EXHIBIT 3

to Sierra Club Comments

Burns & McDonnell
SINCE 1898

Report on the

Prevention of Significant Deterioration – Air Construction Permit Application

Lacey Randall Station – TradeWind Energy, Inc.
Source ID 1930036

Project No. 72125

Updated December 2013

Prevention of Significant Deterioration – Air Construction Permit Application

prepared for

Lacey Randall Station – TradeWind Energy, Inc.
Source ID 1930036
Colby, Kansas

Updated December 2013

Project No. 72125

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

1.0 EXECUTIVE SUMMARY

Pursuant to the requirements specified in the Kansas Administrative Regulations (K.A.R) 28-19-350, TradeWind Energy Inc. (TradeWind) submits this Prevention of Significant Deterioration (PSD) construction permit application for the installation of up to ten reciprocating internal combustion engines (RICE) plus auxiliary equipment at the Lacey Randall Station (hereinafter referred to as the Project) to be located in Thomas County, Kansas approximately 3 miles northeast of Colby, Kansas. The Project will have a total nominal power output of approximately 94 megawatts (MW) and the RICE electric generating units (EGUs) will be fired solely by natural gas.

As required by the above-referenced rules, this permit application contains the following analyses/assessments regarding the emission of regulated pollutants associated with the construction and operation of the Project:

- Evaluation of ambient air quality in the area for each regulated pollutant for which the Project will cause a significant increase in net emissions
- Demonstration by air dispersion analysis that emissions from the Project will not cause or contribute to any exceedance of a National Ambient Air Quality Standard (NAAQS)
- Demonstration by air dispersion analysis that emissions from the Project will not exceed the remaining available PSD Class II increment consumption allowances
- Assessment of any adverse impacts on soils, vegetation, visibility, or growth in the area
- A Best Available Control Technology (BACT) analysis for each regulated pollutant for which the potential-to-emit (PTE) for the Project will result in a significant increase in net emissions

PTE from the Project are shown in Table 1-1. Start-up emissions for the engines are also included in Table 1-1. A full description of equipment associated with the Project is provided in Part 2 of the application.

Table 1-1. Project Potential Emissions and PSD Significance Levels

Pollutant[A]	Preliminary Estimated Potential Emissions (Tons per Year [TPY])[B]	PSD Significance Levels (TPY)
NO_x	**141.57**	40
SO_2	2.09	40
CO	**169.78**	100
PM/PM_{10}[C]	**100.59**	25/15
$PM_{2.5}$[C]	**100.59**	10
VOC	**128.69**	40
Lead	6.44E-06	0.6
H_2SO_4 Mist	0.32	7
CO_2e	**409,409**	75,000

[A] NO_x = nitrogen oxides; CO = carbon monoxide; SO_2 = sulfur dioxide;
VOC = volatile organic compounds; PM= total particulate matter;
PM_{10} = particulate matter less than 10 microns in diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; CO_2e = carbon dioxide equivalent (greenhouse gases);
H_2SO_4 Mist = sulfuric acid mist
[B] Numbers in **bold** indicate the PSD significance level is exceeded
[C] Filterable plus condensable

1.1 HAP Emissions

The Project will be a major source of hazardous air pollutants (HAPs) (greater than 25 tons per year of total HAPs and greater than 10 tons per year of any single HAP).[1] Therefore sections of 40 CFR Part 63-National Emission Standards for Hazardous Air Pollutants (NESHAP) will apply to the Project.

1.2 Project NAAQS Impact Analysis

The existing air quality in the Thomas County area is designated as attainment or unclassifiable with regard to the NAAQS for all criteria pollutants. A Project air dispersion modeling analysis was performed for the pollutants subject to PSD review to assess potential impacts on the NAAQS. The modeling was performed in accordance with relevant Kansas Department of Health and Environment (KDHE) and U.S. Environmental Protection Agency (EPA) modeling guidance. The air dispersion modeling protocol and Ozone Limiting Method (OLM) modeling protocol were submitted to both KDHE and EPA Region 7 for their review in April 2013.

The modeling analysis results (included in Part 6 of this application) demonstrate that the Project will not cause or contribute to a violation of any NAAQS. Further, the PSD Class II increment analysis demonstrates that Project impacts are less than the PSD Class II increments established for the area.

[1] All sources of HAPs that are not major sources are categorized as "area" sources.

Recent Federal Land Manager (FLM) guidance advises that a proposed major source, in the course of a PSD application, must perform an assessment of air quality impacts at Class I areas if these areas are located within approximately 300 kilometers of the proposed facility. As there are no Class I areas that are within 300 kilometers of the Project, an assessment of air quality impacts at Class I areas was not performed.

