ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Air Permits Program

PRELIMINARY
BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION
for
Golden Valley Electric Association
North Pole Power Plant

Prepared by: Brittany Crutchfield
Supervisor: Patrick Dunn
Preliminary Date: March 22, 2018

Table of Contents

Abbreviations/Acronyms

AAC ....Alaska Administrative Code
AAAQS ....Alaska Ambient Air Quality Standards
Department ....Alaska Department of Environmental Conservation
BACT ....Best Available Control Technology
CFB……………………Circulating Fluidized Bed
CFR. ....Code of Federal Regulations
Cyclones………………Mechanical Separators
DFP……………………Diesel Particulate Filter
DLN..............................Dry Low NOx
DOC…………………...Diesel Oxidation Catalyst
EPA ....Environmental Protection Agency
ESP……………………Electrostatic Precipitator
EU.................................Emission Unit
FITR…………………...Fuel Injection Timing Retard
GCPs…………………..Good Combustion Practices
HAP ....Hazardous Air Pollutant
ITR……………………Ignition Timing Retard
LEA……………………Low Excess Air
LNB……………………Low NOx Burners
MR&Rs ....Monitoring, Recording, and Reporting
NESHAPS ....National Emission Standards for Hazardous Air Pollutants
NSCR…………………Non-Selective Catalytic Reduction
NSPS ....New Source Performance Standards
ORL...............................Owner Requested Limit
PSD................................Prevention of Significant Deterioration
PTE................................Potential to Emit
RICE, ICE ....Reciprocating Internal Combustion Engine, Internal Combustion Engine
SCR ....Selective Catalytic Reduction
SIP ....Alaska State Implementation Plan
SNCR…………………Selective Non-Catalytic Reduction
ULSD ....Ultra Low Sulfur Diesel

Units and Measures

gal/hr..............................gallons per hour
g/kWh ....grams per kilowatt hour
g/hp-hr ....grams per horsepower hour
hr/day.............................hours per day
hr/yr ....hours per year
hp...................................horsepower
lb/hr ....pounds per hour
lb/MMBtu......................pounds per million British thermal units
lb/1000 gal.....................pounds per 1,000 gallons
kW ....kilowatts
MMBtu/hr......................million British thermal units per hour
MMscf/hr.......................million standard cubic feet per hour
ppmv..............................parts per million by volume
tpy..................................tons per year

Pollutants

CO ....Carbon Monoxide
HAP ....Hazardous Air Pollutant
NOx ....Oxides of Nitrogen
SO_2 ....Sulfur Dioxide
PM-2.5...........................Particulate Matter with an aerodynamic diameter not exceeding 2.5 microns
PM-10............................Particulate Matter with an aerodynamic diameter not exceeding 10 microns

1. INTRODUCTION

The North Pole Power Plant (North Pole) is an electric generating facility that combusts distillate fuel in combustion turbines to provide power to the Golden Valley Electric Association (GVEA) grid. The power plant contains two fuel oil-fired simple cycle gas combustion turbines, two fuel oil-fired combined cycle gas combustion turbines, one fuel oil-fired emergency generator, and two propane fired boilers.

In a letter dated April 24, 2015, the Alaska Department of Environmental Conservation (Department) requested the stationary sources expected to be major stationary sources in the particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM-2.5) serious nonattainment area perform a voluntary Best Available Control Technology (BACT) review in support of the state agency's required SIP submittal once the nonattainment area is re-classified as a Serious PM-2.5 nonattainment area. The designation of the area as "Serious" with regard to nonattainment of the 2006 24-hour PM-2.5 ambient air quality standards was published in Federal Register Vol. 82, No. 89, May 10, 2017, pages 21703-21706, with an effective date of June 9, 2017. [1]

This report addresses the significant emission units (EUs) listed in the North Pole Power Plant's operating permit AQ0110TVP03. This report provides the Department's preliminary review of the BACT analysis for oxides of nitrogen (NOx) and sulfur dioxide (SO_2) emissions, which are precursor pollutants that can form PM-2.5 in the atmosphere post combustion.

The following sections review GVEA's BACT analysis provided for the North Pole Power Plant for technical accuracy and adherence to accepted engineering cost estimation practices.

2. BACT EVALUATION

A BACT analysis is an evaluation of all available control options for equipment emitting the triggered pollutants and a process for selecting the best option based on feasibility, economics, energy, and other impacts. 40 CFR 52.21(b)(12) defines BACT as a site-specific determination on a case-by-case basis. The Department's goal is to: identify BACT for the permanent emission units (EUs) at the GVEA North Pole Power Plant that emit NOx, PM-2.5, and SO_2, establish emission limits which represent BACT, and assess the level of monitoring, recordkeeping, and reporting (MR&R) necessary to ensure GVEA applies BACT for the EUs. The Department based the BACT review on the five-step top-down approach set forth in Federal Register Volume 61, Number 142, July 23, 1996 (Environmental Protection Agency). Table A presents the EUs subject to BACT review.

[1] Federal Register, Vol. 82, No. 89, Wednesday May 10, 2017 (https://dec.alaska.gov/air/anpms/comm/docs/2017-09391-CFR.pdf)

Table A: Emission Units Subject to BACT Review

EU	EU Name	Description of EU	Rating/Size	Installation Date
1	GT#1	GE Frame 7, Series 7001, Fuel Oil-Fired Model BR Regenerative Simple Cycle Gas Turbine	672 MMBtu/hr (60.5 MW)	1976
2	GT#2	GE Frame 7, Series 7001, Fuel Oil-Fired Model BR Regenerative Simple Cycle Gas Turbine	672 MMBtu/hr (60.5 MW)	1977
5	GT#3	GE LM6000PC Combined Cycle Gas Turbine, Fuel 0-GT (naphtha/LSR fuel) Fired (with water injection for NOx control and CO oxidation catalyst)	455 MMBtu/hr (Higher Heating Value) 43 MW (nominal)	2005
6	GT#4	GE LM6000PC Combined Cycle Gas Turbine, Fuel 0-GT (naphtha/LSR fuel) Fired (with water injection for NOx control and CO oxidation catalyst)	455 MMBtu/hr (Higher Heating Value) 43 MW (nominal)	Est. 2015
7	Emergency Generator	IC Engine, Fuel-Oil Fired	400 kW	2005
11	Propane-Fired Boiler	Bryan Steam RV500 Heater, Gas Fuel-Fired	5.0 MMBtu/hr	2005
12	Propane-Fired Boiler	Bryan Steam RV500 Heater, Gas Fuel-Fired	5.0 MMBtu/hr	2005

GVEA did not include BACT analyses for EUs 3 and 4. These emission units are fuel storage tanks and do not have NOx, PM-2.5, or SO_2 emissions.

Five-Step BACT Determinations

The following sections explain the steps used to determine BACT for NOx, PM-2.5, and SO_2 for the applicable equipment.

Step 1 Identify All Potentially Available Control Technologies

The Department identifies all available control technologies for the EUs and the pollutant under consideration. This includes technologies used throughout the world or emission reductions through the application of available control techniques, changes in process design, and/or operational limitations. To assist in identifying available controls, the Department reviews available controls listed on the Reasonably Available Control Technology (RACT), BACT, and Lowest Achievable Emission Rate (LAER) Clearinghouse (RBLC). The RBLC is an EPA database where permitting agencies nationwide post imposed BACT for PSD sources. It is usually the first stop for BACT research. In addition to the RBLC search, the Department used several search engines to look for emerging and tried technologies used to control NOx, PM-2.5, and SO_2 emissions from equipment similar to those listed in Table A.

Step 2 Eliminate Technically Infeasible Control Technologies

The Department evaluates the technical feasibility of each control option based on source specific factors in relation to each EU subject to BACT. Based on sound documentation and demonstration, the Department eliminates control technologies deemed technically infeasible due to physical, chemical, and engineering difficulties.

Step 3 Rank the Remaining Control Technologies by Control Effectiveness
The Department ranks the remaining control technologies in order of control effectiveness with the most effective at the top.

Step 4 Evaluate the Most Effective Controls and Document the Results as Necessary
The Department reviews the detailed information in the BACT analysis about the control efficiency, emission rate, emission reduction, cost, environmental, and energy impacts for each option to decide the final level of control. The analysis must present an objective evaluation of both the beneficial and adverse energy, environmental, and economic impacts. A proposal to use the most effective option does not need to provide the detailed information for the less effective options. If cost is not an issue, a cost analysis is not required. Cost effectiveness for a control option is defined as the total net annualized cost of control divided by the tons of pollutant removed per year. Annualized cost includes annualized equipment purchase, erection, electrical, piping, insulation, painting, site preparation, buildings, supervision, transportation, operation, maintenance, replacement parts, overhead, raw materials, utilities, engineering, start-up costs, financing costs, and other contingencies related to the control option. Sections 3, 4, and 5 present the Department's Preliminary BACT Determinations for NOx, PM-2.5, and SO_2.

Step 5 Select BACT
The Department selects the most effective control option not eliminated in Step 4 as BACT for the pollutant and EU under review. The Department lists the final BACT requirements determined for each EU in this step. A project may achieve emission reductions through the application of available technologies, changes in process design, and/or operational limitations. The Department reviewed GVEA's BACT analysis and made preliminary BACT determinations for NOx, PM-2.5, and SO_2 for the North Pole Power Plant. These preliminary BACT determinations are based on the information submitted by GVEA in their analysis, information from vendors, suppliers, sub-contractors, RBLC, and an exhaustive internet search.

3. BACT DETERMINATION FOR NO_X

The NOx controls proposed in this section are not planned to be implemented. The optional preliminary precursor demonstration (as allowed under 40 C.F.R. 51.1006) for the precursor gas NOx for point sources illustrates that NOx controls are not needed. DEC is planning to submit with the Serious SIP a final precursor demonstration as justification not to require NOx controls. Please see the preliminary precursor demonstration for NOx posted at http://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip-development. The PM2.5 NAAQS Final SIP Requirements Rule states if the state determines through a precursor demonstration that controls for a precursor gas are not needed for attaining the standard, then the controls identified as BACT/BACM or Most Stringent Measure for the precursor gas are not required to be implemented.[2] Final approval of the precursor demonstration is at the time of the Serious SIP approval.

[2] https://www.gpo.gov/fdsys/pkg/FR-2016-08-24/pdf/2016-18768.pdf

The North Pole Power Plant has two existing 672 MMBtu/hr GE Frame 7, Series 7001 turbines that burn fuel oil, two 455 MMBtu/hr GE LM6000PC gas turbines, one emergency diesel-fired internal combustion engine, and two Bryan Steam RV500 propane heaters subject to BACT. The Department reviewed the control technologies GVEA identified in their analysis and determined NOx BACT for the EUs listed in Table A. The Department based its NOx assessment on BACT determinations found in the RBLC, internet research, and BACT analyses submitted to the Department by Golden Valley Electric Association (GVEA) for the North Pole Power Plant and Zehnder Facility, Aurora Energy, LLC (Aurora) for the Chena Power Plant, U.S. Army Corps of Engineers (US Army) for Fort Wainwright, and the University of Alaska Fairbanks (UAF) for the Campus Power Plant.

