DUFFIELD ASSOCIATES

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October 2, 2013

Mr. Ali Mirzaklhalili, Director
State of Delaware
Department of Natural Resources
and Environmental Control
Division of Air Quality
655 South Bay Road, Suite 5N
Dover, DE 19901

Re: Project No. 8718.CI (Duffield Associates)
Wolf 1 CHP
550 South College Avenue
Newark, New Castle County, Delaware

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Dear Mr. Mirzaklhalili:

Duffield Associates, Inc. (Duffield Associates) respectfully submits this Air Quality Construction Permit Application package for the Combined Heat and Power Plant (CHP) that will be an integral component of the Wolf Technology Center 1 (Wolf 1) proposed for construction on the University of Delaware's Science, Technology and Advanced Research Campus (STAR Campus) in Newark, New Castle County, Delaware. This permit application package has been prepared in accordance with the State of Delaware, Department of Natural Resources and Environmental Control's (DNREC) Regulations Governing the Control of Air Pollution. The applicant is The Data Centers, LLC (TDC), who will own and operate the CHP and attached data centers.

The CHP will be a state-of-the-art, energy efficient, source of uninterruptable power for the associated data center, which is the other significant component of Wolf 1. The CHP design incorporates primary cogeneration of electricity and steam with combined-cycle generation of electricity, utilizing General Electric LM2500 DLE gas combustion turbines and Wartsila 18V50SG reciprocating gas engines as primary combustion equipment. The plant is forecast to achieve an average annual energy efficiency of approximately 60%, in contrast to energy efficiencies of approximately 40% commonly achieved for combined-cycle power plants or to approximately 33% commonly achieved by simple cycle power plants. The CHP will operate solely using natural gas as a fuel source, and the facility will be equipped with advanced-combustion and post-combustion control technologies to control emissions to the atmosphere.

Duffield Associates' analysis concludes that CHP will utilize Best Available Control Technology (BACT) for pollutants regulated under the Delaware Minor New Source Review program. Lowest Achievable Emission Rate (LAER) control technology will be implemented for nitrogen oxides (NO_x) and volatile organic compounds (VOC) emissions, as required under the applicable Nonattainment New Source Review Rules. The results of Duffield Associates' analysis demonstrate that construction and operation of the proposed well-controlled CHP facility will not impact Delaware's air resources adversely.

Cumulative emissions air dispersion modeling included in this application package are based on annual emissions reported for major sources of NO_x and PM_{10} located within 10 kilometers (km) of the CHP, as provided by DNREC. DNREC has requested that cumulative modeling also be performed using permitted annual emissions for those facilities. The applicant will provide cumulative modeling results based on permitted emissions, following Duffield Associates' receipt of those values from DNREC.

Although not addressed in this permit application, TDC plans to design and construct a carbon dioxide (CO_2) capture system to reduce carbon dioxide emissions from the facility. However, at the present time, the design and capture efficiency has not been fully evaluated. As such, we anticipate submitting a separate future application package for the CO_2 capture system in the future.

In addition to the Construction Permit Application, enclosed are two checks made payable to DNREC in the amounts of $_____.00 and $495.00. These checks represent DNREC's Construction Permit and Advertisement Fees, in accordance with the Construction Fee Schedule and Fee Calculator Program, a copy of which is also provided in the Application.

Should DNREC have any questions regarding this Construction Permit Application, please contact M. Richard Beringer, P.E. of Duffield Associates at (302) 239-6634 or via electronic mail at rberinger@duffnet.com.

Thank you in advance for the Department's timely administrative completeness and technical reviews of this Application.

Very truly yours,

DUFFIELD ASSOCIATES, INC.

Michael F. Panhuise, P.E.
Environmental Engineer

M. Richard Beringer, P.E., LEED AP
Senior Environmental Consultant

AJM/MFP/MRB:bac
WORD\8718CI.0913-PSD-ConstructionPermitApplication.RPT

Enclosure: Construction Permit Application Package for Wolf Technology Center 1
Checks

cc: Mr. Michael Bednar – The Data Centers, LLC
Mr. Matthew Rendon – DNREC DAQ (electronic)
Mr. Mohammed Majeed – DNREC DAQ (electronic)
Ms. Tammy Henry – DNREC DAQ (electronic)

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NONATTAINMENT NEW SOURCE REVIEW, MINOR NEW SOURCE REVIEW AND PREVENTION OF SIGNIFICANT DETERIORATION REVIEW AIR QUALITY CONSTRUCTION PERMIT APPLICATION COMBINED HEAT AND POWER PLANT FOR THE WOLF TECHNOLOGY CENTER 1

SCIENCE, TECHNOLOGY, AND ADVANCED RESEARCH CAMPUS NEWARK, DELAWARE

October 2013

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Prepared for:

State of Delaware
Department of Natural Resources
and Environmental Control
Division of Air Quality
655 South Bay Road, Suite 5N
Dover, Delaware 19901

On behalf of:

The Data Centers, LLC
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West Chester, Pennsylvania 19380

Prepared by:

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Project No. 8718.CI

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EXECUTIVE SUMMARY

This report presents the Nonattainment New Source Review, Minor New Source Review and Prevention of Significant Deterioration (PSD) assessment of air quality for the Combined Heat and Power Plant (CHP) that is an integral component of the proposed Wolf Technology Center 1 (Wolf 1) to be located within the University of Delaware's Science, Technology, and Advanced Research Campus (STAR Campus) in Newark, New Castle County, Delaware. The report is part of a construction permit application package for the Wolf 1 CHP equipment that will generate air emissions and the associated air pollution control equipment.

The CHP will be a natural gas-fired facility that will produce electricity using combined-cycle generation and produce thermal energy to support the data center (data storage facility), which is the other significant component of Wolf 1. Steam will be generated from heat produced in gas turbines and reciprocating engines using heat recovery steam generators (co-generation). This recovered energy source will power condensing steam turbines in combined-cycle that will: 1) drive electricity generators; 2) drive a chiller that will provide conditioned air to the data center; and 3) support absorption chillers that condition inlet air to the gas turbines when ambient air temperatures would otherwise reduce the efficiency of turbine combustion.