1.3 BACT for Reciprocating Internal Combustion Engines

A "top-down" BACT analysis was performed for each of the pollutants in Table 1-1 in which the PTE was above the associated PSD significance level: NO_x, CO, VOC, $PM/PM_{10}/PM_{2.5}$, and CO_2e (greenhouse gases).

Pre-combustion and controlled combustion systems coupled with state-of-the-art pollution control equipment and consistently achievable emission limitations has been selected as BACT for this Project. Emissions of NO_x from the RICE will be limited by lean burn combustion and further reduced and controlled by selective catalytic reduction (SCR) systems. Emissions of CO and VOC will be limited by good combustion practices and further reduced by oxidation catalysts (also referenced as a CO catalyst). Use of clean fuels and good combustion practices will control emissions of $PM/PM_{10}/PM_{2.5}$. Greenhouse gas emissions will be limited by the use of efficient lean-burn engines, and by use of natural gas as a fuel.

Table 1-2 displays the BACT results.

Table 1-2. Summary of BACT Results: RICE

Pollutant	Systems and Controls	BACT Emission Limitation (lb/hr)[A]	Equivalent Emissions[B] (g/bhp-hr)	Averaging Period
NO_x	Selective catalytic reduction (SCR) system	1.45	0.0525	30-day
CO	Good combustion practices, oxidation catalyst	2.67	0.0967	30-day
VOC	Good combustion practices, oxidation catalyst	2.67	0.0967	30-day
$PM/PM_{10}/PM_{2.5}$	Combustion controls and low ash fuels	2.22	NA	3-hr
CO_2e	Use of efficient lean-burn engines, use of natural gas as a fuel	9,329.27	337.81	Annual

[A] Engine emission rate while operating at loads of 50 percent and greater under steady state conditions unless otherwise noted.

[B] Equivalent emissions in gram per brake horsepower hour (g/bhp-hr) for loads of 50% and higher are shown for comparison to the RACT/BACT/LAER Clearinghouse (RBLC) emission rates purposes only. These are not proposed as BACT emission limitations.

[C] Due to the testing methods and sources of PM in the emission exhaust, PM is only expressed in lb/hr and it is not appropriate to determine an equivalent g/bhp-hr. In addition, the RBLC limits are primarily expressed in lb/hr.

1.4 BACT Analysis for Auxiliary Equipment

The auxiliary equipment to be installed at the Project consists of a gas heater (using natural gas for fuel), an emergency diesel fire pump, an emergency diesel generator, and a fuel oil storage tank. A BACT analysis was performed for the pollutants in Table 1-1 that are emitted in total Project quantities above the PSD significance levels for the each of the auxiliary equipment. The following controls and operational practices have been established as applicable BACT requirements for the auxiliary equipment as shown in Table 1-3.

Table 1-3. Summary of BACT Results: Auxiliary Equipment

Pollutant	Emissions Unit	Limiting Systems and Controls	BACT Emission Limitation	
NO_x	Gas Heater	Low NO_x Burners and Combustion Control	100	lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	0.007	gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.00	gm/hp-hr
CO	Gas Heater	Good Combustion Practices	84	lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	2.61	gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.70	gm/hp-hr
VOC	Gas Heater	Good Combustion Practices	5.5	lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	0.007	gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.00	gm/hp-hr
	Fuel Oil Storage Tank	Submerged Fill Pipe	0.156	tpy
$PM/PM_{10}/PM_{2.5}$	Gas Heater	Combustion Control	7.6	lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	3.29E-04	gm/hp-hr
	Emergency Fire Pump	Combustion Controls and Low Ash Fuels	2.20E-01	gm/hp-hr
CO_2e	Gas Heater	Use of Clean Fuels, Maintaining and Tuning the Heater, Recordkeeping	117.00	lb/MMBtu
	Emergency Diesel-fired Generator	Combustion Control	164	lb/MMBtu
	Emergency Fire Pump	Selection of the Most Efficient Engines that Meet the Applicant's Project Needs	164	lb/MMBtu
	Circuit Breakers	Enclosed-Pressure SF_6 Circuit Breakers	<0.5%	leakage

[A] g/hp-hr = gram per horsepower hour

1.5 Additional Impacts Analysis

The potential impacts of the Project on visibility, soils, vegetation, and growth are discussed in Section 8.0of this application. As shown by the analysis, the addition of the Project will not have a significant impact on visibility, soils, growth, or vegetation in the surrounding area.