3.1 NOx BACT for the Fuel Oil-Fired Simple Cycle Gas Turbines (EUs 1 and 2)

Possible NOx emission control technologies for the fuel oil-fired simple cycle turbine were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.110 for Liquid Fuel-Fired Simple Cycle Gas Turbines (rated at 25 MW or more). The search results for simple cycle gas turbines are summarized in Table 3-1.

Table 3-1. RBLC Summary of NOx Controls for Fuel Oil-Fired Simple Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits (ppmv)
Selective Catalytic Reduction	2	7
Low NOx Burners	12	5 – 15
Good Combustion Practices	3	15

RBLC Review
A review of similar units in the RBLC indicates selective catalytic reduction, low NOx burners, and good combustion practices are the principle NOx control technologies installed on fuel oil-fired simple cycle gas turbines. The lowest NOx emission rate listed in the RLBC is 5 parts per million by volume (ppmv).

Step 1 - Identification of NOx Technology for the Simple Cycle Gas Turbines
From Research, the Department identified the following technologies as available for control of NOx emissions from fuel oil-fired simple cycle turbines rated at 25 MW or more:

(a) Selective Catalytic Reduction (SCR)
SCR is a post-combustion gas treatment technique for reducing nitric oxide (NO) and nitrogen dioxide (NO_2) in the turbine exhaust stream to molecular nitrogen (N_2), water, and oxygen (O_2). In the SCR process, aqueous or anhydrous ammonia (NH_3) is injected into the flue gas upstream of a catalyst bed. The catalyst lowers the activation energy of the NOx decomposition reaction. NOx and NH_3 combine at the catalyst surface forming an ammonium salt intermediate, which subsequently decomposes to produce elemental N_2 and water. Depending on the overall NH_3-to-NOx ratio, removal efficiencies are generally 80 to 90 percent. Challenges associated with using SCR on fuel oil-fired simple cycle gas turbines include a narrow window of acceptable inlet and exhaust temperatures (500°F to 800°F), emission of NH_3 into the atmosphere (NH_3 slip) caused by non-stoichiometric reduction reaction, and disposal of depleted catalysts. The Department

considers SCR a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(b) Water Injection
Water/steam injection involves the introduction of water or steam into the combustion zone. The injected fluid provides a heat sink which absorbs some of the heat of reaction, causing a lower flame temperature. The lower flame temperature results in lower thermal NOx formation. Both steam and water injections are capable of obtaining the same level of control. The process requires approximately 0.8 to 1.0 pound of water or steam per pound of fuel burned. The main technical consideration is the required purity of the water or steam, which is required to protect the equipment from dissolved solids. Obtaining water or steam of sufficient purity requires the installation of rigorous water treatment and deionization systems. Water/steam injection is a proven technology for NOx emissions reduction from turbines. However, the arctic environment presents significant challenges to water/steam injection due to cost of water treatment, freezing potential due to extreme cold ambient temperatures, and increased maintenance problems due to accelerated wear in the hot sections of the turbines. Moreover, the vendor of the turbines does not recommend using water/steam injection to control NO_x emissions from the turbines because of the extra maintenance problems. The Department considers water/steam injection a technically feasible control technology for the fuel-oil simple cycle gas turbines.

(c) Dry Low NOx (DLN)
Two-stage lean/lean combustors are essentially fuel-staged, premixed combustors in which each stage burns lean. The two-stage lean/lean combustor allows the turbine to operate with an extremely lean mixture while ensuring a stable flame. A small stoichiometric pilot flame ignites the premixed gas and provides flame stability. The NOx emissions associated with the high temperature pilot flame are insignificant. Low NOx emission levels are achieved by this combustor design through cooler flame temperatures associated with lean combustion and avoidance of localized "hot spots" by premixing the fuel and air. DLN is designed for natural gas-fired or dual-fuel fired units and is not effective in controlling NOx emissions from fuel oil-fired units. The Department does not consider DLN a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(d) Limited Operation
Limiting the operation of emission units reduces the potential to emit for those units. EU 1 currently operates under a combined owner requested limit (ORL) with EUs 5 and 6 to restrict the combined NOx emissions from these three units to no more than 1,600 tons per 12 month rolling period. EU 2 also operated under an ORL to restrict operation to no more than 7,992 hours per 12 month rolling period. The Department considers limited operation a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(e) Good Combustion Practices (GCPs)
GCPs typically include the following elements:

1. Sufficient residence time to complete combustion;
2. Providing and maintaining proper air/fuel ratio;
3. High temperatures and low oxygen levels in the primary combustion zone;
4. High enough overall excess oxygen levels to complete combustion and maximize thermal efficiency.

Combustion efficiency is dependent on the gas residence time, the combustion temperature, and the amount of mixing in the combustion zone. GCPs are accomplished primarily through combustion chamber design as it relates to residence time, combustion temperature, air-to-fuel mixing, and excess oxygen levels. The Department considers GCPs a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

Step 2 - Eliminate Technically Infeasible NOx Control Technologies for Gas Turbines
As explained in Step 1 of Section 3.1, the Department does not consider dry low NOx as technically feasible technology to control NO_x emissions from the fuel oil-fired simple cycle gas turbines.

Step 3 - Rank the Remaining NOx Control Technologies for the Simple Cycle Gas Turbines
The following control technologies have been identified and ranked for control of NOx emissions from the fuel oil-fired simple cycle turbines:

(a + b)	Selective Catalytic Reduction & Water Injection	(95% Control)
(a)	Selective Catalytic Reduction	(90% Control)
(b)	Water Injection	(70% Control)
(g)	Good Combustion Practices	(Less than 40% Control)
(d)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis of the control technologies available for the fuel oil-fired simple cycle turbines to demonstrate that the use of water injection with SCR, SCR, or water injection in conjunction with limited operation is not economically feasible on these units. A summary of the analysis for EU 1 is shown in Table 3-2, and the summary of the analysis for EU 2 is shown in Table 3-3:

Table 3-2. GVEA Economic Analysis for Technically Feasible NOx Controls (EU 1)

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
SCR and Water Injection	160	1,440	$31,262,640	$9,214,910	$6,872
SCR	240	1,630	$26,213,360	$5,569,212	$4,597
Water Injection	432	1,168	$4,600,000	$3,610,916	$4,009
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

Table 3-3. GVEA Economic Analysis for Technically Feasible NOx Controls (EU 2)

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
SCR and Water Injection	236	2,127	$31,262,640	$3,249,764	$4,221
SCR	354	2,009	$26,213,360	$825,940	$2,791
Water Injection	638	1,725	$4,600,000	$2,503,774	$1,952
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of NOx reduction does not justify the use of SCR, water injection, or SCR and water injection for the fuel oil-fired simple cycle gas turbines based on the excessive cost per ton of NOx removed per year.

GVEA proposes the following as BACT for NOx emissions from the fuel oil-fired simple cycle gas turbines:

(a) NOx emissions from the operation of the fuel oil-fired simple cycle gas turbines will be controlled with good combustion practices; and

(b) NOx emissions from the fuel oil-fired simple cycle gas turbines will not exceed 0.88 lb/MMBtu over a 4-hour averaging period.

Department Evaluation of BACT for NOx Emissions from the Simple Cycle Gas Turbines

The Department revised the emissions tables to reflect the limited operation as the baseline for emissions reduction for the control devices. Additionally, the equipment life was revised to 20 years. A summary of the analyses is shown below:

Table 3-4. Department Economic Analysis for Technically Feasible NOx Controls (EU 1)

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
SCR and Water Injection	1,600	1,440	$31,262,640	$9,214,910	$5,357
SCR	1,600	1,360	$26,213,360	$5,569,212	$3,175
Water Injection	1,600	1,168	$4,600,000	$3,610,916	$2,903
Capital Recovery Factor = 0.0944 (7% interest rate for a 20 year equipment life)					

Table 3-5. Department Economic Analysis for Technically Feasible NOx Controls (EU 2)

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
SCR and Water Injection	2,363	2,127	$31,262,640	$3,249,764	$3,516
SCR	2,363	2,009	$26,213,360	$825,940	$2,165
Water Injection	2,363	1,725	$4,600,000	$2,503,774	$1,824
Capital Recovery Factor = 0.0944 (7% interest rate for a 20 year equipment life)					

The Department's preliminary economic analysis indicates the level of NOx reduction justifies the use of SCR and water injection as BACT for the fuel oil-fired simple cycle gas combustion turbines located in the Serious PM-2.5 nonattainment area.

Step 5 - Preliminary Selection of NOx BACT for the Simple Cycle Gas Turbines

The Department's preliminary finding is that BACT for NOx emissions from the simple cycle gas-fired combustion turbines is as follows:

(a) NOx emissions from EUs 1 and 2 shall be controlled by operating and maintaining selective catalytic reduction and water injection at all times the units are in operation;

(b) NOx emissions from EUs 1 and 2 shall not exceed 0.044 lb/MMBtu averaged over a 3-hour period; and

(c) Initial compliance with the proposed NOx emission limit will be demonstrated by conducting a performance test to obtain an emission rate.

Table 3-6 lists the proposed NOx BACT determination for this facility along with those for other fuel oil-fired simple cycle gas turbines located in the Serious PM-2.5 nonattainment area.

Table 3-6. Comparison of NOx BACT for Simple-Cycle Gas Turbines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
North Pole	2 Simple Cycle Combustion Gas Turbines	1,344 MMBtu/hr	0.044 lb/MMBtu	Selective Catalytic Reduction Water Injection
Zehnder	2 Simple Cycle Combustion Gas Turbines	536 MMBtu/hr	0.044 lb/MMBtu	Selective Catalytic Reduction Water Injection

3.2 NOx BACT for the Fuel Oil-Fired Combined Cycle Gas Turbines (EUs 5 and 6)

Possible NOx emission control technologies for fuel oil-fired combined cycle gas turbines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.290, Combined Cycle Liquid Fuel-Fired Gas Turbines (rated at 25 MW or more). The search results for combined cycle gas turbines are summarized in Table 3-7.