The CHP must operate in a manner that provides uninterruptable energy to the data center in the form of conditioned air and electricity, which means that multiple power producing units in the CHP must be operating at all times, in case one or two units must be shut down. The proposed combination of varied electrical generating units and the generating capacity of the CHP will ensure that uninterruptable power is provided to the data center. This fundamental requirement results in electricity and steam production in excess of the data center demand. To efficiently use the excess electricity and steam, The Data Centers, LLC (TDC) plans to provide electricity to the City of Newark (through the Delaware Municipal Electric Corporation (DEMEC)) and steam to the University of Delaware under the terms of power purchase agreements.

The proposed Wolf 1 CHP will be classified as a major stationary source subject to Nonattainment New Source Review requirements for nitrogen oxides (NO_x) and volatile organic compounds (VOCs). The project site is located within the Philadelphia-Wilmington-Atlantic City (PA-NJ-MD-DE) area for ozone. Currently, this area is designated by the State of Delaware as marginal attainment for 8-hour ozone, but maintains legacy "severe" non-attainment ozone area status from a Federal (and permitting) perspective. While the project site is also located in the Philadelphia–Wilmington (PA-NJ-DE) non-attainment area for particulate matter smaller than 2.5 micrometers in size ($PM_{2.5}$), the facility will be a minor source of $PM_{2.5}$ and is subject to the State of Delaware Minor New Source Review. The facility will also be a minor source of carbon monoxide (CO), sulfur dioxide (SO_2), and hazardous air pollutants (HAPs) and these emissions are subject to State of Delaware Minor New Source Review. Emissions of greenhouse gases (GHG), sulfuric acid (H_2SO_4) mist and particulate matter smaller than 10 micrometers in size (PM_{10}) are subject to Prevention of Significant Deterioration (PSD) review.

The Wolf 1 CHP will use state-of-the-art control technology to limit air emissions incorporating Lowest Achievable Emission Rate (LAER) control technology as required for ozone precursor substances under the applicable Nonattainment New Source Review rules and Best Available

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Control Technology (BACT) for pollutants regulated under the PSD and State of Delaware Minor New Source Review requirements. Conservative air dispersion modeling procedures, approved by the State of Delaware, Department of Natural Resources and Environmental Control (DNREC) and Federal Environmental Protection Agency (EPA), have been used to demonstrate that the proposed facility, under forecast operating modes and worst-case meteorological conditions, would not result in adverse air quality impacts.

The assessment concludes that the proposed construction and subsequent operation of the Wolf 1 CHP will not cause or contribute to State of Delaware or National Ambient Air Quality Standards (NAAQS) being exceeded and will not cause PSD increments to be exceeded. In most cases, the Wolf 1 CHP impacts were below levels considered to be significant under PSD rules. In summary, the construction and operation of the proposed Wolf 1 CHP will not impact the State of Delaware's existing air quality resources adversely.

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1.0 INTRODUCTION

The Data Centers, LLC (TDC) is proposing to develop, construct, and operate a self-sustaining data center complete with an electrical power production plant at the University of Delaware's Science, Technology, and Advanced Research (STAR) Campus in Newark, New Castle County, Delaware (see Figure 1). The planned construction start date for the facility is winter-2014 after obtaining required approvals and permits, with a planned commercial operation date of June 2015 or sooner.

The Wolf Technology Center 1 (Wolf 1) is a unique data management and storage center designed to serve multiple users in 288,000 square feet of secure environment with an uninterruptible source of power and cooling. TDC is planning to construct a Leadership in Energy and Environmental Design (LEED) certified sustainable campus that includes a state-of-the-art data center powered by an onsite Combined Heat and Power (CHP) facility. The CHP facility will provide required electricity and cooling heat for the data center facility and supporting buildings. This facility will provide a technologically advanced, secure environment servicing organizations that need to reliably manage and store vast amounts of data around the clock. TDC expects customers would be banks and other financial institutions, universities, insurance companies, telecommunications firms and public and private sector researchers.

CHP is an approved and recognized technology by the US Environmental Protection Agency (EPA) and the US Department of Energy (DOE) as providing reliable, efficient power, with minimized adverse environmental impact. TDC is a member of the EPA Combined Heat and Power Partnership (see Figure 8). Facilities such as hospitals and schools use CHP. However, this would be the first instance that a CHP has been used to provide dedicated uninterrupted power to a data center. Data centers traditionally are a drain on the utility grid that provides power to the facility. A provisional patent has been awarded to TDC for the concept embodied in the proposed facility and an application for a non-provisional patent is in development. The TDC managers have data center planning, engineering, construction management, corporate and outsourced information technology (IT) management, regulatory economics, environmental affairs, corporate planning, project finance, and financial engineering experience as well as close relationships with internationally renowned engineering and construction companies and state-of-the-art equipment and service suppliers. Veolla Energy, an energy partner of TDC, operates an award winning 170 MW similar facility, in Philadelphia, called the Grays Ferry Cogeneration Plant. This facility provides steam service to over 400 buildings including industry, hospitals, universities, hotels and residences.

The proposed CHP will be a natural gas-fired, cogeneration and combined-cycle facility that generates electricity and steam. The Wolf 1 CHP conceptual design and site layout is included as Figure 2. The Wolf 1 CHP aggregated combustion units (gas turbines and reciprocating engines) and steam turbines producing electricity will have a combined maximum nominal power capacity of approximately 279 MW, accounting for the capacity of the gas combustion turbine held in reserve. The planned operating electricity output of the CHP, based on six combustion turbines, three reciprocating gas engines and

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the three steam turbines will be approximately 181 MW. Approximately 131 MW of electricity is required to operate Wolf 1. Approximately 50 MW is anticipated to be supplied to the City of Newark (through DEMEC) under normal conditions.