6.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

Per K.A.R. 28-19-350, an owner of a facility applying for a PSD construction permit must perform a Best Available Control Technology (BACT) analysis for each regulated NSR pollutant for which there would be a significant net emissions increase at the stationary source. This requirement applies to any proposed emissions unit at which a net emissions increase in the air pollutant would occur as a result of a physical change or change in the method of operation in the emissions unit.

As can be seen in Table 2-1., the Project is subject to PSD review for CO, NO_x, $PM/PM_{10}/PM_{2.5}$, VOC, and CO_2e (greenhouse gases).

Therefore, a BACT analysis was performed for each of these pollutants. A summary of the selected control technologies and the associated BACT emission limitations for the RICE is presented in Table 6-1.

Table 6-1. Summary of BACT Results: RICE

Pollutant	Control Technology	BACT Emission Limitation (lb/hr)[A]	Equivalent Emissions[B] (g/bhp-hr)	Averaging Time
NO_x	Selective Catalytic Reduction (SCR) System	1.45	0.053	30-day
CO	Good Combustion Practices, Oxidation Catalyst	2.67	0.10	30-day
VOC	Good Combustion Practices, Oxidation Catalyst	2.67	0.10	30-day
$PM_{10}/PM/PM_{2.5}$	Combustion Controls and Low Ash Fuels	2.22	NA	3-hr
CO_2e	Use of Efficient Lean-Burn Engines, Use of Natural Gas, and Maintain Efficiency of Engines Through Maintenance Procedures	9,329	338	Annual

[A] Maximum engine emission rate under steady state conditions unless otherwise noted.
[B] Equivalent emissions in gram per brake horsepower hour (g/bhp-hr) for loads of 50% and higher are shown for comparison to the RBLC emission rates purposes only. These are not proposed as BACT emission limitations.
[C] Due to the testing methods and sources of PM in the emission exhaust, PM is only expressed in lb/hr and it is not appropriate to determine an equivalent g/bhp-hr. In addition, the RBLC emission limitations are primarily expressed in lb/hr.

Table 6-2 displays the BACT results for the auxiliary equipment (gas heater, emergency fire pump and emergency diesel-fired generator).

Table 6-2. Summary of BACT Results: Auxiliary Equipment

Pollutant	Emissions Unit	Limiting Systems and Controls	BACT Emission Limitation
NO_x	Gas Heater	Low NO_x Burners and Combustion Control	100 lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	0.007 gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.00 gm/hp-hr
CO	Gas Heater	Good Combustion Practices	84 lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	2.61 gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.70 gm/hp-hr
VOC	Gas Heater	Good Combustion Practices	5.5 lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	0.007 gm/hp-hr
	Emergency Fire Pump	Combustion Control	3.00 gm/hp-hr
	Fuel Oil Storage Tank	Submerged Fill Pipe	0.156 tpy
$PM/PM_{10}/PM_{2.5}$	Gas Heater	Combustion Control	7.6 lb/MMcf
	Emergency Diesel-fired Generator	Combustion Control	3.29E-04 gm/hp-hr
	Emergency Fire Pump	Combustion Controls and Low Ash Fuels	2.20E-01 gm/hp-hr
CO_2e	Gas Heater	Use of Clean Fuels, Maintaining and Tuning the Heater, Recordkeeping	117.00 lb/MMBtu
	Emergency Diesel-fired Generator	Combustion Control	164 lb/MMBtu
	Emergency Fire Pump	Selection of the Most Efficient Engines that Meet the Applicant's Project Needs	164 lb/MMBtu
	Circuit Breakers	Enclosed-Pressure SF_6 Circuit Breakers	<0.5% leakage

6.1 PSD BACT Process

6.1.1 The "Top-Down" Process

As part of the permitting process, a major stationary source needs to prepare a BACT analysis in conjunction with a PSD permit application. While there is no legal requirement to perform the BACT analysis utilizing a specific criteria or process, EPA has developed guidance that establishes a five-step "top down" BACT process/methodology.[8]

For purposes of this application, TradeWind has conducted its BACT analysis consistent with EPA's top down approach, which consists of the following steps for each pollutant to be emitted from each source:

Step 1 – Identify all potential control technologies
Step 2 – Determine technical feasibility (of potential technologies)
Step 3 – Rank control technologies by control effectiveness
Step 4 – Evaluate most effective controls and document results
Step 5 – Select BACT

Each of these steps is discussed in further detail below.

Step 1 – Identify all potential control technologies. The first step in a "top-down" analysis is to identify, for all applicable emission units, all "available" control options. Available control options are defined as those air pollution control technologies or techniques that have a practical potential for application to the emissions unit and the regulated pollutant under evaluation and have been demonstrated in practice.