Table 3-7. RBLC Summary of NOx Controls for Combined Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits
Selective Catalytic Reduction	8	2 – 5 ppmv
Low NOx Burner	8	0.023 - 0.14 (g/hp-hr)
Good Combustion Practices	1	0.01 (g/hp-hr)
No Control Specified	2	0.070 - 0.12 (g/hp-hr)

RBLC Review
A review of similar units in the RBLC indicates selective catalytic reduction, low-NOx burners, and good combustion practices are the principle NOx control technologies installed on fuel oil-fired combined cycle gas turbines. The lowest NOx emission rate listed in the RBLC is 0.01 g/hp-hr:

Step 1 - Identification of NOx Control Technology for the Combined Cycle Gas Turbines
From research, the Department identified the following technologies as available for control of NOx emissions from fuel oil-fired combined cycle gas turbines rated at 25 MW or more:

(a) Selective Catalytic Reduction
The theory of SCR was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. The Department considers SCR a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(b) Water Injection
The theory of water injection was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. EU 5 currently operates with water injection for NOx emissions controls and EU 6 will also utilize water injection for NOx control when it is installed. The Department considers water injection a feasible control technology for the fuel oil-fired combined cycle gas turbines.

(c) Dry Low NOx
The theory of DLN was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. DLN is designed for natural gas-fired or dual-fuel fired units and is not effective in controlling NOx emissions from fuel oil-fired units. The Department does not consider DLN to be a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(d) Limited Operation
Limiting the operation of emission units reduces the potential to emit for those units. EUs 5 and 6 currently operate under a combined ORL with EU 1 to restrict the combined NOx emissions from these three units to no more than 1,600 tons per 12 month rolling period. The Department considers limited operation a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(f) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of NOx emissions. The Department considers GCPs a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

Step 2 - Eliminate Technically Infeasible NOx Controls for Combined Cycle Gas Turbines
As explained in Step 1 of Section 3.1, the Department does not consider DLN a technically feasible technology to control NO_x emissions from fuel oil-fired combined cycle gas turbines.

Step 3 - Rank the Remaining NOx Control Technologies for Combined Cycle Gas Turbines
The following control technologies have been identified and ranked for control of NOx from the fuel oil-fired combined cycle gas turbines:

(a)	Selective Catalytic Reduction	(90% Control)
(g)	Good Combustion Practices	(Less than 40% Control)
(b)	Water Injection	(0% Control)
(d)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis of the installation of SCR on the combined cycle gas turbines to demonstrate that the use of SCR in conjunction with water injection and limited operation is not economically feasible on these units. A summary of the analysis is shown below:

Table 3-8. GVEA Economic Analysis for Technically Feasible NOx Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annual Costs ($/year)	Cost Effectiveness ($/ton)
SCR	175.4 (per unit)	303 (per unit)	$8,860,032	$2,204,632	$7,278
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of NOx reduction does not justify the use of SCR for the fuel oil-fired combined cycle gas turbines based on the excessive cost per ton of NOx removed per year.

GVEA proposes the following as BACT for the fuel oil-fired combined cycle gas turbines:

(a) NOx emissions from the fuel oil-fired combined cycle gas turbines shall be controlled with water injection;

(b) NOx emissions from the fuel oil-fired combined cycle gas turbines shall not exceed 0.24 lb/MMBtu per 4-hour averaging period; and

(c) Compliance with the proposed emission limit will be demonstrated by conducting an initial stack test to obtain an emission rate.

Department Evaluation of BACT for NOx Emissions from the Combined Cycle Gas Turbines
The Department revised the cost analysis provided by GVEA for the installation of SCR in conjunction with the existing water injection to reflect limited operation and water injection as the baseline for emissions reduction for the control devices. Additionally, the equipment life was revised to 20 years. A summary of the analysis is shown below:

Table 3-9. Department Economic Analysis for Technically Feasible NOx Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annual Costs ($/year)	Cost Effectiveness ($/ton)
SCR	47.8 (per unit)	430 (per unit)	$8,860,032	$1,485,481	$4,148
Capital Recovery Factor = 0.094 (7% interest rate for a 20 year equipment life)					

The Department's preliminary economic analysis indicates that the level of NOx reduction justifies the installation of SCR for the combined cycle gas combustion turbines located in the Serious PM-2.5 nonattainment area.

Step 5 - Preliminary Selection of NOx BACT for the Combined Cycle Gas Turbines
The Department's preliminary finding is that the BACT for NOx emissions from the fuel oil-fired combined cycle gas turbines is as follows:

(a) NOx emissions from EUs 5 and 6 shall be controlled by operating and maintaining selective catalytic reduction in conjunction with water injection at all times the units are in operation; and

(b) NOx emissions from EUs 5 and 6 shall not exceed 0.024 lb/MMBtu over a 3-hour averaging period.

3.3 NOx BACT for the Large Diesel-Fired Engine (EU 7)

Possible NOx emission control technologies for large engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes 17.100 to 17.190, Large Internal Combustion Engines (>500 hp). The search results for large diesel-fired engines are summarized in Table 3-11.

Table 3-11. RBLC Summary of NOx Controls for Large Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Selective Catalytic Reduction	3	0.5 - 0.7
Other Add-On Control	1	1.0
Federal Emission Standards	13	3.0 - 6.9
Good Combustion Practices	31	3.0 - 13.5
No Control Specified	60	2.8 - 14.1

RBLC Review
A review of similar units in the RBLC indicates selective catalytic reduction, good combustion practices, and compliance with federal emission standards are the principle NOx control technologies installed on large diesel-fired engines. The lowest NOx emission rate listed in the RBLC is 0.5 g/hp-hr.

Step 1 - Identification of NOx Control Technology for the Large Diesel-Fired Engine
From research, the Department identified the following technologies as available for control of NOx from large diesel-fired engines rated at 500 horsepower or greater:

(a) Selective Catalytic Reduction
The theory of SCR was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. The Department considers SCR a technically feasible control technology for the large diesel-fired engine.

(b) Turbocharger and Aftercooler
Turbocharger technology involves the process of compressing intake air in a turbocharger upstream of the air/fuel injection. This process boosts the power output of the engine. The air compression increases the temperature of the intake air so an aftercooler is used to reduce the intake air temperature. Reducing the intake air temperature helps lower the peak flame temperature which reduces NOx formation in the combustion chamber. EU ID 7 is currently operating with a turbocharger and aftercooler. The Department considers turbocharger and aftercooler a technically feasible control technology for the large diesel-fired engine.

(c) Fuel Injection Timing Retard (FITR)
FITR reduces NOx emissions by the delay of the fuel injection in the engine from the time the compression chamber is at minimum volume to a time the compression chamber is expanding. Timing adjustments are relatively straightforward. The larger volume in the compression chamber produces a lower peak flame temperature. With the use of FITR the engine becomes less fuel efficient, particular matter emissions increase, and there is a limit with respect to the degree the timing may be retarded because an excessive timing delay can cause the engine to misfire. The timing retard is generally limited to no more than three degrees. Diesel engines may also produce more black smoke due to a decrease in exhaust temperature and incomplete combustion. FITR can achieve up to 50 percent NOx reduction. Due to the increase in particulate matter emissions resulting from FITR, this technology will not be carried forward.

(d) Ignition Timing Retard (ITR)
ITR lowers NOx emissions by moving the ignition event to later in the power stroke, after the piston has begun to move downward. Because the combustion chamber volume is not at a minimum, the peak flame temperature is not as high, which lowers combustion temperature and produces less thermal NOx. Use of ITR can cause an increase in fuel usage, an increase in particulate matter emissions, and engine misfiring. ITR can achieve between 20 to 30 percent NOx reduction. Due to the increase in particulate matter emissions resulting from ITR, this technology will not be carried forward.

(e) Federal Emission Standards
RBLC NOx determinations for federal emission standards require the engines meet the requirements of 40 C.F.R. 60 NSPS Subpart IIII, 40 C.F.R 63 Subpart ZZZZ, non-road engines (NREs), or EPA tier certifications. NSPS Subpart IIII applies to stationary compression ignition internal combustion engines that are manufactured or reconstructed after July 11, 2005. EU 7 was manufactured prior to July 11, 2005 and has not been reconstructed since. Therefore, EU 7 is not subject to NSPS Subpart IIII. EU 7 is considered a commercial emergency engine and is therefore exempt from NESHAP Subpart ZZZZ. For these reasons federal emission standards will not be carried forward as a control technology.

(f) Limited Operation
EU 7 currently operates under an annual hour limit of no more than 52 hours per 12 month rolling period. The Department considers limited operation a technically feasible emissions control method.

(g) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of NOx emissions. The Department considers GCPs a technically feasible control technology for the large diesel-fired engine.

Step 2 - Eliminate Technically Infeasible NOx Control Technologies for the Large Engine
As explained in Step 1 of Section 3.3, the Department does not consider fuel injection timing retard, ignition timing retard, and federal emission standards as technically feasible technologies to control NOx emissions from the large diesel-fired engine.

Step 3 - Rank the Remaining NOx Control Technologies for the Large Diesel-Fired Engine
The following control technologies have been identified and ranked for the control of NOx emissions from the large diesel-fired engine.

(a)	Selective Catalytic Reduction	(90% Control)
(g)	Good Combustion Practices	(Less than 40% Control)
(b)	Turbocharger and Aftercooler	(0% Control)
(f)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis for the installation of SCR on the large diesel-fired engine. A summary of the analysis is shown below:

Table 3-12. GVEA Economic Analysis for Technically Feasible NOx Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
SCR	0.05	0.45	$100,000	$14,238	$31,639
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of NOx reduction does not justify installing SCR on the large diesel-fired engine based on the excessive cost per ton of NOx removed per year.

GVEA proposed the following as BACT for NOx emissions from the large diesel-fired engine:

(a) NOx emissions from the operation of the large diesel-fired engine shall be controlled by limiting operation to no more than 52 hours per 12 month rolling period;

(b) NOx emissions from the operation of the large diesel-fired engine shall be controlled by operating a turbocharger and aftercooler; and

(c) NOx emissions from the diesel-fired engine shall not exceed 0.031 lb/hp-hr over a 4-hour averaging period.

Department Evaluation of BACT for NOx Emissions from the Large Diesel-Fired Engine
The Department reviewed GVEA's proposal for the large diesel-fired engine and finds that SCR is an economically infeasible control technology. The Department does not agree with some of the assumptions provided in GVEA's cost analysis that cause an overestimation of the cost effectiveness. However, since EU 7 is limited to 52 hours per year, the Department finds it unnecessary to revise the cost analysis as a decrease in 0.05 tpy of NOx from EU 7 will not be cost effective for installing SCR.

Step 5 - Preliminary Selection of NOx BACT for the Large Diesel-Fired Engine
The Department's preliminary finding is that the BACT for NOx emissions from the large diesel-fired engine is as follows:

(a) NOx emissions from EU 7 shall be controlled by limiting its operation to no more than 52 hours per 12 month rolling period;

(b) NOx emissions from EU 7 shall be controlled by operating a turbocharger and aftercooler at all times the unit is operating; and

(c) NOx emissions from EU 7 shall not exceed 0.024 lb/hp-hr[3] over a 3-hour averaging period.

Table 3-13 lists the proposed NOx BACT determination for this facility along those for other diesel-fired engines rated at more than 500 hp located in the Serious PM-2.5 nonattainment area.