The power demand of Wolf 1 is anticipated to peak during summer conditions at approximately 131.5 megawatts (MW) and drop to approximately 130.8 MW during the winter. This power demand can be met by the CHP through operation of:

- Four nominally 23 MW gas combustion turbines driving electricity generators;
- One nominally 18 MW reciprocating gas engine driving an electricity generator;
- Three nominally 20 MW condensing steam turbines driving electricity generators; and
- One condensing steam turbine driving a chiller unit.

This operating equipment configuration is termed "N". However, this arrangement of equipment does not ensure reliable, uninterruptable power production, which is a requirement for data storage facilities such as Wolf 1.

To support reliable, uninterruptable power supply, six gas combustion turbines (two more than minimum required) and two reciprocating gas engines (two more than minimum required) must be operated, which is known in industry parlance as "N+2" operations. The minimum efficient operating loads of the additional power units are approximately 50% of the rated capacities. In this configuration, up to two operating (power production units) can fail and the required uninterruptable power demand of the data center can be met. A seventh gas combustion turbine would not be operated. As a further reliability measure, it would be held in reserve for use when other power generating equipment is off-line for maintenance.

The "N+2" mode of operation described above would result in the production of approximately 41.2 MW of excess electrical power and approximately 46,000 pounds per hour (lb/hr) of excess steam during the summer. Excess steam during the winter would rise to approximately 450,000 lb/hr, due to the absence of chiller loads (both the steam driven chiller and turbine inlet chiller systems would not be operating). Excess electrical power during the winter would rise to approximately 42 MW, due to the reduced data center and CHP loads. To make efficient use of this excess power, TDC plans to provide the electricity to the City of Newark (through DEMEC) and the steam to the University of Delaware through power purchase agreements (PPA).

The Wolf 1 CHP will produce electricity using energy efficient combined-cycle technology. The installed combustion-based power generating equipment will consist of seven General Electric (GE) LM2500 DLE gas turbines and three Wartsila 18V50SG lean burn reciprocating gas engines. The combustion turbines and engines will drive electricity generators. Heat recovery steam generators (HRSG) connected to the exhaust systems of the combustion equipment will produce steam. The steam will be used in combined-cycle to power three condensing steam turbines that will drive electricity generators, a condensing steam turbine driven chiller unit, and up to seven steam

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absorption inlet chillers to support efficient combustion in the gas turbines during the summer. The turbine driven chiller unit (not the inlet chillers) will supply conditioned air to the data center. The combination of varied electrical generating units and the planned generating capacity of the CHP will ensure that efficiently produced, uninterruptable power is provided to the data center.

Wolf 1 CHP will emit several regulated air pollutants: nitrogen oxides (NO_x); carbon monoxide (CO); particulate matter (PM), including PM less than or equal to 10 micrometers in aerodynamic diameter (PM_{10}) and PM less than or equal to 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$); volatile organic compounds (VOCs); sulfur dioxide (SO_2); sulfuric acid (H_2SO_4) mist; and greenhouse gases (GHGs). The facility will also potentially emit several hazardous air pollutants (HAPs). (Incomplete combustion of natural gas will produce minor amounts of organic HAPs). In addition, PM will be emitted from the cooling towers as water vapor drift losses. The cooling tower PM emissions are linked to the dissolved solids content of the water vapor. Finally, some ammonia, which will be used in the selective catalytic reduction (SCR) NO_x control process, will also be emitted. Estimated hourly and annual emissions are summarized in Sections 2.3 and 2.4 of this report. NO_x and VOC emissions have been addressed through the application of lowest achievable emission rate (LAER) technology. All other emissions have been addressed through application of best available control technology (BACT). Air dispersion modeling of NO_2 and PM_{10} emissions has indicated that the emissions will have an acceptable impact on air quality and will not adversely impact human health.

The project site is located within the Philadelphia-Wilmington-Atlantic City (PA-NJ-MD-DE) area for ozone. This area currently is designated by the State of Delaware as marginal attainment for 8-hour ozone, but maintains the legacy "severe" non-attainment ozone area status from a Federal (and permitting) perspective. The project site is also located in the Philadelphia–Wilmington (PA-NJ-DE) Area for $PM_{2.5}$. This area is considered non-attainment for $PM_{2.5}$. The project site location is in attainment or not listed for all other National Ambient Air Quality Standards (NAAQS).

The STAR Campus has many advantages for the proposed project. The project is a re-use of a former Chrysler Newark Assembly Plant site (a State of Delaware Certified Brownfield Site). The project will bring new "blue" and "white" collar jobs to an area that was impacted badly by the closure of the former Chrysler plant and the recent economic recession. Star Campus has ample room for the proposed development and is supported by existing infrastructure and is located close to outlets for the excess electricity and steam produced by necessity at the facility and is zoned properly for the intended use. The proposed project site within STAR Campus currently is paved, has no significant wildlife habitat and no wetlands. The project site is not located in a Federal Emergency Management Agency (FEMA) identified 100-year flood plain.

In Chapter 7, Part 1125, Delaware Administrative Code [DE Admin. Code]), the Delaware Department of Natural Resources and Environmental Control (DNREC) has adopted the Federal Environmental Protection Agency (EPA) rules pertaining to Prevention of Significant Deterioration (PSD) as contained in Chapter 40, Part 52.21,

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Code of Federal Regulations (40 CFR 52.21). Section 3.0 of this report provides a detailed review of applicable PSD, NNSR, and other DNREC requirements for permitting of the Wolf 1 CHP.

This report is organized as follows:

Section	1.0	Provides an overview and a summary of the key regulatory determinations.
Section	2.0	Describes the proposed facility and associated air emissions.
Section	3.0	Describes Federal and State air quality standards and discusses applicability of PSD and other NSR requirements and procedures applicable to the proposed facility.
Section	4.0	Provides a summary of applicable state and federal emissions standards.
Section	5.0	Provides an analysis of control technologies, including Best Available Control Technology (BACT) for several pollutants subject to PSD review and Lowest Achievable Emissions Rate (LAER) for pollutants subject to NNSR.
Section	6.0	Presents the alternatives analyses required for NNSR.
Section	7.0	Describes the modeling approach for source impact analyses.
Section	8.0	Presents the results of source impact analyses.
Section	9.0	Summarizes analyses of additional impacts in the plant vicinity.
Section	10.0	Describes air emissions screening for Class I Areas.

