete top-down BACT analysis for the proposed diesel storage tank, a brief discussion of the available options is provided.

An RBL search was conducted to identify possible control technologies for VOC emissions from storage tanks holding volatile liquids (RBL process ID 42.009). The RBL database structure does not allow for a straightforward search based on fuel type stored, so results were reviewed to identify RBL entries for organic liquids with a vapor pressure similar to diesel fuel (e.g., jet fuel, kerosene, fuel oils).

The detailed RBL search results tables are provided in Appendix D (Table D.6-1).

The following control technologies were identified:

- ▶ Fixed roof tank with white or light paint color;
- ▶ Submerged fill design;
- ▶ Drain-dry construction.¹⁰⁴

All these control options are considered available, technically feasible, and effective for control of emissions from diesel fuel storage. BACT for the diesel tank is determined to be a fixed-roof tank with a light paint color (as available), a submerged fill design, and drain-dry construction. Since environmental, aesthetic, and other factors may limit the availability of paint colors, a specific color is not listed as BACT.

4.8 BACT Analyses for Circuit Breakers

4.8.1 Greenhouse Gases (CO₂)

The project will result in fugitive GHG emissions from equipment leaks from the PRS substation circuit breakers. The substation circuit breakers will be rated at 115 kV and 345 kV and contain SF₆, which is a greenhouse gas, as an insulator. While the electrical equipment containing SF₆ is designed not to leak, a BACT analysis for GHG has been performed to address any potential leaks that would cause SF₆ to be emitted.

4.8.1.1 Steps 1-4 Circuit Breaker GHG BACT Analysis

The only applicable control technology for circuit breakers containing SF₆ is the minimization of leaks. This is accomplished using enclosed circuit breaker technology with a leak detection system and an alarm to indicate the presence of a leak. The International Electrotechnical Commission (IEC) has established a standard of 0.5 percent or 1 percent for leak rates (IEC Standard 62271-1, 2004), which is recognized by the EPA's SF₆ Reduction Partnership as an effective criterion for minimizing fugitive SF₆ emissions.

Non-GHG insulating material can be technically feasible for certain applications and is available for use in lower-voltage circuit breaker configurations. General Electric, Meiden America Switchgear, Mitsubishi Electric, Hitachi Energy USA, and Siemens Energy have developed SF₆-free circuit breaker technology. The Hitachi technology, while not GHG-free, is only available for 50 Hz International Electrotechnical Commission (IEC) configuration and is not compatible with the 60 Hz electrical standard in the United States.¹⁰⁵ In addition, the use of alternative dielectric fluids is not practicable for high-voltage applications.

¹⁰⁴ I.e., the tank bottom and sump are designed to allow full drainage of the tank and sump.

¹⁰⁵ Eastern Research Group, Inc. (ERG), *Assessment of the Use of Sulfur Hexafluoride (SF₆) Gas Insulated Switchgears (GIS) within the Offshore Wind Sector*, August 24, 2023.

Circuit breakers using SF₆ are presently superior in their performance to alternative systems such as dielectric oil, high pressure air blast or vacuum circuit breakers. Moreover, EPA's SF₆ Reduction Partnership has recognized that there is no clear alternative to using SF₆ and fugitive emissions are reduced by implementing detection, repair and replacement strategies.¹⁰⁶ Alternative dielectrics currently on the market cannot be used with existing SF₆ switchgear, typically require mixtures of two or more single gas components, and are not widely in use. They would also require a re-design of the electrical equipment to make it physically larger in order to maintain the required electrical performance.¹⁰⁷ For this reason, use of an alternate dielectric gas in the circuit breakers is considered not technically feasible for the PRS substation.

4.8.1.2 Selection of BACT (Step 5)

Summary of Applicable Limits from NSPS/NESHAP/State Rules. The fugitive emissions from the circuit breakers are not subject to any NSPS, NESHAP, or state rules. As such, there is no floor for an allowable CO₂e limit.

RBLC Review. The detailed RBLC search results tables are provided in Appendix D (Table D.7-1).

Selection of BACT. NPPD has determined that a maximum allowable leak rate of 0.5% SF₆ monitored by a leak detection system is BACT for the control of GHG emissions from equipment leaks from the circuit breakers. Compliance with this BACT limit will be demonstrated by maintaining records of the parameters monitored by the leak detection system and installation of a low leak circuit breaker system design.

¹⁰⁶ EPA SF₆ Emission Reduction Partnership for Electric Power Systems, 2014 Annual Report, U.S. Environmental Protection Agency, March 2015. https://www.epa.gov/sites/default/files/2021-03/documents/sf6_2014_ann_report.pdf

¹⁰⁷ Electric Power Research Institute (EPRI), *SF₆ Management for Substations*, 2010.