Step 2 – Determine technical feasibility (of potential options). In the second step, the technical feasibility of each control option identified in Step 1 is evaluated with respect to the source-specific factors. A demonstration of technical infeasibility should be documented and should show, based on physical, chemical, and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review. Technically infeasible control options are then eliminated from further consideration in the BACT analysis.

Step 3 – Rank control technologies by control effectiveness. All remaining control alternatives not eliminated in Step 2 are ranked and then listed in order of overall control effectiveness for the pollutant

[8] U.S. Environmental Protection Agency. New Source Review Workshop Manual – Draft. North Carolina: Office of Air Quality Planning and Standards, 1990.

under review, with the most effective control alternative at the top. A list should be prepared for each pollutant and for each emissions unit (or grouping of similar units) subject to a BACT analysis.

Step 4 – Evaluate most effective controls and document results. After the identification of available and technically feasible control technology options, the energy, environmental, and economic impacts of each such option are taken into account and the technology for control of emissions of the pollutant is selected at Step 4. Section 6.1.2 describes the economic analyses used in this BACT analysis.

Step 5 – Select BACT. The BACT emission limitation determination is made at Step 5.

6.1.2 General Principles

The BACT analysis for the Project is also based on the following concepts:

- There is no single prescriptive approach to determining the appropriate control technology and emission limitation for a given project
- BACT does not redefine the facility as proposed (including fuels)
- The control technology must be available and feasible for this specific project
- Emission limitations are defined on a "case-by-case" analysis that considers site specific factors
- Emission limitations must be "achievable" on a long-term, day in and day out, basis

There is no prescriptive approach to performing a case-by-case control technology and emission limitation analysis. PSD permitting authorities determine emission limitations on a case-by-case basis. These case-by-case determinations must take into account source-specific and site-specific characteristics. This is not a "cookie-cutter" approach, and there is no single right answer to determining either the appropriate control technology or the appropriate emission limitation for a specific source or for a specific pollutant.

KDHE is not required to set any emission limitation at the most stringent emission limitation that has been demonstrated by a facility using similar emissions control technology. Similarly, an emission limitation does not need to be set at the most stringent emission limitation found in another permit. Rather, KDHE has the authority and the ability to evaluate and determine the proper control technologies and emissions limitations for a particular project based on project-specific factors, including location. The BACT process does not require that each determination establish an emission limitation that is equal to or more stringent than the most stringent previous determination.

Further, in establishing emission limitations, KDHE must confirm that those limitations are achievable by the specific facility that is subject to them: (1) over the life of the facility; and (2) during all operating conditions, not just ideal conditions. The use of a safety factor or margin is well-established in the air permitting context to appropriately account for the uncertainty and operational variability that will occur over the life of a facility. This safety factor must be sufficient to allow a permit holder to comply on a continuous basis. Emission limitations are not required to be based on the lowest emissions rate or highest control efficiency ever documented by a similar facility for a short-term period. The emission limitations must account for a full range of operating conditions and the inherent variability of complex fuel combustion and air pollution control systems.

In order to be considered in the BACT process, a control technology must be commercially available (*i.e.*, it must be offered for sale at commercial scale through commercial channels). Permit applicants are not required to explore Research &Development (R&D) projects to determine whether or not a particular technology is potentially feasible. In addition, in order to be considered feasible technology for purposes of inclusion in an analysis, a particular technology must have been previously demonstrated, on a long-term basis, at commercial scale.

In its March 2011 guidance, EPA affirmed that a BACT review for a project should not operate to redefine the project. "EPA has recognized that a Step 1 list of options need not necessarily include inherently lower polluting processes that would fundamentally redefine the nature of the source proposed by the permit applicant. BACT should generally not be applied to regulate the applicant's purpose or objective for the proposed facility." The March 2011 guidance continues, "The 'redefining the source' issue is ultimately a question of degree that is within the discretion of the permitting authority." Similarly, EPA's March 2011 "Guidance for Determining Best Available Control Technology for Reducing Carbon Dioxide Emissions from Bioenergy Production" states, "However, while Step 1 is intended to capture a broad array of potential options for pollution control, this step of the process is not without limits. EPA has recognized that a Step 1 list of options need not necessarily include inherently lower polluting processes that would fundamentally redefine the nature of the source proposed by the permit applicant. BACT should generally not be applied to regulate the applicant's purpose or objective for the proposed facility."

6.1.3 Economic Analyses

This section contains information regarding the economic analyses and how they were performed in Step 4 for each piece of equipment. Economic analyses were performed for add-on controls for auxiliary equipment and these tables are located in Appendix E.