Additional information is contained in the following Appendices:

Appendix A	Provides the requisite DNREC air quality construction permit application forms (AQM Forms).
Appendix B	Provides air pollutant emissions estimates and supporting information and calculations.
Appendix C	Includes a copy of the modeling protocol dated August 2013, which outlines Wolf 1 CHP's methodology in demonstrating compliance with the air quality impact analyses.
Appendix D	Contains the comments on the modeling protocol received from DNREC, EPA Region III, and the U.S. Fish & Wildlife Service (USFWS) and responses to those comments.
Appendix E	Contains the BACT/LAER tables.
Appendix F	Provides the Class II plume modeling input and output files on compact disc.

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Appendix G Contains the Material Safety Data Sheets (MSDSs) for natural gas and ammonia.

1.1 ENERGY AND ENVIRONMENTAL EFFICIENCY

Efficient energy use and concepts form the founding ideal behind the proposed Wolf 1 CHP. Data centers have high energy demands and those energy demands must be met 100% of the time, with no interruptions, for data centers to function reliably. Conventionally, data centers have been supplied electrical energy from distribution grids, such as the PJM grid that serves the State of Delaware. Energy inputs to the PJM distribution grid come from many sources, such as wind farms, solar arrays, hydroelectric facilities, nuclear power plants, waste-to-energy power plants, biomass power plants, and conventional fossil fuel power plants. In the eastern United States, most grid power is provided by nuclear power plants and conventional combustion-based fuel plants.

The energy transformation in combustion-based processes occurs when carbon in the fuel source combines with oxygen to form CO_2, transforming the latent energy of the fuel to heat energy. Engines (internal combustion or external combustion) in the power plants convert heat energy to other forms of useful energy, such as electricity. Facilities can be designed to convert heat energy to useful energy in a single system known as simple cycle or through multiple systems known as a cogeneration and combined-cycle.

Simple cycle conversions of heat to electrical energy generally are less than 50% thermally efficient, and frequently are less than 33% thermally efficient. In other words, approximately 67% of the available heat energy is wasted and a large fraction of the air emissions produced by combustion yield no benefit. Simple cycle electricity power plants are typified by facilities that currently provide base load electricity to the PJM grid. Due to the plants being located remotely from points of energy use they cannot operate as combined heat and power plants, which results in a wasting of thermal energy. Another simple cycle example is a facility operated intermittently to produce electricity to meet peak grid demands ("peaker plants"). Simple cycle energy conversions can also be used to produce steam as a final product. The power plant that formerly supported the Chrysler Newark Assembly Plant at STAR Campus was a simple cycle plant that converted heat energy to steam. Under the circumstances described, the heat energy not transferred by the simple cycle process to electricity is released to the atmosphere, a body of water, or the ground providing no benefits.

When combustion heat energy from a <u>single</u> heat source is converted to <u>multiple forms</u> of useful energy, in multiple operating systems, the process is termed cogeneration or combined heat and power. Examples of cogeneration facilities are power plants located in cities like New York and Philadelphia, where heat energy is converted to electrical energy and steam, which is used to heat local buildings (distributed heating). The energy transfer efficiency of these facilities can be as

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high as 80%, but more commonly is about 50%. The examples cited point to a key aspect of combined heat and power facilities – they must be located close to the end use of the energy they provide. Heat energy (including steam) cannot be transported efficiency over large distances. Recognizing the significant energy and environmental conservation potential of CHP, the United States Department of Energy has set a goal of obtaining 20% of the power used in the United States from combined heat and power systems by 2030.

When combustion heat energy from a single heat source is converted to a single useful form of energy through multiple operating systems, the process is termed combined-cycle. Examples of combined-cycle facilities are electrical power plants that use two or more operating systems to generate electricity from a single heat source. Combined-cycle electrical power plants commonly can achieve thermal energy efficiencies of 40 to 50%. Most modern, base load, electricity power plants are being designed as combined-cycle plants.

The proposed Wolf 1 CHP facility is intended to blend the efficiency of cogeneration with the efficiency of combined-cycle operations. The thermal efficiency of the plant should be approximately 60% during summer and winter operating conditions. The proposed location of the facility on the STAR Campus is a key factor to the success of combined heat and power. Steam generated by the facility can be used on-site and can be distributed to the University of Delaware for use from that location through a dedicated pipeline. This steam production would offset the production of steam at UD using growing need for expansion of UD power plant.

The remote location of grid-supplying power plants necessitates transmission of the electrical energy over power lines to points of use. The transmission of energy results in unproductive losses of electrical energy to heat due to resistance within the power lines. Further losses occur each time the electricity is transformed (voltage increased or decreased). This aspect of the current power grid system compounds the energy inefficiency of remote energy conversion and non-productive environmental emissions.

The transmission system is also vulnerable to disruption due to accidents and natural disasters. In the context of data centers, this disruption potential sets-off a chain of responses. Existing grid–connected data centers typically require at least dual power feeds that originate from operationally separate locations in the distribution grid. This solution combats the potential for a disruption of power in a portion of the grid resulting in a loss of power to a data center. However, dual feeds do not ensure uninterruptable power and do not address conditions of wide-spread power outages, like those that occurred during superstorm Sandy in 2012. In response, existing grid-connected data centers typically have massive battery back-up systems that can instantaneously maintain short-term electrical power to critical devices, while emergency power generation located on-site is activated and brought up to full production. Typically, the emergency power system is powered

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by diesel engines, and has sufficient capacity to meet the full-power demand of the data center for a longer term. These solutions to short-comings of using grid-based electricity often result in large areas of land dedicated to battery storage and emergency power generation, plus extensive capital investment in equipment that receives minimal use. The larger diesel emergency generator engines typically are started and run once per month for approximately one hour as part of maintenance and reliability requirements. This practice results in the production of considerable air emissions with no useful benefit. Due to the emergency use limitation, these engines are not held to the same standards as other large sources of air emissions.