[3] Table 3.4-1 of US EPA's AP-42 Emission Factors. https://www3.epa.gov/ttn/chief/ap42/ch03/final/c03s04.pdf

Table 3-13. Comparison of NOx BACT Limits for Large Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
Fort Wainwright	8 Large Diesel-Fired Engines	> 500 hp	4.77 – 10.88 g/hp-hr	Limited Operation Good Combustion Practices Federal Emission Standards
UAF	Large Diesel-Fired Engine	13,266 hp	0.0020 g/hp-hr	Selective Catalytic Reduction Turbocharger and Aftercooler Good Combustion Practices Limited Operation
GVEA North Pole	Large Diesel-Fired Engine	600 hp	10.88 g/hp-hr	Turbocharger and Aftercooler Good Combustion Practices Limited Operation
GVEA Zehnder	2 Large Diesel-Fired Engines	11,000 hp (each)	3.69 g/hp-hr	Turbocharger and Aftercooler Good Combustion Practices Limited Operation

3.4 NOx BACT for the Propane-Fired Boilers (EUs 11 and 12)

Possible NOx emission control technologies for propane-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 13.310, Gas-Fired Boilers (<100 MMBtu/hr). The search results for gas-fired boilers are summarized in Table 3-14.

Table 3-14. RBLC Summary of NOx Control for Gas-Fired Boilers

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Good Combustion Practices	19	0.011 – 0.05
Low NOx Burners	41	0.01 – 0.07
Selective Catalytic Reduction	4	0.006 – 0.06
Selective Non-Catalytic Reduction	1	0.14
No Control Specified	9	0.006 – 0.036

RBLC Review
A review of similar units in the RBLC indicates good combustion practices, low NOx burners, selective catalytic reduction, and selective non-catalytic reduction are the principle NOx control technologies installed on gas-fired boilers. The lowest emission rate listed in the RBLC is 0.006 lb/MMBtu.

Step 1 - Identification of NOx Control Technology for the Propane-Fired Boilers
From research, the Department identified the following technologies as available for control of NOx emissions from the propane-fired boilers:

(a) Low NOx Burners
Using LNBs can reduce formation of NOx through careful control of the fuel-air mixture during combustion. Control techniques used in LNBs includes staged air, and staged fuel, as well as other methods that effectively lower the flame temperature. Experience

suggests that significant reduction in NOx emissions can be realized using LNBs. The U.S. EPA reports that LNBs have achieved reduction up to 80%. The Department considers LNBs a technically feasible control technology for the propane-fired boilers.

(b) Ultra-Low NOx Burners
Ultra-low NOx burners operate on the same principle as LNB described above, but have advanced designs for achieving higher NOx destruction efficiencies. Designs that promote superior NOx destruction efficiencies often have a higher investment cost than typical LNBs. For smaller EUs manufacturers do not offer ultra-low NOx burners because of incremental emissions reduction is not cost effective as compared to standard LNBs. Ultra-low NOx burners are not available for EUs 11 and 12. The Department does not consider the use of ultra-low NOx burners a technically feasible control technology for the propane-fired boilers.

(c) Selective Catalytic Reduction
The theory of SCR was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. The RLBC indicated that no applications of SCR have been demonstrated in practice for gas-fired boilers rated at less than 25 MMBtu/hr. EUs 11 and 12 are each rated at 5 MMBtu/hr. The Department does not consider SCR to be a technically feasible control technology for the propane-fired boilers.

(d) Flue Gas Recirculation
Flue gas recirculation (FGR) involves recycling a portion of the combustion gases from the stack to the boiler combustion air intake. The combustion products are low in oxygen, and when mixed with the combustion air, lower the overall excess oxygen concentration. This process acts as a heat sink to lower the peak flame temperature as well as the residence time at peak flame temperature. These effects work together to limit thermal NOx formation. The typical NOx removal efficiency using FGR is 20-25%. The Department considers FGR to be a technically feasible control technology for the propane-fired boilers.

(e) Fuel Type
The RBLC identified the use of natural gas or propane as fuel to reduce NOx emissions, or the use of gas meeting public utility specifications. Natural gas services are not available in Fairbanks or North Pole, but propane is available and is currently fired in EUs 11 and 12. The Department considers fuel type to be a technically feasible control technology for the propane-fired boilers.

(f) Scrubber
The RBLC identified one instance of a scrubber being used for NOx emission control on a galvanizing line furnace rated at 98.7 MMBtu/hr. Galvanizing line furnaces operate at very high temperatures, more than 1,000 °F, to promote chemical reactions for the galvanizing process. EUs 11 and 12 are much smaller units, rated at 5 MMBtu/hr, and are used for comfort heating, with a working temperature of approximately 250 °F. NOx formation is known to increase with higher operating temperatures. Given the disparity in

size, purpose, and operating temperature between these units, the Department does not consider a scrubber a technically feasible control technology for the propane-fired boilers.

(g) Limited Operation
Limiting the operation of emission units reduces the potential to emit for those units. EUs 11 and 12 are the only sources of heat for the North Pole Power Plant. Therefore, it is not appropriate to limit the operation of these units. The Department does not consider limited operation a technically feasible control technology for the propane-fired boilers.

(h) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of NOx emissions. The Department considers GCPs a technically feasible control technology for the propane-fired boilers.

Step 2 - Eliminate Technically Infeasible NOx Technologies for the Propane-Fired Boilers
As explained in Step 1 of Section 3.5, the Department does not consider Ultra-low NOx burners, selective catalytic reduction, scrubbers, and limited operation as technically feasible technology to control NOx emissions from the propane-fired boilers.

Step 3 - Rank the Remaining NOx Control Technologies for the Propane-Fired Boilers
The following control technologies have been identified and ranked by efficiency for the control of NOx emissions from the propane-fired boilers.

(a) Low NOx Burners (80% Control)
(d) Flue Gas Recirculation (20% - 25% Control)
(f) Good Combustion Practices (Less than 40% Control)
(b) Fuel Type (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis of the installation of Low NOx Burners on the startup heater. A summary of the analysis is shown in Table 3-15:

Table 3-15. GVEA Economic Analysis for Technically Feasible NOx Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
Low NOx Burner	0.7	2.4	$38,650	$5,503	$2,276
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of NOx reduction does not justify the use of LNB or FGR for the propane-fired boilers based on the excessive cost per ton of NOx removed per year.

GVEA proposed the following as BACT for the propane-fired boilers:

(a) Burn only propane as fuel in EUs 11 and 12;

(b) NOx emissions from the operation of the propane-fired boilers shall be controlled with good combustion practices;

(c) NOx emissions from the propane-fired boilers shall not exceed 13 lb/kgal over a 4-hour averaging period; and

(d) Compliance with the emission limit will be demonstrated with records of maintenance following original equipment manufacturer recommendations for operation and maintenance and periodic measurements of O_2 balance.

Department Evaluation of BACT for NOx Emissions from the Propane-Fired Boilers

The Department revised the emissions tables to reflect an 80% control efficiency. Additionally, the equipment life was revised to 20 years. A summary of the analysis is shown in Table 3-16:

Table 3-16. Department Economic Analysis for Technically Feasible NOx Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
Low NOx Burner	0.6	2.5	$38,650	$3,648	$1,471
Capital Recovery Factor = 0.0944 (7% interest rate for a 20 year equipment life)					

The Department's preliminary economic analysis indicates the level of NOx reduction justifies the installation of low NOx burners on the propane-fired boilers located in the Serious PM-2.5 nonattainment area.

Step 5 - Preliminary Selection of NOx BACT for the Propane-Fired Boilers

The Department's preliminary finding is that the BACT for NOx emissions from the propane-fired boilers is as follows:

(a) NOx emissions from EUs 11 and 12 shall be controlled by installing low NOx burners in conjunction with using propane as fuel at all times the units are in operation;

(b) NOx emissions from EUs 11 and 12 shall not exceed 2.6 lb/1000 gal averaged over a 3-hour period; and

(c) Compliance with the preliminary emission rate limit will be demonstrated with records of maintenance following original equipment manufacturer recommendations for operation and maintenance and periodic measurements of O_2 balance.

Table 3-17 lists the proposed NOx BACT determination for this facility along with those for other propane-fired boilers rated at less than 100 MMBtu/hr in the Serious PM-2.5 nonattainment area.

Table 3-17. Preliminary NOx BACT Limits for the Propane-Fired Boilers

Facility	Process Description	Capacity	Limitation	Control Method
GVEA North Pole	Two Small Propane-Fired Boilers	< 100 MMbtu/hr	2.6 lb/1000 gal	Propane as Fuel Low NOx Burners Good Combustion Practices

4. BACT DETERMINATION FOR PM-2.5

The Department based its PM-2.5 assessment on BACT determinations found in the RBLC, internet research, and BACT analyses submitted to the Department by GVEA for the North Pole Power Plant and Zehnder Facility, Aurora for the Chena Power Plant, US Army for Fort Wainwright, and UAF for the Combined Heat and Power Plant.

4.1 PM-2.5 BACT for the Fuel Oil-Fired Simple Cycle Gas Turbines (EUs 1 and 2)

Possible PM-2.5 emission control technologies for the fuel oil-fired simple cycle gas turbines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.110 Simple Cycle Gas Turbines (rated at 25 MW or more) The search results for simple cycle gas turbines are summarized in Table 4-1.

Table 4-1. RBLC Summary of PM-2.5 Control for Simple Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits
Good Combustion Practices	25	0.0038 – 0.0076 lb/MMBtu
Clean Fuels	12	5 – 14 lb/hr

RBLC Review

A review of similar units in the RBLC indicates restrictions on fuel sulfur contents and good combustion practices are the principle PM control technologies installed on simple cycle gas turbines. The lowest PM-2.5 emission rate listed in the RBLC is 0.0038 lb/MMBtu.

Step 1 - Identification of PM-2.5 Control Technology for the Simple Cycle Gas Turbines

From research, the Department identified the following technologies as available for control of PM-2.5 emissions from fuel oil-fired simple cycle gas turbines:

(a) Low Sulfur Fuel
Low sulfur fuel has been known to reduce particulate matter emissions. PM-2.5 emission rates for low sulfur fuel are not available and therefore a BACT emissions rate cannot be set for low sulfur fuel. The Department does not consider low sulfur fuel a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(b) Low Ash Fuel
Residual fuels and crude oil are known to contain ash forming components, while refined fuels are low ash. Fuels containing ash can cause excessive wear to equipment and foul combustion components. EUs 1 and 2 are fired exclusively on distillate fuel which is a form of refined fuel, and potential PM-2.5 emissions are based on emission factors for distillate fuel. The Department considers low ash fuel a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(c) Limited Operation
Limiting the operation of emission units reduces the potential to emit for those units. Due to EUs 1 and 2 currently operating under limits, the Department considers limited operation as a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of PM. The Department considers GCPs a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

Step 2 - Eliminate Technically Infeasible PM-2.5 Technologies for the Simple Cycle Gas Turbines
As explained in Step 1 of Section 4.1, the Department does not consider low sulfur fuel as a technically feasible technology to control PM-2.5 emissions from the fuel oil-fired simple cycle gas turbines.