For the controls that require an economic analysis, capital costs include the initial cost of components intrinsic to the complete control system. For both oxidation catalyst and SCR systems, these capital costs would include the catalyst modules, transition piece, support frame, piping, provisions for catalyst cleaning and removal, instrumentation, and installation costs. Additionally, the SCR system requires the installation of an ammonia injection system. Annual costs consist of the financial efficiency losses, parasitic loads, and revenue loss from operation of the control system; overhead, maintenance, labor, raw materials and utilities are included.

Capital and operating costs have been estimated in accordance with EPA guidance. The capital cost estimating technique used in this analysis is based on a factored method of determining direct and indirect installation costs. This technique is a modified version of the "Lang Method," where installation costs are expressed as a function of known equipment costs. This method is consistent with the latest EPA guidance manual [Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual] on estimating control technology costs (EPA 2002).

Purchased equipment costs represent the delivered cost of the control equipment, auxiliary equipment, and instrumentation. Auxiliary equipment consists of all structural, mechanical, and electrical components required for continuous operation of the device. Depending on the control strategy that is used, these costs may include such items as reagent storage tanks, supply piping, the engine outlet transition piece, a catalyst removal crane, spare parts, and the catalyst and air dilution system. In this BACT evaluation, basic equipment costs were obtained from data provided by vendors and from recent projects with similar units. Instrumentation is usually not included in the basic equipment cost, so the OAQPS manual allows that instrumentation may be estimated to be 10 percent of the basic equipment cost.

Direct installation costs consist of the direct expenditures for materials and labor including site preparation, foundations, structural steel, insulation, erection, piping, electrical, painting, and enclosure structures. Indirect installation costs include engineering and supervision of contractors, construction and field expenses, construction fees, contingencies, and additional permits and licensing costs.

Direct installation costs are expressed as a function of the purchased equipment cost and are based on the average installation requirements of typical systems. Indirect installation costs are designated as a percentage of the total direct cost (purchased equipment cost plus the direct installation cost) of the system. Other indirect costs include equipment start-up and performance testing, contingency funds, working capital and interest during construction.

Annualized costs are comprised of direct and indirect operation costs. Direct costs include electricity losses, labor, maintenance, replacement parts, raw materials, and utilities. Indirect operating costs include overhead, taxes, insurance, general administration, contingencies, and capital charges. Annualized cost factors used to estimate total annualized costs for the SCR and oxidation catalyst systems are presented in their respective discussions in the sections that follow. These tables are consistent with the EPA guidance on estimating control technology costs (EPA 2002).

Direct operating labor costs vary according to the system operating mode and operating time. Labor supervision is estimated as 15 percent of operating labor. Maintenance costs have been included and are itemized as appropriate. Replacement part costs, such as the cost to replace an aged or failed catalyst, have been included where appropriate. Reagent and utility costs are based upon estimated annual consumption. Based on the experience of other facilities, catalyst is assumed to require replacement at a minimum of every three years due to failure or aging.

Most indirect operating costs are calculated as a percentage of the total capital cost. The indirect capital costs are based on the capital recovery factor (CRF), defined as:

$$CRF = \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

Where:

i = interest rate

n = equipment economic life (years)

A control system's economic life is typically 10 to 20 years. In this analysis, a 20-year equipment economic life (typical length of financing) was used. The average interest rate is assumed to be seven percent. The CRF is calculated to be 0.094.

The cost-effectiveness for each system is calculated by dividing the annualized cost of the available control technology by the annual emissions reduction. The annual emissions reduction is the difference between the baseline emission rate and the controlled emission. All BACT capital and annual cost tables are contained in Appendix E.

6.1.4 GHG BACT Process

Based on EPA GHG Guidance,[9] the GHG greenhouse gases BACT process is similar to the PSD BACT process summarized above. Potential control strategies are identified at Step 1 and technologically infeasible options are then eliminated at Step 2. The remaining technically feasible control technologies are ranked at Step 3. The most effective control technologies from an environmental, energy, and economic perspective are evaluated and the most appropriate control technology is selected at Step 4. Finally, the BACT emission limitation is made at Step 5. The general principles of PSD BACT analysis discussed above are equally applied to the GHG BACT process.

6.2 BACT Technology and Emission Limitations for Similar Units

The first step in the "top-down" BACT process is the identification of potentially available control technologies. A good source of information on such technologies is EPA's RACT/BACT/LAER Clearinghouse (RBLC) database maintained on EPA's Technology Transfer Network website at www.epa.gov/ttn/catc. This database includes recent BACT determinations for similar projects.