The Wolf 1 CHP and data center concept seeks to alter the above paradigm by eliminating the weakness of reliance on grid-based power, while expending limited capital and land on productive equipment.

The location of the CHP adjacent to the data center significantly shortens the distribution system required for energy delivery, thereby improving reliability. This feature also limits losses of energy to line resistance and voltage transformations, which improves the efficiency of the energy usage.

In the CHP, the initial conversion of latent fuel energy to heat energy occurs in an engine. Gas turbines, operating based on Brayton cycle thermodynamics, will be used to convert heat energy to mechanical energy. Reciprocating engines, operating based on Otto cycle thermodynamics, also will be used to convert heat energy to mechanical energy. Both the Brayton cycle and the Otto cycle operations can only use a portion of the heat energy liberated by the combustion of fuel. The unused heat energy will be used to make steam in Heat Recovery Steam Generators (HRSGs) and the steam will be used to store the recovered heat energy for subsequent use. The coupling of mechanical energy conversion and heat energy storage is termed cogeneration. The stored heat energy will be converted to mechanical energy through steam turbines (or engines) operating in Rankine cycle thermodynamics. The coupling of multiple thermodynamic cycles to convert heat energy to mechanical energy is termed combined-cycle operation. The steam will also be use thermal heating or other processes based on heat transfer.

CO_2 is a product of combustion of fuel containing carbon, which is inherent in any power generation technology using fossil or renewable fuel. The basic theoretical combustion equation for natural gas, which is mostly methane (CH_4), is:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

CO_2 emissions are the product of the chemical reaction between the fuel and the oxygen, not a byproduct caused by imperfect combustion. Therefore, CO_2 emissions cannot be reduced by improving the combustion efficiency, and there is no technology available that can reduce CO_2 generation from the combustion of carbon-based fuels. In fact, improvements in combustion efficiency always increase the production of CO_2, while decreasing the production of unwanted

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byproducts. The only effective means to minimize the amount of CO_2 generated by a fuel-burning power plant is through high-efficiency use of the heat energy released by the chemical reaction, which leads to lower fuel consumption. Reduced fuel consumption results in reduced CO_2 emissions. Minimizing the amount of fuel required (in units of million British thermal units) to produce a given amount of power output (in units of kilowatt-hours) results in the least amount of CO_2 generated for required power.

Maximizing energy transfer efficiencies is the most effective means of obtaining useful energy from fuel combustion while minimizing CO_2 production. Combustion converts latent energy in fuel to heat energy. In an ideally efficient combustion process, all of the heat energy released could be transferred to other forms of useful energy (i.e., 100% efficient energy transfer). Ideal efficiency cannot be achieved with current technology. There are numerous losses of energy largely due to heat transfer and friction losses. However, the idea is to develop systems that approach ideal heat transfer as closely as possible.

1.2 SUMMARY OF REGULATORY MATTERS

Equipment that will produce air emissions at the proposed facility will include:

- Seven gas combustion turbine units coupled to individual HRSGs and electricity generators;
- Three reciprocating gas engine units coupled to individual HRSGs and electricity generators; and
- Two cooling towers.

The combustion units and associated HRSG units will be arranged in one-on-one configurations. The steam generated in the HRSGs will power three condensing steam turbines coupled to three electricity generators and another condensing steam turbine coupled to a chiller unit. Steam will also power absorptive chillers that will provide cooled inlet air to the combustion turbines during warm weather, thereby improving the combustion efficiency of the turbines. The combustion turbines will be GE LM2500 Dry Low Emissions (DLE) units. The reciprocating gas engines will be Wartsila 18V50SG lean burn units. The turbines and reciprocating engines will be fueled with "pipeline-quality natural gas" obtained from Eastern Shore Natural Gas Company, containing no more than 0.5 grains of total sulfur per 100 standard cubic feet (gr S/100 scf). This upper limit for total sulfur was used in the accompanying emissions estimates, which resulted in the modeling of conservatively high emissions values[1].

[1] Pipeline-quality natural gas is defined by 40 CFR 72.2 as containing 0.5 grains or less of total sulfur per 100 standard cubic feet. One year of monthly natural gas sulfur content data was obtained from Williams Transco (a natural gas provider for Eastern Shore). The highest sulfur content from September 2012 through August 2013 was reported as 0.398 grains S per 100 scf. Williams Transco natural gas sulfur content data has been included in Appendix B.

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At least four of the combustion turbines and one of the reciprocating engines are anticipated to operate full-time at loads near the unit rated capacities to meet data center load requirements. Two of the other turbines and two other engines are anticipated to operate at varying loads between 100% and 50% of capacity to insure reliable, uninterruptable power to the data center. Anticipated annual hours of operation are further described in Section 2.0 of this report. Based on the anticipated operating hours and loading, the CHP will have the potential to emit 74.11 tons per year (tpy) of NO_x, 78.83 tpy of carbon monoxide (CO); 59.29 tpy of total PM, including PM_{10} and $PM_{2.5}$; 20.73 tpy of sulfur dioxide (SO_2); and 81.36 tpy of volatile organic compounds (VOCs). No lead emissions are anticipated due to the use of natural gas as combustion fuel. Regarding non-criteria pollutants potentially subject to PSD review, the CHP will emit approximately 8.02 tpy of H_2SO_4 mist, which results from the oxidation of SO_2 in the non-selective oxidation catalyst units incorporated to treat CO and VOC emissions, and negligible amounts of other substances on the PSD list. The resultant H_2SO_4 mist has been estimated conservatively by assuming that 50% of the sulfur in fuel is converted to sulfur trioxide (SO_3) by the oxidation catalyst and that all of the SO_3 is converted to H_2SO_4 mist. In addition, approximately 72.58 tpy of ammonia introduced in the SCR systems will not be consumed in reactions with NO_x and will be emitted (ammonia slip).