Step 3 - Rank the Remaining PM-2.5 Control Technologies for the Simple Cycle Gas Turbines
The following control technologies have been identified and ranked by efficiency for the control of PM-2.5 emissions from the fuel oil-fired simple cycle gas turbines:

(d)	Good Combustion Practices	(Less than 40% Control)
(b)	Low Ash Fuel	(0% Control)
(c)	Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA proposes the following as BACT for PM-2.5 emissions from the fuel oil-fired simple cycle gas turbines:

(a) PM-2.5 emissions from EUs 1 and 2 shall not exceed 0.12 lb/MMBtu over a 4-hour averaging period; and

(b) Maintain good combustion practices.

Step 5 - Preliminary Selection of PM-2.5 BACT for the Simple Cycle Gas Turbines
The Department's preliminary finding is that BACT for PM-2.5 emissions from the fuel oil-fired simple cycle gas turbine is as follows:

(a) PM-2.5 emissions from EUs 1 and 2 shall be controlled by combusting only low ash fuel;

(b) Maintain good combustion practices at all times of operation by following the manufacturer's operation and maintenance procedures; and

(c) PM-2.5 emissions from EUs 1 & 2 shall not exceed 0.012 lb/MMBtu over a 3-hour averaging period.

Table 4-2 lists the proposed PM-2.5 BACT determination for this facility along with those for other fuel oil-fired simple cycle gas turbines located in the Serious PM-2.5 nonattainment area.

Table 4-2. Comparison of PM-2.5 BACT for Simple Cycle Gas Turbines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
GVEA – North Pole	Two Fuel Oil-Fired Simple Cycle Gas Turbines	1,344 MMBtu/hr	0.012 lb/MMBtu[4] (3-hour averaging period)	Good Combustion Practices
GVEA – Zehnder	Two Fuel Oil-Fired Simple Cycle Gas Turbines	536 MMBtu/hr	0.012 lb/MMBtu[4] (3-hour averaging period)	Good Combustion Practices

4.2 PM-2.5 BACT for the Combined Cycle Gas Turbines (EUs 5 and 6)

Possible PM-2.5 emission control technologies for the fuel oil-fired combined cycle gas turbines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.210, Liquid Fuel-Fired Combined Cycle Combustion Turbines (rated at 25 MW or more). The search results for combined cycle gas turbines are summarized in Table 4-3.

Table 4-3. RBLC Summary for PM-2.5 Control for the Combined Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits
Good Combustion Practices	9	4 – 19.35 lb/hr
Clean Fuels	12	4.7 – 60.6 lb/hr

RBLC Review

A review of similar units in the RBLC indicates good combustion practices and clean fuels are the principle PM-2.5 control technologies installed on fuel oil-fired combined cycle gas turbines. The lowest NOx emission rate listed in the RBLC is 4 lb/hr.

Step 1 - Identification of PM-2.5 Control Technology for the Combined Cycle Gas Turbines

From research, the Department identified the following technologies as available for control of PM-2.5 emissions from fuel oil-fired combined cycle gas turbines rated at 25 MW or more:

(a) Low Sulfur Fuel
Low sulfur fuel has been known to reduce particulate matter emissions. The Department considers low sulfur fuel a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(b) Limited Operation
Limiting the operation of emission units reduces the potential to emit for those units. EUs 5 and 6 currently operate under a combined ORL with EU 1 to restrict the combined NOx emissions from these three units to no more than 1,600 tons per 12 month rolling period. The Department considers limited operation a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

[4] Table 3.1-2a of US EPA's AP-42 Emission Factors. https://www3.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf

(c) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of particulate matter. The Department considers GCPs a technically feasible control technology for the fuel oil-fired combined cycle turbines.

Step 2 - Eliminate Technically Infeasible PM-2.5 Controls for the Combined Cycle Gas Turbines
As explained in Step 1 of Section 4.1, the Department does not consider low sulfur fuel as technically feasible technology to control PM-2.5 emissions from the fuel oil-fired combined cycle gas turbines.

Step 3 - Rank the Remaining PM-2.5 Controls for the Combined Cycle Gas Turbines
The following control technologies have been identified and ranked by efficiency for the control of PM-2.5 emissions from the combined cycle gas turbines:

(c) Good Combustion Practices	(Less than 40% Control)
(b) Limited Operation	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA proposes the following as BACT for PM-2.5 emissions from the fuel oil-fired combined cycle gas turbines:

(a) PM-2.5 emissions shall not exceed 0.12 lb/MMBtu over a 4-hour averaging period; and

(b) Maintain good combustion practices.

Department Evaluation of BACT for PM-2.5 Emissions from the Combined Cycle Gas Turbines

The Department reviewed GVEA's proposal and found that in addition to maintaining good combustion practices, limited operation is also a technically feasible control technology.

Step 5 - Preliminary Selection of PM-2.5 BACT for the Combined Cycle Gas Turbines
The Department's preliminary finding is that BACT for PM-2.5 emissions from the combined cycle gas turbines is as follows:

(a) PM-2.5 emissions from EUs 5 and 6 shall be limited by complying with the combined annual NOx limit listed in Operating Permit AQ0110TVP03 Conditions 13 and 12, respectively;

(b) PM-2.5 emissions from EUs 5 and 6 shall not exceed 0.012 lb/MMBtu[5] over a 3-hour averaging period; and

(c) Maintain good combustion practices by following the manufacturer's operating and maintenance procedures at all times of operation.

[5] Table 3.1-2a of US EPA's AP-42 Emission Factors. https://www3.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf

4.3 PM-2.5 BACT for the Large Diesel-Fired Engine (EU 7)

Possible PM-2.5 emission control technologies for the large diesel-fired engine were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes 17.110-17.190, Large Internal Combustion Engines (>500 hp). The search results for large diesel-fired engines are summarized in Table 4-5.

Table 4-5. RBLC Summary of PM-2.5 Control for Large Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Federal Emission Standards	12	0.03 – 0.02
Good Combustion Practices	28	0.03 – 0.24
Limited Operation	11	0.04 – 0.17
Low Sulfur Fuel	14	0.15 – 0.17
No Control Specified	14	0.02 – 0.15

RBLC Review
A review of similar units in the RBLC indicates that good combustion practices, compliance with the federal emission standards, low ash/sulfur diesel, and limited operation are the principle PM-2.5 control technologies installed on large diesel-fired engines. The lowest PM-2.5 emission rate in the RBLC is 0.02 g/hp-hr.

Step 1 - Identification of PM-2.5 Control Technology for the Large Diesel-Fired Engine
From research, the Department identified the following technologies as available for controls of PM-2.5 emissions from diesel fired engines rated at 500 hp or greater:

(a) Diesel Particulate Filter (DPF)
DPFs are a control technology that is designed to physically filter particulate matter from the exhaust stream. Several designs exist which require cleaning and replacement of the filter media after soot has become caked onto the filter media. Regenerative filter designs are also available that burn the soot on a regular basis to regenerate the filter media. DPF can reduce PM-2.5 emissions by 85%. The Department considers DPF a technically feasible control technology for the large diesel-fired engine.

(b) Diesel Oxidation Catalyst (DOC)
DOC can reportedly reduce PM-2.5 emissions by 30% and PM emissions by 50%. A DOC is a form of "bolt on" technology that uses a chemical process to reduce pollutants in the diesel exhaust resulting in decreased concentrations. They replace mufflers on vehicles, and require no modifications. More specifically, this is a honeycomb type structure that has a large area coated with an active catalyst layer. As CO and other gaseous hydrocarbon particles travel along the catalyst, they are oxidized thus reducing pollution. The Department considers DOC a technically feasible control technology for the large diesel-fired engine.

(c) Positive Crankcase Ventilation
Positive crankcase ventilation is the process of re-introducing the combustion air into the cylinder chamber for a second chance at combustion after the air has seeped into and collected in the crankcase during the downward stroke of the piston cycle. This process

allows any unburned fuel to be subject to a second combustion opportunity. Any combustion products act as a heat sink during the second pass through the piston, which will lower the temperature of combustion and reduce the thermal NOx formation. Positive crankcase ventilation is included in the design of EU 7. The Department considers positive crankcase ventilation a technically feasible control technology for the large diesel-fired engine.

(d) Low Sulfur Fuel
Low sulfur fuel has been known to reduce particulate matter emissions. The Department considers low sulfur fuel as a technically feasible control technology for the large diesel-fired engine.

(e) Low Ash Diesel
Residual fuels and crude oil are known to contain ash forming components, while refined fuels are low ash. Fuels containing ash can cause excessive wear to equipment and foul engine components. EU 7 is fired exclusively on distillate fuel which is a form of refined fuel. The potential PM-2.5 emissions are based on emission factors for distillate fuel. The Department considers low ash diesel a technically feasible control technology for the large diesel-fired engine.

(f) Federal Emission Standards
The theory behind the federal emission standards for EU 7 was discussed in detail in the NOx BACT for the large diesel-fired engine and will not be repeated here. Due to EU 7 not being subject to either 40 C.F.R. 60 Subpart IIII or 40 C.F.R. 63 Subpart ZZZZ the Department does not consider federal emission standards a technically feasible control technology for the large diesel-fired engine.

(g) Limited Operation
The theory behind limited operation for EU 7 was discussed in detail in the NOx BACT for the large diesel-fired engine and will not be repeated here. Due to EU 7 currently operating under an annual hour limit of no more than 52 hours per 12 month rolling period, the Department considers limited operation a technically feasible control technology for the large diesel-fired engine.

(h) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of NOx emissions. The Department considers GCPs a technically feasible control technology for the large diesel-fired engine.

Step 2 - Eliminate Technically Infeasible PM-2.5 Control Technologies for the Large Engine
PM-2.5 emission rates for low sulfur fuel are not available and therefore a BACT emissions rate cannot be set for low sulfur fuel. Low sulfur fuel is not a technically feasible control technology. As explained in Step 1 of Section 4.3, federal emission standards are not technically feasible control technology for control of PM-2.5 emissions from the large diesel-fired engine.

Step 3 - Rank the Remaining PM-2.5 Control Technologies for the Large Diesel-Fired Engine
The following control technologies have been identified and ranked by efficiency for the control of PM-2.5 emissions from the large diesel-fired engines:

(a) Diesel Particulate Filters (85% Control)
(g) Good Combustion Practices (Less than 40% Control)
(b) Positive Crankcase Ventilation (0% Control)
(d) Low Ash Diesel (0% Control)
(f) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA Proposal

GVEA provided an economic analysis for the installation of diesel particulate filter. A summary of the analysis for is shown below:

Table 4-6. GVEA Economic Analysis for Technically Feasible PM-2.5 Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annual Costs ($/year)	Cost Effectiveness ($/ton)
Diesel Particulate Filter	0.005	0.03	$30,229	$4,304	$143,008
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates that the level of PM-2.5 reduction does not justify the use of a diesel particulate filter based on the excessive cost per ton of PM-2.5 removed per year.