Advanced queries of the database were conducted to identify control technology determinations from January 2003 to April 2013 for sources similar to the RICE to be used for the Project. Queries were also made for the Project's auxiliary equipment for the same time period. The results of the RBLC queries can be found in Appendix D in Tables D1 to D7.

To identify previous control technology determinations for comparable sources, two types of queries were run for each set of operational modes. The first query was a "basic search" in which the RBLC database was searched for:

- Internal Combustion Engines (>500 hp), 17.130 – Natural gas combustion

In addition to the RBLC database search, other known RICE electric generating units (EGU) projects that are known by TradeWind and permitted (but filed under a different category in the RBLC) were located within the RBLC and included in the tables as well. All known projects that used natural gas engines of similar engine size (4-10 MW) and were subject to PSD review were included in the RBLC search. To the extent practicable, clearly non-applicable projects were removed from the RBLC tables presented in this application. For example, the following process types are incorrectly used in the RBLC to identify internal combustion engine projects; therefore, these categories were also examined:

[9] PSD and Title V Permitting Guidance for Greenhouse Gases, U.S. EPA, Office of Air Quality Planning and Standards, March 2011.

- Boilers (>250 MMBtu/hr), 11.310 - Natural gas combustion
- Combined Cycle Combustion Turbines (<25 MW), 15.210 - Natural gas combustion

Additionally, the most recent and relevant permit for comparison to this application is Mid-Kansas Electric, LLC's Rubart Station PSD air permit issued by KDHE in January 2013. Although Rubart Station proposed to use Caterpillar engines instead of Wärtsilä, the projects are very similar and Rubart Station BACT limits have been included in this BACT analysis.

Permitted BACT emission rates for other internal combustion engines have been compared to the RICE to be used in the Project. The best comparison is made to other turbo-charged, four-stroke, lean-burn machines (turbo charged, as opposed to naturally aspirated). However, differences in size (MW) and speed (rpm) of some other permitted engines makes such units dissimilar to the Project RICE. EPA's RBLC provides insufficient data to determine if other permitted machines are indeed turbo-charged, four-stroke, lean-burn engines. Most of the RBLC-listed machines are slow speed, gas-compression machines or higher speed, non-turbo machines. These differences must be taken into account when comparing the RICE to be used in this Project to other previously-permitted engines. Of the vendors and engines that are commercially available, Wärtsilä, Jenbacher, and Caterpillar manufacture and sell natural gas-fired reciprocating engines that are appropriate for this Project. However, only Wärtsilä has permitted and *operated* units of this size that are natural-gas fired. Permits for projects that include similar-sized Wärtsilä RICE and the Rubart CAT RICE have been collected by TradeWind. The Wärtsilä permitted emission rates are listed in Table 6-3, below. These projects represent the most applicable technology that is similar to this Project.

Table 6-3. Emission Rates for Engines Similar to Project Engines at Full Load (g/bhp-hr)

Plant	State	NO_x[A]	CO[A]	VOC[A]	PM_{10} total[A]
Western 102	Nevada	0.054	0.087	0.087	0.094
Plains End 2	Colorado	0.059	4.000	1.000	0.102
Goodman	Kansas	0.097	0.097	0.097	--
Humboldt	California	0.064	0.086	0.106	0.075
Pearsall	Texas	0.087	0.308	0.308	0.181
Antelope	Texas	0.052	0.096	0.157	0.075
Lea County	New Mexico	0.054	0.104	0.104	0.080
Woodland 3	California	0.053	0.084	0.074	0.052
Hutchinson	Minnesota	0.030	0.746	0.299	0.082
Quail Brush	California	0.048	0.057	0.057	0.050
Greenville Electric	Texas	0.086	0.308	0.308	0.181
Mid-Kansas Rubart Station (Caterpillar)	Kansas	0.07	0.13	0.20	0.044

[A] The values are originally given in different units and here converted to similar units for comparison purposes (rounded to integral values). Also, many of these plants were not subject to PSD review. All units have CO catalysts and SCR, except for Hutchinson which does not have a CO catalyst. Note that emissions levels vary based on engine size, type and location.

6.3 New Source Performance Standards

6.3.1 Subpart JJJJ

Subpart JJJJ—Standards of Performance for Stationary Spark Ignition Internal Combustion Engines became effective March 18, 2008.[10] The RICE engines are subject to the NSPS Subpart JJJJ limits for non-emergency spark ignited (SI) natural gas engines greater than 500 HP manufactured after July 1, 2010. The applicable emission limitations are listed in Section 5.2.

All BACT emission limitations for the Project are more stringent than the applicable NSPS.