Worst-case projections of hazardous air pollutants (HAPs) emissions were made for the CHP. Incomplete combustion of natural gas will produce small amounts of organic HAPs. The estimated HAP emissions were compared to major source thresholds found in Section 112(a)(1) of the Clean Air Act (CAA). The major source thresholds for HAPs are 10 tpy for an individual HAP and 25 tpy for total HAPs. The Wolf 1 CHP will emit a maximum individual HAP of 9.81 tpy (formaldehyde), based on US EPA AP-42 emission factors, and approximately 13.44 tpy of total HAPs. As such, the facility is a minor source of HAPs.

EPA's PSD and Title V GHG Tailoring Rule became effective on August 2, 2010. GHGs are defined as the following six pollutants: CO_2, methane, nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons, and perfluorocarbons. Carbon dioxide equivalent [CO_{2e}] is defined as the sum of the six GHG pollutants multiplied by their respective global warming potential (GWP) coefficients. Potential CO_{2e} emissions for the Wolf 1 CHP facility are estimated to be 1,008,910 tpy. (Note: For comparison to PSD applicability thresholds, CO_{2e} emissions are provided in units of short tons per year.) The potential CO_{2e} emissions exceed the PSD applicability threshold of 75,000 tpy outlined in the Tailoring Rule and are subject to GHG BACT review.

Based on these annual potential emissions rates, the facility will be a minor source of CO, sulfur dioxide SO_2, $PM_{2.5}$ and hazardous air pollutants (HAPs) and these emissions are subject to State of Delaware Minor New Source Review requirements, including BACT analysis. Emissions of greenhouse gases (GHG), sulfuric acid (H_2SO_4) mist and particulate matter smaller than 10 micrometers in

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size (PM_{10}) are subject to Prevention of Significant Deterioration (PSD) review and BACT analysis. Section 3.0 of this report provides a more detailed description of GHG PSD applicability and requirements.

Currently, New Castle County is in attainment for all National Ambient Air Quality Standards (NAAQS) except ozone (O_3) and $PM_{2.5}$. Although New Castle County is currently designated as a "moderate" nonattainment area for the 8-hour ozone standard, the requirements applicable to the previous designation as a "severe" nonattainment area for the 1-hour ozone standard are still in force for permitting.

Due to this classification, a LAER analysis has been conducted for NO_x and VOCs emissions, which are ozone precursor substances that will be emitted in excess of the 25-tpy nonattainment new source review (NNSR) thresholds. As required by Federal and Delaware regulations, emission reduction credits (ERCs) for NO_x and VOCs will be acquired at ratios of 1.3 ERCs to 1 ton of emissions before operations commence at the proposed Wolf 1 CHP. Estimated $PM_{2.5}$ emissions do not exceed the NNSR threshold. As such, $PM_{2.5}$ emissions have been addressed in accordance with State of Delaware minor new source review (MNSR) requirements.

1.3 ANALYSIS RESULTS

As presented in this report, the required air quality analyses resulted in the following conclusions:

- The use of good combustion practices and natural gas as a fuel is considered to be BACT for $PM/PM_{10}/PM_{2.5}$. The CHP combustion units will use the latest available technologies applicable to gas turbines and reciprocating engines to maximize combustion efficiency and minimize PM/PM_{10} emissions rates;
- Installation of an oxidation catalyst system is considered BACT for CO and LAER for VOC control of emissions from gas turbines and reciprocating engines. At operating conditions, the 3-hour average exhaust concentrations of CO are projected to be 3 parts per million by volume, dry (ppmvd), corrected to 15% oxygen, for the GE LM2500 DLE and Wartsila 18V50SG combustion units;
- Low-NO_x combustion technology in combination with selective catalytic reduction (SCR) emission control systems are proposed as LAER for controlling NO_x emissions from the gas combustion turbines. At operating conditions, 3-hour average exhaust concentrations of NO_x are projected to be 2 ppmvd, corrected to 15% oxygen. Four-cycle, spark induced ignition lean burn combustion coupled with SCR emission controls are proposed as LAER for controlling NO_x emissions from the reciprocating gas engines. Under operating conditions, exhaust concentrations of NO_x are projected to be a maximum of 0.132 lb per MWh;
- Use of the gas combustion turbines and reciprocating gas engines in energy efficient combined-cycle and cogeneration operations is proposed as BACT for

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GHG emissions. Combined-cycle operation produces the least GHG emissions per MWh of electricity produced by current combustion-based technologies. Cogeneration further maximizes use of thermal energy released by combustion, which in turn, ensures the least amount of GHG is emitted to meet thermal and electrical energy demands;

- The proposed emissions of air pollutants will be less than emissions from many existing combustion-based power generation facilities located in the mid-Atlantic. To the extent that electricity generated at the Wolf 1 CHP displaces electricity produced at other gas-fired plants that do not incorporate combined-cycle technology, emissions of air pollutants from regional power generation will decrease, and an improvement in the regional air quality will result. This benefit increases when the electricity produced at the Wolf 1 CHP displaces electricity production at power plants fueled by petroleum or coal and off-sets at other fossil fuel combustion facilities;
- The proposed CHP is projected to emit PM/PM10 at levels subject to PSD review, as they exceed PSD significant emissions rate (SER) levels. Per recent EPA guidelines, NO2 emissions are also subject to PSD review. The facility air quality impact analysis has demonstrated that impacts will be below the PSD monitoring de minimis levels for each of these pollutants. Therefore, the facility qualifies for an exemption from the PSD preconstruction ambient air monitoring requirements per 40 CFR 52.21(i)(8)(i);
- The PSD Class II air quality analysis demonstrated that pollutants emitted by normal operating conditions will be below the significant impact levels (SILs) for each averaging time with the exception of NO2 for the 1-hour averaging period. Modeling of emissions generated by full capacity operations of the CHP has indicated that those emissions would exceed SILs for NO2 (annual and 1-hour) and for PM10 (24-hour). Modeling of an intermittent condition, identified as "island mode," also indicated that NO2 and PM10 emissions would exceed SILs. Therefore, conservative multisource interactive assessments (cumulative modeling)of NAAQS attainment and PSD Class II increment consumption were required to demonstrate compliance with the applicable NAAQS;
- The PSD Class I air quality analysis demonstrated that impacts for the pollutants at Class I areas within 300 kilometers (km) of the facility site were below the initial Q/D ratio of 10. Based on this screening criterion, the facility air quality analysis is not anticipated to be detrimental to soils and vegetation and will not impair visibility at the Class I areas. Short-range modeling performed using AERMOD demonstrated Class I SILs were met at a distance of 50 km from the facility, less than the projected distances to the Class I areas; and
- The facility air pollutant emissions will be well controlled to levels consistent with BACT and LAER. As a result, operation of the Wolf 1 CHP will have minimal adverse impact to local and regional air quality.