GVEA proposes the following as BACT for PM-2.5 emissions from the large diesel-fired engine:

(a) PM-2.5 emissions from EU 7 shall be controlled by operating with positive crankcase ventilation;
(b) Maintaining good combustion practices;
(c) PM-2.5 emissions from EU 7 shall be controlled by limiting operation to no more than 52 hours per 12 month rolling period; and
(d) PM-2.5 emissions from EU 7 shall not exceed 0.0022 lb/hp-hr[6] over a 4-hour averaging period.

Department Evaluation of BACT for PM-2.5 Emissions from the Large Diesel-Fired Engine
The Department reviewed GVEA's proposal for the large diesel-fired engine and finds that installing a diesel particulate filter is an economically infeasible control technology. The Department does not agree with some of the assumptions provided in GVEA's cost analysis that

[6] Emissions Inventory Data: http://dec.alaska.gov/Applications/Air/airtoolsweb/PointSourceEmissionInventory/XmlInventory?reportingYear=2017&organizationKey=10&facilityKey=110&addEmissionUnits=0&addReleasePoints=0

cause an overestimation of the cost effectiveness. However, since EU 7 is limited to 52 hours per year, the Department finds it unnecessary to revise the cost analysis as a decrease in 0.03 tpy of PM-2.5 from EU 7 will not be cost effective for installing a diesel particulate filter.

Step 5 - Preliminary Selection of PM-2.5 BACT for the Large Diesel-fired Engine
The Department's preliminary finding is that the BACT for PM-2.5 emissions from the large diesel-fired engine is as follows:

(a) PM-2.5 emissions from EU 7 shall be controlled by operating with positive crankcase ventilation;
(b) PM-2.5 emissions from EU 7 shall be controlled by limiting operation to no more than 52 hours per 12 month rolling period; and
(c) PM-2.5 emissions from EU 7 shall not exceed 0.0022 lb/hp-hr[7] over a 3-hour averaging period.

Table 4-7 lists the proposed PM-2.5 BACT determination for the facility along with those for other diesel-fired engines rated at more than 500 hp located in the Serious PM-2.5 nonattainment area.

Table 4-7. Comparison of PM-2.5 BACT for the Large Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
UAF	Large Diesel-Fired Engine	13,266 hp	0.32 g/hp-hr	Positive Crankcase Ventilation Limited Operation
Fort Wainwright	8 Large Diesel-Fired Engines	> 500 hp	0.15 – 10.9 g/hp-hr	Limited Operation Ultra-Low Sulfur Diesel Federal Emission Standards
GVEA North Pole	Large Diesel-Fired Engine	600 hp	0.0022 g/hp-hr	Positive Crankcase Ventilation Good Combustion Practices
GVEA Zehnder	2 Large Diesel-Fired Engines	11,000 hp (each)	0.12 g/hp-hr	Limited Operation Good Combustion Practices

4.5 PM-2.5 BACT for the Propane-Fired Boilers (EUs 11 and 12)

Possible PM-2.5 emission control technologies for the propane-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 13.310, Gas-Fired Boilers (<100 MMBtu/hr). The search results for gas-fired boilers are summarized in Table 4-8.

Table 4-8. RBLC Summary of PM-2.5 Control for Gas-Fired Boilers

Control Technology	Number of Determinations	Emission Limits (lb/MMBtu)
Good Combustion Practices	49	0.0019 – 0.0095
Electrostatic Precipitator	3	0.015 – 0.032

[7] Emissions Inventory Data: http://dec.alaska.gov/Applications/Air/airtoolsweb/PointSourceEmissionInventory/XmlInventory?reportingYear=2017&organizationKey=10&facilityKey=110&addEmissionUnits=0&addReleasePoints=0

RBLC Review

A review of similar units in the RBLC indicates that good combustion practices and electrostatic precipitators are the principle PM-2.5 control technology determined for propane-fired boilers. The lowest PM-2.5 emission rate listed in the RBLC is 0.0019 lb/MMBtu.

Step 1 - Identification of PM-2.5 Control Technology for the Propane-Fired Boilers

From research, the Department identified the following technologies as available for control of PM-2.5 emissions from propane-fired boilers:

(a) Low Sulfur Fuel

The boilers (EUs 11 and 12) are fired using propane, which is an inherently low sulfur fuel. Condition 11 of AQ0110TVP03 limits the sulfur content of the propane combusted in the boilers to 120 ppmv. Recent tests indicate that the propane fired in the boilers contains less than 3 ppm H_2S as determined by the length-of-stain methodology. The Department considers low sulfur fuel a technically feasible control technology for the propane-fired boilers.

(b) Flue Gas Recirculation

The theory behind FGR was discussed in detail in the NOx BACT for the propane-fired boilers and will not be repeated here. The Department considers FGR a technically feasible control technology for the propane-fired boilers.

(c) Baghouse

Baghouses are comprised of an array of filter bags contained in housing. Air passes through the filter media from the "dirty" to the "clean" side of the bag. These devices undergo periodic bag cleaning based on the build-up of filtered material on the bag as measured by pressure drop across the device. The cleaning cycle is set to allow operation within a range of design pressure drop. Baghouses are characterized by the type of cleaning cycle - mechanical-shaker, pulse-jet, and reverse-air. Fabric filter systems have control efficiencies of 95% to 99.9% [8] and are generally specified to meet a discharge concentration of filterable particulate (e.g., 0.01 grains per dry standard cubic feet). The only entry for a baghouse in the RBLC was for a 30 MMBtu/hr furnace for glass melting at an insulation manufacturing facility and the unit is subject to the PM emission standards under 40 C.F.R. 63 Subpart NNN. EUs 11 and 12 are much smaller units at 5 MMBtu/hr, are used for providing space heating, and have a much lower working temperature. Due to the differences in size, purpose, and operating temperatures, the Department does not consider a baghouse a technically feasible control technology for the propane-fired boilers.

(d) Limited Operation

Limiting the operation of emission units reduces the potential to emit for those units. EUs 11 and 12 are the only sources of heat for the North Pole Power Plant. Therefore, it is not appropriate to limit the operation of these units. The Department does not consider the

[8] https://www3.epa.gov/ttn/catc/dir1/ff-shaker.pdf
https://www3.epa.gov/ttn/catc/dir1/ff-pulse.pdf
https://www3.epa.gov/ttn/catc/dir1/ff-revar.pdf

use of limited operation a technically feasible control technology for the propane-fired boilers.

(e) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle gas turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of PM-2.5 emissions. The Department considers GCPs a technically feasible control technology for the propane-fired boiler.

Step 2 - Eliminate Technically Infeasible PM-2.5 technologies for the Propane-Fired Boilers
As explained in Step 1 of Section 4.5, the Department does not consider a baghouse and limited operation as technically feasible PM-2.5 control technologies. Flue gas recirculation is not recommended by the vendor as a control technology for EUs 11 and 12, and therefore is not considered a technically feasible control technology.

Step 3 - Rank the Remaining PM-2.5 Control Technologies for the Propane-Fired Boilers
GVEA has accepted the only technically feasible control technology for EUs 11 and 12. Therefore, ranking is not required.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA proposes the following as BACT for the propane-fired boilers:

(a) Burn low sulfur fuel in EUs 11 and 12;
(b) PM-2.5 emissions from EUs 11 and 12 shall not exceed 0.7 lb/1000 gal over a 4-hour averaging period; and
(c) Compliance with the emission limit will be demonstrated with records of maintenance following original equipment manufacturer recommendations for operation and maintenance and periodic measurements of O_2 balance.

Department Evaluation of BACT for PM-2.5 Emissions from the Propane-Fired Boilers
The Department reviewed GVEA's proposal for EUs 11 and 12 and finds that an emission rate achievable with good combustion practices is also BACT for the propane-fired boilers.

Step 5 - Preliminary Selection of PM-2.5 BACT for the Propane-Fired Boilers
The Department's preliminary finding is that BACT for PM-2.5 emissions from the propane-fired boilers is as follows:

(a) Burn only propane as fuel in EUs 11 and 12;
(b) PM-2.5 emissions from the operation of the propane-fired boilers shall be controlled with good combustion practices;
(c) PM-2.5 emissions from EUs 11 and 12 shall not exceed 0.7 lb/1000 gal over a 3-hour averaging period; and
(d) Compliance with the emission limit will be demonstrated with records of maintenance following original equipment manufacturer recommendations for operation and maintenance and periodic measurements of O_2 balance.

5. BACT DETERMINATION FOR SO_2

The Department based its SO_2 assessment on BACT determinations found in the RBLC, internet research, and BACT analyses submitted to the Department by GVEA for the North Pole Power Plant and Zehnder Facility, Aurora for the Chena Power Plant, US Army for Fort Wainwright, and UAF for the Combined Heat and Power Plant.

5.1 SO_2 BACT for the Fuel Oil-Fired Simple Cycle Gas Turbines (EUs 1 and 2)

Possible SO_2 emission control technologies for the fuel oil-fired simple cycle gas turbines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.190 for Simple Cycle Gas Turbines (rated at 25 MW or more) The search results for simple cycle gas turbines are summarized in Table 5-1.

Table 5-1. RBLC Summary of SO_2 Controls for Fuel Oil-Fired Simple Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits
Ultra-Low Sulfur Diesel	7	0.0015 % S by wt.
Fuel Oil (0.05 % S by wt.)	2	0.0026 – 0.055 lb/MMBtu
Good Combustion Practices	3	0.6 lb/hr

RBLC Review

A review of similar units in the RBLC indicates that limiting the sulfur content of fuel and good combustion practices are the principle SO_2 control technologies determined as BACT for fuel oil-fired simple cycle gas turbines. The lowest SO_2 emission rate listed in the RBLC is combustion of ULSD at 0.0015 % S by wt.