6.4 BACT For Nitrogen Oxides (NO_x) – RICE

6.4.1 STEP 1. Identify All Potential Control Technologies

NO_x is primarily formed in combustion processes in three ways: 1) the combination of elemental nitrogen with oxygen in the combustion air within the high temperature environment of the combustor (thermal

[10] "Standards of Performance for Stationary Spark Ignition Internal Combustion Engines," Title 40 Code of Federal Regulations, Part 60, Subpart JJJJ. 2011 ed.

NO_x); 2) reactions of nitrogen with hydrocarbon radicals from the fuel (prompt NO_x); and 3) the oxidation of nitrogen contained in the fuel (fuel NO_x). Natural gas contains negligible amounts of fuel-bound nitrogen, although some molecular nitrogen is present. Therefore, it is assumed that essentially all NO_x emissions from the engines originate as thermal NO_x. The rate of formation of thermal NO_x is a function of residence time and free oxygen and is exponential with peak flame temperature. NO_x control techniques are aimed at controlling one or more of these variables during combustion. Controlling the air-to-fuel ratio can reduce the amount of NO_x [11]

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

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

6.4.2 STEP 2. Identify Technically Feasible Control Technologies

6.4.2.1 Non-Selective Catalytic Reduction (NSCR)

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

The NSCR technique is effectively limited to engines with normal exhaust oxygen levels of 4 percent or less. This includes four-stroke rich-burn naturally-aspirated engines and some four-stroke rich- burn turbo-charged engines. Engines operating with NSCR require tight air-to-fuel control to maintain high reduction effectiveness without high hydrocarbon emissions. To achieve effective NO_x reduction

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

performance, the engine may need to be run with a richer fuel adjustment than normal. This exhaust excess oxygen level is usually closer to 1 percent.

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

6.4.2.2 Selective Catalytic Reduction (SCR)

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

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

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

6.4.2.3 Lean-Burn Combustion

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

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

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

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

6.4.2.4 Summary of the Technically Feasible Control Options

The technical feasibility of the NO_x control options for the engines is summarized in Table 6-4. The expected performance (steady state) has been determined considering the vendor guarantees.

Table 6-4. Summary of Technically Feasible NO_x Control Technologies for the RICE

Control System		Expected Performance (lb/hr)	Technical Feasibility	Comments
Combustion Controls	Lean-burn Combustion	34.70	Feasible	Standard on the Project's RICE
Post Combustion Controls	Non-Selective Catalytic Reduction	N/A	Not Feasible	Only used on rich-burn engines
	Selective Catalytic Reduction	1.45	Feasible	SCR is part of standard package for the Project's RICE

6.4.3 STEP 3. Rank the Technically Feasible Control Technologies

Add-on controls are a technically feasible option on the Project's RICE. The RICE will come as lean-burn engines and include SCR as part of the standard packages. Although the SCR is included with the RICE engines, it is an add-on control. Therefore, lean-burn combustion will be considered as baseline.

The technically feasible NO_x control technologies for the RICE are ranked by control effectiveness in Table 6-5.

Table 6-5: Ranking of Technically Feasible NO_x Control Technologies for the RICE

Control Technology	Reduction (%)	Controlled Emission Level (lb/hr)
Lean-burn combustion/ with SCR	96	1.45
Lean-burn combustion	Baseline	34.70

6.4.4 STEP 4. Evaluate the Most Effective Controls

6.4.4.1 Environmental, Energy, and Economic Feasibility of Control Options

The next step in the top-down BACT analysis is to review each of the technically feasible control options for environmental, energy, and economic impacts. First, all technically feasible controls will be discussed for environmental and energy impacts. Next, if the top control is not chosen, an economic analysis to determine capital and annual control costs in terms of cost-effectiveness (i.e., dollars per ton of pollutant removed) of each control system will be conducted. Because TradeWind has selected the top control, the following information is presented for informational purposes only.

6.4.4.2 Selective Catalytic Reduction (SCR)

Energy Impacts

As with all add-on controls, operation of an SCR system results in a loss of energy due to the pressure drop across the SCR catalyst. To compensate for the energy loss in the SCR system, additional natural gas combustion is required to maintain the net energy output, which also results in additional air pollutant emissions. However, the extra fuel required for the controls does not outweigh the benefit of reducing emissions of NOx.