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2.0 DESCRIPTION OF PROPOSED FACILITY

2.1 FACILITY DESCRIPTION, LOCATION MAPS, AND PLOT PLAN

As discussed in Section 1.0, the proposed Wolf 1 CHP facility will be located in the University of Delaware's Science Technology and Advanced Research (STAR) Campus in Newark, Delaware. Figure 1 shows the site location within the State of Delaware, within the local area and within STAR Campus. Figure 2 shows the anticipated site layout plan. Beside the power generating equipment, the only other stationary source of air emissions at the facility will include the wet mechanical draft cooling towers. As part of the air emissions minimization design of the facility, TDC has obtained authorization to install an electric fire pump in lieu of the typically required diesel powered pump, due to the uninterruptable nature of electricity production and supply at the facility.

Major components of the Wolf 1 CHP will consist of:

- Seven combustion turbines with seven HRSG units and seven electricity generators;
- Three reciprocating gas engines with three HRSG units and three electricity generators;
- Three condensing steam turbines with three electricity generators;
- Two wet mechanical draft cooling towers;
- One steam driven chiller unit and one mechanical chiller unit;
- Seven steam absorption chillers for inlet air to the gas turbines;
- Ancillary equipment, including raw and demineralized water storage tanks; and
- Ammonia storage and handling equipment.

The combustion turbines will be energy efficient GE LM2500 DLE units rated at 23.2 MW (winter) and 22.4 MW (summer). These units are equipped with dry-low NO_x burners to suppress NO_x formation. The combustion turbines will be equipped with inlet cooling, which is designed to lower the temperature of the turbine intake air during periods of higher ambient air temperatures (summer), thereby supporting combustion efficiency year-round. Four of the combustion turbines are anticipated to operate at close to 100% load in support of data center loads. Two of the turbines are anticipated to operate at loads between 50% and 100% of capacity. Minimum operating load of 50% will be necessary to support reliable, uninterruptable electricity to the data center. One turbine is not anticipated to operate unless another turbine or a gas reciprocating engine is shut down for maintenance or other reasons.

The reciprocating gas engines will be 4-stroke, lean-burn energy efficient, Wartsila 18V50SG units rated at 18.8 MW. These engines are equipped with low NO_x

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systems that include a pre-combustion chamber, where a rich mixture of fuel is ignited by spark, which in turn ignites a lean fuel mixture in the main combustion chamber to ensure efficient fuel combustion and low generation of emissions. One of the reciprocating gas engines is anticipated to operate at 100% load to support data center electricity loads. The other two engines are anticipated to operate at loads between 50% and 100% of capacity. Minimum operating load of 50% will be necessary to support reliable, uninterruptable electricity to the data center. The reciprocating engines will be shut down periodically for maintenance.

The HRSG units will produce steam using exhaust heat from the gas turbines and reciprocating gas engines. The steam will be used in three condensing steam turbines connected to generators to produce electricity, one steam turbine driven chiller unit for the Data Center, and seven steam absorption chillers that will be used to cool inlet air for the combustion turbines. Excess steam will also be exported to the University of Delaware for use on their campus. Each of the steam turbines coupled to electricity generators will be capable of generating up to 20 MW of electrical power.

Emissions control systems proposed for the facility include:

- Dry low-NOx technology in gas combustion turbines,
- Lean burn technology in 4-stroke, reciprocating gas engines,
- SCR systems located in each of the HRSG. In an SCR system, NO_x-laden flue gas, which is created as a byproduct of combustion processes, is reduced to elemental nitrogen and water vapor through the injection of ammonia (NH_3) into the flue gas in front of a catalyst bed. The chemical primary reactions in the SCR are:

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6\ H_2O$$

$$4NH_3 + 2NO_2 + O_2 \rightarrow 3N_2 + 6\ H_2O$$

- Oxidation catalyst units in the HRSGs and good combustion practices for control of CO and VOCs. In oxidation catalyst units, flue gas passes over a metal catalyst (typically platinum) to oxidize CO into CO_2. The chemical reaction is $CO + \frac{1}{2}O_2 \rightarrow CO_2$. The chemical reactions for VOCs vary with the substance, but generally result in the formation of CO_2 and H_2O; and
- Exclusive use of pipeline-quality natural gas and efficient combustion practices to minimize $PM/PM_{10}/PM_{2.5}$ emissions, and formation of SO_2 and H_2SO_4.

Two mechanical draft cooling towers will be used to condense spent steam exiting the steam turbines or used as part of the chiller cooling system. The cooling towers will be equipped with multi-pass drift eliminators designed to limit water vapor drift. Water captured by the drift eliminator will be directed to the cold water basin of the cooling towers. Since the cooling water contains total dissolved solids

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(TDS), the cooling tower drift results in PM emissions. As the cooling tower water is recycled, the TDS concentration of the water increases as the number of recirculation cycles increases and water is evaporated. However, the cooling tower cells will be equipped with high-efficiency drift eliminators (i.e., 99.999%) to reduce the drift loss to 0.0005%. The drift eliminator serves to reduce water loss in cooling (which reduces water use), reduces the TDS concentrating effect of water recirculation, and reduces PM emissions by lessening the amount of water vapor emissions and lessening the TDS concentration of the water vapor emissions. The water used in the cooling tower will be obtained from the potable water system supplied by United Water Delaware.

Figure 2 presents the proposed facility site plan showing major process equipment and structures, emissions points, and property boundaries. Primary access to the site will be via an entrance on the eastern side of the facility. The entrance will have a security gate to control site access, and the perimeter of the site will be fenced.