Step 1 - Identification of SO_2 Control Technology for the Simple Cycle Gas Turbines

From research, the Department identified the following technologies as available for control of SO_2 emissions from fuel oil-fired simple cycle gas turbines rated at 25 MW or greater:

(a) Ultra Low Sulfur Diesel (ULSD)
ULSD has a fuel sulfur content of 0.0015 percent sulfur by weight or less. Using ULSD would reduce SO_2 emissions because the fuel oil-fired simple cycle gas turbines are combusting standard diesel that has a sulfur content of up to 0.5 percent sulfur by weight. Switching to ULSD could reach a great than 99 percent decrease in SO_2 emissions from the fuel oil-fired simple cycle gas turbines. The Department considers ULSD a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(b) Low Sulfur Fuel
Low sulfur fuel has a fuel sulfur content of 0.05 percent sulfur by weight. Using low sulfur fuel would reduce SO_2 emissions because the fuel oil-fired simple cycle gas turbines are combusting standard diesel that has a sulfur content of up to 0.5 percent sulfur by weight. Switching to low sulfur fuel could reach a 93 percent decrease in SO_2 emissions from the fuel oil-fired simple cycle gas turbines during non-startup operation. The Department considers low sulfur diesel a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(c) Limited Operation
The theory behind limited operation for EUs 1 and 2 was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle gas turbines and will not be repeated here. Due to EUs 1 and 2 currently operating under limits, the Department considers limited operation a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle gas turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2. The Department considers GCPs a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

Step 2 - Eliminate Technically Infeasible SO_2 Technologies for the Simple Cycle Gas Turbines
All control technologies identified are technically feasible for the fuel oil-fired simple cycle gas turbines.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Simple Cycle Gas Turbines
The following control technologies have been identified and ranked for control of SO_2 from the fuel oil-fired simple cycle gas turbines:

(a) Ultra Low Sulfur Diesel (99.7% Control)
(b) Low Sulfur Diesel (93% Control)
(d) Good Combustion Practices (Less than 40% Control)
(c) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis for switching the fuel combusted in the simple cycle gas turbines to ultra-low sulfur diesel and low sulfur fuel. A summary of the analyses for each of EUs 1 and 2 is shown below:

Table 5-2. GVEA Economic Analysis for Technically Feasible SO_2 Controls for EU 1

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD (0.0015 % S wt.)	1,486.4	1,481.9	$15,212,500	$14,855,778	$10,025
Low Sulfur Fuel (0.05 % S wt.)	1,486.4	1,337.8	???	???	???
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

Table 5-3. GVEA Economic Analysis for Technically Feasible SO_2 Controls for EU 2

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD (0.0015 % S wt.)	1,356.1	1,352.0	$15,212,500	$13,796,591	$10,204
Low Sulfur Fuel (0.05 % S wt.)	1,356.1	1,220.5	???	???	???
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of SO_2 reduction does not justify the fuel switch to ULSD or Low Sulfur Fuel in the simple cycle turbines based on the excessive cost per ton of SO_2 removed per year.

GVEA proposes the following as BACT for SO_2 emissions from the simple cycle gas turbines:

(a) SO_2 emissions from the fuel oil-fired simple cycle gas turbines will be controlled by complying with NOx limits for EUs 1 and 2 listed in Operating Permit AQ0110TVP03 Conditions 13 and 12, respectively;

(b) SO_2 emissions from the fuel oil-fired simple cycle gas turbines will be limited by maintain good combustion practices; and

(c) Restricting the sulfur content to 500 ppm in fuel.

Department Evaluation of BACT for SO_2 Emissions from the Simple Cycle Gas Turbines

The Department revised the cost analyses provided for the fuel switch to ULSD in the simple cycle gas turbines assuming a 20 year equipment life. Additionally, the Department reviewed the cost information provided by GVEA to appropriately evaluate the total capital investment of installing two new 1.5 million gallon ULSD storage tanks at GVEA's North Pole Power Plant. A summary of these analyses is shown in Table 5-4 and Table 5-5.

Table 5-4. Department Economic Analysis for Technically Feasible SO_2 Controls for EU 1

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD	1,486.4	1481.9	$10,875,319	$13,542,927	$9,139
Capital Recovery Factor = 0.0944 (7% interest rate for a 20 year equipment life)					

Table 5-5. Department Economic Analysis for Technically Feasible SO_2 Controls for EU 2

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD	1,356.1	1,352.0	$10,875,319	$12,483,739	$9,233
Capital Recovery Factor = 0.0944 (7% interest rate for a 20 year equipment life)					

The Department's preliminary economic analysis indicates the level of SO_2 reduction justifies the use of ULSD as BACT for the fuel oil-fired simple cycle gas turbines located in the Serious PM-2.5 nonattainment area.

Step 5 - Preliminary Selection of SO_2 BACT for the Simple Cycle Gas Turbines
The Department's preliminary finding is that BACT for SO_2 emissions from the fuel oil-fired simple cycle gas turbines is as follows:

(a) SO_2 emissions from EUs 1 and 2 shall be controlled by limiting the sulfur content of fuel combusted in the turbines to no more than 0.0015 percent by weight.

(b) Compliance with the proposed fuel sulfur content limit will be demonstrated with fuel shipment receipts and/or fuel test results for sulfur content.

Table 5-6 lists the proposed SO_2 BACT determination for this facility along with those for other fuel oil-fired simple cycle gas turbines located in the Serious PM-2.5 nonattainment area.

Table 5-6. Comparison of SO_2 BACT for Simple Cycle Gas Turbines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
GVEA – North Pole	Two Fuel Oil-Fired Simple Cycle Gas Turbines	1,344 MMBtu/hr	0.0015 % S wt.	Ultra-Low Sulfur Diesel
GVEA – Zehnder	Two Fuel Oil-Fired Simple Cycle Gas Turbines	536 MMBtu/hr	0.0015 % S wt.	Ultra-Low Sulfur Diesel

5.2 SO_2 BACT for the Fuel Oil-Fired Combined Cycle Gas Turbines (EUs 5 and 6)

Possible SO_2 emission control technologies for the fuel oil-fired combined cycle gas turbines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 15.290 for Liquid Fuel-Fired Combined Cycle Gas Turbines rated at 25 MW or more. The search results for combined cycle gas turbines are summarized in Table 5-7.

Table 5-7. RBLC Summary of SO_2 Control for Oil-Fired Combined Cycle Gas Turbines

Control Technology	Number of Determinations	Emission Limits
Ultra-Low Sulfur Diesel	1	6.7 lb/hr

RBLC Review
A review of similar units in the RBLC indicates combustion of ultra-low sulfur diesel is the principle SO_2 control technology installed on fuel oil-fired combined cycle gas turbines. The SO_2 emission rate listed in the RBLC is 6.7 lb/hr.

Step 1 - Identification of SO_2 Control Technology for the Combined Cycle Gas Turbines
From research, the Department identified the following technologies as available for the control of SO_2 emissions from the fuel oil-fired combined cycle gas turbines:

(a) Ultra-Low Sulfur Diesel
The theory of ULSD was discussed in detail in the SO_2 BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. The Department considers ULSD a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(b) Light Straight Run Turbine Fuel (LSR)
EU 5 typically combusts LSR when not in startup. EU 6 will also combust LSR when not in startup when installed. The sulfur content of the LSR is limited to no more than 0.05 percent by weight as required by Condition 15.1 of Operating Report AQ0110TVP03. The Department considers operating LSR a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(c) Low Sulfur Fuel
The theory of low sulfur fuel was discussed in detail in the SO_2 BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. The Department considers low sulfur fuel a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

(d) Limited Operation
The theory behind limited operation for EUs 5 and 6 was discussed in detail in the NOx BACT for the fuel oil-fired combined cycle gas turbines and will not be repeated here. Due to EUs 5 and 6 currently operating under limits, the Department considers limited operation a technically feasible control technology for the fuel oil-fired simple cycle gas turbines.

(e) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired combined cycle gas turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2 emissions. The Department considers GCPs a technically feasible control technology for the fuel oil-fired combined cycle gas turbines.

Step 2 - Eliminate Technically Infeasible SO_2 Technologies for the Combined Cycle Gas Turbines
All control technologies identified are technically feasible for the fuel oil-fired combined cycle gas turbines.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Combined Cycle Gas Turbines
The following control technologies have been identified and ranked by efficiency for control of SO_2 emissions from the fuel oil-fired combined cycle gas turbines:

(a)	Ultra-Low Sulfur Diesel	(50% Control)
(e)	Good Combustion Practices	(Less than 40% Control)
(b)	Light Straight Run Turbine Fuel	(0% Control)
(d)	Limited Operation	(0% Control)
(c)	Low Sulfur Fuel	(0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Low sulfur fuel is listed as 0% control as it has the same fuel sulfur content requirements as the light straight run turbine fuel that is currently combusted in the fuel oil-fired combined cycle gas turbines.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis for switching the fuel combusted in the combined cycle gas turbines to ultra-low sulfur diesel. A summary of the analyses for EUs 5 and 6 is shown below:

Table 5-8. GVEA Economic Analysis for Technically Feasible SO_2 Control for EUs 5 and 6

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD	6.0	3.0	--	$27,846,454	$9,282,151
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of SO_2 reduction does not justify the use of ULSD or low sulfur fuel based on the excessive cost per ton of SO_2 removed per year.

GVEA proposes the following as BACT for SO_2 emissions from the combined cycle gas turbines:

(a) SO_2 emissions from EUs 5 and 6 shall combust Light Straight Run Turbine Fuel (30 ppm S in fuel)

Department Evaluation of BACT for SO_2 Emissions from the Combined Cycle Gas Turbines

The Department reviewed GVEA's proposal for the fuel oil-fired combined cycle gas turbines and finds that switching from LSR to ULSD is not economically feasible. The Department does not agree that the cost effectiveness should be based upon the annual cost of USLD, but on the difference in cost between the current fuel and ULSD. However, due to the reduction in SO_2 from LSR to ULSD only being 3.0 tpy the Department did not revise the cost analysis.

Step 5 - Preliminary Selection of SO_2 BACT for the Combined Cycle Gas Turbines

The Department's preliminary finding is that BACT for SO_2 emissions from the fuel oil-fired combined cycle gas turbines is as follows:

(a) SO_2 emissions from EUs 5 and 6 shall be controlled by limiting the fuel combusted in the turbines to light straight run turbine fuel (30 ppm S in fuel); and

(b) Compliance with the proposed fuel sulfur content limit will be demonstrated with fuel shipment receipts and/or fuel test results for sulfur content.

The following table lists the proposed BACT determination for this facility along with the proposed BACT determinations for similar emission units (fuel oil-fired combined cycle turbines) located in the Fairbanks serious non-attainment area for fine particulate matter.

5.3 SO_2 BACT for the Large Diesel-Fired Engine (EU 7)

Possible SO_2 emission control technologies for large engines were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process codes 17.100 to 17.190, Large Internal Combustion Engines (>500 hp). The search results for large diesel-fired engines are summarized in Table 5-9.

Table 5-9. RBLC Summary Results for SO_2 Control for Large Diesel-Fired Engines

Control Technology	Number of Determinations	Emission Limits (g/hp-hr)
Low Sulfur Diesel	27	0.005 – 0.02
Federal Emission Standards	6	0.001 – 0.005
Limited Operation	6	0.005 – 0.006
Good Combustion Practices	3	None Specified
No Control Specified	11	0.005 – 0.008

RBLC Review
A review of similar units in the RBLC indicates combustion of low sulfur fuel, limited operation, good combustion practices, and compliance with the federal emission standards are the principle SO_2 control technologies installed on large diesel-fired engines. The lowest SO_2 emission rate listed in the RBLC is 0.001 g/hp-hr.