Environmental Impacts

Urea, which is decomposed in an external reactor to form ammonia, will be used in the SCR. The SCR system consists of an ammonia injection system and a catalytic reactor. Unreacted ammonia may escape through to the exhaust gas. This is commonly called "ammonia slip." It is estimated that ammonia slip from an SCR on this size of engine could be 10 ppm; this may be considered to be an environmental impact. The ammonia that is released may also react with other pollutants in the exhaust stream to create fine PM_{10} in the form of ammonium salts. SCR catalysts must also be replaced on a routine basis. In some cases, these catalysts may be classified as hazardous waste. This typically requires either returning the material to the manufacturer for recycle and reuse or disposal in permitted landfills. None of this outweighs the benefit of reducing emissions of NO_x because of the environmental and health benefits of reducing NO_x emissions.

Economic Impacts

Engine manufacturers currently install SCRs as standard equipment on the RICE that combust natural gas for power generation in the United States. As SCR is the top control technology listed and because SCR is standard equipment on the engines being considered, there is no need to calculate an annualized cost of the control for the purposes of this analysis.

6.4.4.3 Lean-Burn Combustion

Energy Impacts

Lean-burn combustion and clean-burn technology are usually accompanied by an efficiency penalty (typically 2 to 3 percent) and an increase in power output (typically 5 to 6 percent). The increase in power output results from the increase in mass flow required to maintain engine inlet temperature at manufacturer's specifications. Because there is a power increase, no energy impacts are associated with lean-burn combustion and clean-burn technology.

Environmental Impacts

Lean-burn combustion may increase CO and VOC emissions. However, this increase does not outweigh the advantage of decreased NO_x emissions because NO_x emissions are considered to be more detrimental to the environment and human health.[13]

Economic Impacts

The RICE vendors under consideration currently install lean-burn combustion with clean-burn technology as standard on the engines. Because lean-burn combustion is standard equipment on the engines, there is no calculated annualized cost of the control for the economic impacts evaluation.

The maximum technically feasible control applied to RICE is SCR with lean-burn combustion. Because this is the highest level of add-on control for engines of this size, BACT for control of NO_x emissions from the RICE is lean-burn combustion with clean-burn technology with SCR.

6.4.5 STEP 5. NO_x BACT Emission Limitation

BACT determinations shown in the RBLC (Table D-1) for engines that are in the 4.5- to 9.3-MW size range located in attainment areas were in the range of 0.07 gram per brake horsepower-hour (g/bhp-hr) to 20.2 g/bhp-hr using either lean-burn combustion (or clean burn technology) or SCR for natural gas-fired engines.

The BACT emission limitation for NO_x is 1.45 lb/hr for steady state loads of 50 percent and higher, based on vendor guarantees. This rate is equivalent to 0.053 g/hp-hr for loads of 50 percent and higher. This represents the lowest emission rates that can be achieved for these types of natural gas RICE EGUs.

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

6.5 BACT FOR Carbon Monoxide (CO) – RICE

6.5.1 STEP 1. Identify Potential Control Strategies

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

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

The technologies identified for reducing CO emissions from the engines are an oxidation catalyst (also referred to as a CO catalyst) and combustion controls. The standard technology for reducing CO emissions is to maintain "good combustion" through proper control and monitoring of the combustion process through the air-to-fuel ratio. A survey of the RBLC database (Table D-2) indicates that combustion controls is the most prevalent BACT control, with several oxidation catalysts listed as BACT.

6.5.2 STEP 2. Identify Technically Feasible Control Technologies

6.5.2.1 Oxidation Catalyst

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

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

6.5.2.2 Combustion Control

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

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

6.5.2.3 Summary of the Technically Feasible Control Options

The technical feasibility of the CO control options for the RICE being considered are summarized in Table 6-6. The expected performance has been determined considering the performance of existing systems, vendor guarantees, permitted emission limitations, and the design requirements for the engines.

Table 6-6. Summary of Technically Feasible CO Control Technologies for the RICE

Control System		Expected Performance (lb/hr)	Feasibility	Comments
Combustion Control		46.36	Feasible	Standard on the RICE. Not an add-on control.
Post Combustion Controls	Oxidation Catalyst	2.67	Feasible	Produces CO_2 emissions. Standard on the RICE.

6.5.3 STEP 3. Rank the Technically Feasible Control Technologies

The technically feasible CO control technologies for the RICE are ranked by control effectiveness in Table 6-7.

Table 6-7. Ranking of Technically Feasible CO Control Technologies for the RICE

Control Technology	Reduction (%)	Controlled Emission Level (lb/hr)
Oxidation Catalyst	94	2.67
Combustion Control	Not applicable (baseline)	46.36

6.5.4 STEP 4. Evaluate the Most Effective Control Technologies

6.5.4.1 Environmental, Energy, and Economic Feasibility of Control Options

Because TradeWind has selected the top control, the following information is presented for informational purposes only.