Step 1 - Identification of SO_2 Control Technology for the Large Diesel-Fired Engine
From research, the Department identified the following technologies as available for control of SO_2 emissions from diesel-fired engines rated at 500 hp or greater:

(a) Ultra-Low Sulfur Diesel
The theory of ULSD was discussed in detail in the SO_2 BACT for the fuel oil-fired simple cycle gas turbines and will not be repeated here. The Department considers ULSD a technically feasible control technology for the large diesel-fired engine.

(b) Federal Emission Standards
The theory of federal emission standards was discussed in detail in the NOx BACT for the large diesel-fired engine and will not be repeated here. The Department does not consider federal emission standards a feasible control technology for the large diesel-fired engine.

(c) Limited Operation
The theory of limited operation for EU 7 was discussed in detail in the NOx BACT for the large diesel-fired engine and will not be repeated here. The Department considers limited operation as a technically feasible control technology for the large diesel-fired engine.

(d) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of NOx emissions. The Department considers GCPs a technically feasible control technology for the large diesel-fired engine.

Step 2 - Eliminate Technically Infeasible SO_2 Control Technologies for the Large Engine
As explained in Step 1 of Section 5.4, the Department does not consider federal emission standards a technically feasible control technology to control SO_2 emissions from the large diesel-fired engine.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Large Diesel-Fired Engine
The following control technologies have been identified and ranked by efficiency for the control of SO_2 emissions from the large diesel-fired engine:

(a) Ultra-Low Sulfur Diesel (99% Control)
(d) Good Combustion Practices (Less than 40% Control)
(c) Limited Operation (0% Control)

Control technologies already in practice at the stationary source or included in the design of the EU are considered 0% control for the purpose of the SIP BACT for existing stationary sources.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA provided an economic analysis of the control technologies available for the large diesel-fired engine to demonstrate that the use of ULSD with limited operation is not economically feasible on these units. A summary of the analysis for EU 7 is shown below:

Table 5-9. GVEA Economic Analysis for Technically Feasible SO_2 Controls

Control Alternative	Potential to Emit (tpy)	Emission Reduction (tpy)	Total Capital Investment ($)	Total Annualized Costs ($/year)	Cost Effectiveness ($/ton)
ULSD	0.00015	0.0099	--	$444	$45,072
Capital Recovery Factor = 0.1424 (7% interest rate for a 10 year equipment life)					

GVEA contends that the economic analysis indicates the level of SO_2 reduction does not justify the use of ULSD based on the excessive cost per ton of SO_2 removed per year.

GVEA proposed the following as BACT for SO_2 emissions from the diesel-fired engine:

(a) SO_2 emissions from the large diesel-fired engine shall not exceed 0.05 weight percent sulfur; and

(b) Maintain good combustion practices.

Department Evaluation of BACT for SO_2 Emissions from the Large Diesel-Fired Engine

The Department reviewed GVEA's proposal for the large diesel-fired engine and finds that ULSD is not an economically feasible control technology. The Department does not agree that the cost effectiveness be based upon the annual cost of USLD, but on the difference in cost between the current fuel and ULSD. However, due to the annual operational limit on EU 7, and the reduction in SO_2 emissions by using ULSD only being 0.0099 tpy the Department did not revise the cost analysis.

Step 5 - Preliminary Selection of SO_2 BACT for the Large Diesel-Fired Engine

The Department's preliminary finding is that the BACT for SO_2 emissions from the diesel-fired engine is as follows:

(a) SO_2 emissions from EU 7 shall be controlled by combusting fuel that does not exceed 0.05 weight percent sulfur at all time the unit is in operation;

(b) SO_2 emissions from the operation of the large diesel-fired engine shall be controlled by limiting operation to no more than 52 hours per 12 month rolling period;

(c) Compliance with the SO_2 emission limit while firing diesel fuel will be demonstrated by fuel shipment receipts and/or fuel test results for sulfur content; and

(d) Maintain good combustion practices by following the manufacturer's maintenance procedures at all times of operation.

The following table lists the proposed BACT determination for this facility along with those for other diesel-fired engines rated at more than 500 hp in the Serious PM-2.5 nonattainment area.

Table 5-10. Comparison of SO_2 BACT for Large Diesel-Fired Engines at Nearby Power Plants

Facility	Process Description	Capacity	Limitation	Control Method
Fort Wainwright	8 Large Diesel-Fired Engines	> 500 hp	15 ppmw S in fuel	Limited Operation Good Combustion Practices Ultra-Low Sulfur Diesel
UAF	Large Diesel-Fired Engine	13,266 hp	15 ppmw S in fuel	Limited Operation Good Combustion Practices Ultra-Low Sulfur Diesel
GVEA North Pole	Large Diesel-Fired Engine	600 hp	500 ppmw S in fuel	Limited Operation Good Combustion Practices
GVEA Zehnder	2 Large Diesel-Fired Engines	11,000 hp	15 ppmw S in fuel	Good Combustion Practices Ultra-Low Sulfur Diesel

5.4 SO_2 BACT for the Propane-Fired Boilers (EUs 11 and 12)

Possible SO_2 emission control technologies for the propane-fired boilers were obtained from the RBLC. The RBLC was searched for all determinations in the last 10 years under the process code 13.310, Gas-Fired Boilers (<100 MMBtu/hr). The search results for gas-fired boilers are summarized in Table 5-11.

Table 5-11. SO_2 Control for Gas-Fired Boilers with a Rating < 100 MMBtu/hr

Control Technology	Number of Determinations	Emission Limits
Low Sulfur Fuel	6	0.03 – 0.12 lb/hr
Good Combustion Practices	4	0.0048 – 0.6 lb/MMBtu
Pipeline Quality Natural Gas	28	0.0006 – 0.0048 lb/MMBtu
No Control Specified	4	0.0021 lb/MMBtu

RBLC Review

A review of similar units in the RBLC indicates that good combustion practices and combustion of low sulfur fuel are the principle SO_2 control technologies installed on propane-fired boilers. The lowest SO_2 emission rate listed in the RBLC is 0.0006 lb/MMBtu.

Step 1 - Identification of SO_2 Control Technology for the Propane-Fired Boilers

From research, the Department identified the following technologies as available for SO_2 control for the propane-fired boilers:

(a) Low Sulfur Fuel
The theory of low sulfur fuel was discussed in detail in the PM-2.5 BACT for the propane-fired boilers and will not be repeated here. The Department considers low sulfur fuel a technically feasible control technology for the propane-fired boilers.

(b) Good Combustion Practices
The theory of GCPs was discussed in detail in the NOx BACT for the fuel oil-fired simple cycle gas turbines and will not be repeated here. Proper management of the combustion process will result in a reduction of SO_2. The Department considers GCPs a technically feasible control technology for the propane-fired boilers.

Step 2 - Eliminate Technically Infeasible SO_2 Technologies for the Propane-Fired Boilers

All identified control devices are technically feasible technologies for the propane-fired boilers.

Step 3 - Rank the Remaining SO_2 Control Technologies for the Propane-Fired Boilers

GVEA has accepted the only technically feasible control technology for the propane-fired boilers. Therefore, ranking is not required.

Step 4 - Evaluate the Most Effective Controls

GVEA BACT Proposal

GVEA proposed the following as BACT for SO_2 emissions from the propane-fired boilers:

(a) SO_2 emissions from the operation of the propane-fired boilers shall be controlled by using low sulfur fuel at all times of operation.

(b) SO_2 emissions from the propane-fired boilers shall not exceed 0.0012 lb/kgal over a 4-hour averaging period.

Step 5 - Preliminary Selection of SO_2 BACT for the Propane-Fired Boilers

The Department's preliminary finding is that BACT for SO_2 emissions from the propane-fired boilers is as follows:

(a) SO_2 emissions from EUs 11 and 12 shall be controlled by only combusting propane and shall not exceed 120 ppmv, or 0.0012 lb/kgal; and

(b) Compliance with the preliminary emission rate limit will be demonstrated with fuel shipment receipts and/or fuel tests for sulfur content.

6. BACT DETERMINATION SUMMARY

Table 6-1. NOx BACT Limits

EU ID	Description	Capacity	BACT Limit	BACT Control
1	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	0.044 lb/MMBtu	Limited Operation Selective Catalytic Reduction Water Injection Good Combustion Practices
2	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	0.044 lb/MMBtu	
5	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.024 lb/MMBtu	Limited Operation Selective Catalytic Reduction Water Injection Good Combustion Practices
6	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.024 lb/MMBtu	
7	Large Diesel-Fired Engine	619 hp	6.9 g/hp-hr	Turbocharger and Aftercooler Limited Operation Good Combustion Practices
11	Propane-Fired Boiler	5.0 MMBtu/hr	2.6 lb/kgal	Propane as Fuel Low NOx Burners Good Combustion Practices
12	Propane-Fired Boiler	5.0 MMBtu/hr	2.6 lb/kgal	

Table 6-2. PM-2.5 BACT Limits

EU ID	Description	Capacity	BACT Limit	BACT Control
1	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	0.12 lb/MMBtu	Low Ash Fuel Limited Operation Good Combustion Practices
2	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	0.12 lb/MMBtu	
5	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.12 lb/MMBtu	Limited Operation Good Combustion Practices
6	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.12 lb/MMBtu	
7	Large Diesel-Fired Engine	619 hp	0.0022 lb/hp-hr	Limited Operation Good Combustion Practices
11	Propane-Fired Boiler	5.0 MMBtu/hr	0.7 lb/kgal	Propane as Fuel Good Combustion Practices
12	Propane-Fired Boiler	5.0 MMBtu/hr	0.7 lb/kgal	

Table 6-3. SO_2 BACT Limits

EU ID	Description	Capacity	BACT Limit	BACT Control
1	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	15 ppm S in fuel	Limited Operation Ultra-Low Sulfur Diesel Good Combustion Practices
2	Fuel Oil-Fired Simple Cycle Gas Turbine	672 MMBtu/hr	15 ppm S in fuel	
5	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.05 wt% S in fuel	Limited Operation Light Straight Run Turbine Fuel Good Combustion Practices
6	Fuel Oil-Fired Combined Cycle Gas Turbine	455 MMBtu/hr	0.05 wt% S in fuel	
7	Large Diesel-Fired Engine	619 hp	500 ppm S in fuel	Limited Operation Good Combustion Practices
11	Propane-Fired Boiler	5.0 MMBtu/hr	0.0012 lb/kgal	Propane as Fuel Good Combustion Practices
12	Propane-Fired Boiler	5.0 MMBtu/hr	0.0012 lb/kgal	