2.2 PROCESS DESCRIPTION AND PROCESS FLOW DIAGRAM

The proposed combined-cycle facility will consist of seven nominal 23.2 MW, GE LM2500 DLE gas combustion turbines and three nominal 18.8 MW, Wartsila 18V50SG 4-stroke, lean burn, reciprocating gas engines with spark induced ignition. Each of these combustion units will be connected to individual HRSGs and electricity generators. Steam produced in the HRSGs will power three nominal 20 MW steam turbines connected to electrical generators. Figure 3 presents a process flow diagram for the proposed facility.

Gas combustion turbines and reciprocating gas engines are heat engines that convert latent fuel energy into work using compressed hot gas as the working medium. These devices deliver mechanical output by means of a rotating shaft that is used to drive electricity generators, thereby converting a portion of the engine's mechanical output to electrical energy. To maintain combustion turbine efficiency during warm weather, inlet ambient air will be cooled using chillers (one per turbine unit). Both types of combustion units will be equipped with low NO_x emission technology. In essence, this technology consists of a pre-combustion chamber where a rich mixture of fuel is ignited and then fed into the main combustion chambers where it ignites a lean fuel mixture. This technology improves combustion efficiency and reduces combustion temperatures, which in turn, reduces emissions.

The hot exhaust gases from the combustion units flow to the HRSGs for the production of steam. Within the HRSG units, the exhaust gases will be combined with aqueous ammonia and pass through a SCR and separate catalytic oxidizer. The SCR unit will transform most of the exhaust NO_x to elemental nitrogen and water vapor. Some unreacted ammonia will pass through SCR and remain entrained in the exhaust gasses, known as ammonia slip. The ammonia slip rate will not exceed 7 ppmvd corrected to 15% oxygen content on a three hour average. The catalytic oxidizers will transform CO and VOCs principally into CO_2 and water

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vapor. After passing through the HRSGs, exhaust gasses will flow through flues or stacks and be discharged to the atmosphere. Each gas turbine HRSG will have a dedicated stack and discharge at approximately 140 feet above ground level. Each reciprocating gas engine HRSG will have a dedicated flue within a common stack. The discharge point for the flues will be approximately 140 feet above ground level.

Steam generated in the HSRGs will be used within the Wolf 1 CHP. Additionally, surplus/excess steam will be exported to the University of Delaware for their use. Steam-based energy use within the Wolf 1 CHP will be based on condensing steam turbines and steam absorption chillers. The steam turbines will drive three electricity generators and one chiller unit. That chiller unit will provide conditioned air to the data center. The absorption chillers will cool inlet air for the gas turbines. Spent steam from the turbines will flow to condensing units (steam to water heat exchangers). Steam condensate, with the exception of blow-down, will be circulated back to the HRSG units. Blow-down water will be discharged to the existing public sanitary sewer system, which has adequate capacity to handle the proposed discharge. Cooling water for the condensing units will be circulated to cooling towers to exhaust residual heat. Water vapor generated by the cooling tower processes will be mostly (all but 0.0005%) captured by drift eliminators, condensed and returned to the cooling tower cold water basin for recirculation. Water vapor that escapes the drift eliminators will discharge to the atmosphere. This water vapor will contain dissolved solids, which have been addressed as particulate emissions in this report.

The operation of the SCR will require an onsite ammonia storage tank.

2.3 HOURLY EMISSIONS RATES AND STACK PARAMETERS

Table 2-1 below provides maximum hourly criteria and non-criteria pollutant emissions rates for each gas combustion turbine and each reciprocating gas engine at 100% loads and winter operating conditions, as well as for the cooling towers. Winter operating conditions use a higher heat input and, therefore, increased emissions.

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Table 2-1. Maximum Hourly Pollutant Emission Rates per unit (Winter Conditions)

	Pollutant						
Source	**NO_x (lbs/hr)**	**CO (lbs/hr)**	**VOC (lbs/hr)**	**PM (lbs/hr)**	**SO_2 (lbs/hr)**	**H_2SO_4 (lbs/hr)**	**Ammonia (lbs/hr)**
GE LM2500 DLE Combustion Turbines	1.6	0.37	0.46	1.5	0.31	0.234	2.11
Wartsila 18V50SG Reciprocating Gas Engines	2.48	5.37	5.37	1.38	0.08	0.147	1.3
Cooling Tower 1	-	-	-	0.14	-	-	-
Cooling Tower 2	-	-	-	0.65	-	-	-

Criteria pollutant emission rates were obtained from manufacturer provided performance information for the power generating equipment, where available, or from government sources for emissions estimating including EPA's AP-42, "Compilation of Air Pollutant Emission Factors". Performance criteria for the air pollution control devices (SCR and oxidation catalysts) were obtained based on a BACT/LAER analysis discussed in Section 5.0 of this document. Appendix B includes emission tables documenting equipment performance information and emission estimates.

Table 2-2 provides the stack parameters used in the air dispersion modeling.

Table 2-2.a Stack Parameters at Full Capacity Operations
(7 turbines @ 100% load, and 3 engines @ 100% load)

Inputs	**Combustion Turbines/ HRSG**	**Reciprocating Gas Engines/ HRSG**	**Steam Turbine Cooling Tower (CT1)**	**Chiller Tower (CT2)**
Temperature (°F)	345	345	98	98
Stack Height (ft)	140	140	45	45
Stack Inside Diameter (ft)	8.0	5.0	26.0	38.0
Stack Exit Velocity (ft/sec)	60.6	70.0	28.3	30.0
Stack Exit Flow Rate (ft^3/min)	182,898.0	82,465.0	901,720.0	2,044,018.0

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Table 2-2.b Stack Parameters at General Operating Conditions
(6 turbines @ 100% load, and 2 engines @ 100% load)

Inputs	Combustion Turbines/ HRSG	Reciprocating Gas Engines/ HRSG	Steam Turbine Cooling Tower (CT1)	Chiller Tower (CT2)
Temperature (°F)	345	345	98	98
Stack Height (ft)	140	140	45	45
Stack Inside Diameter (ft)	8.0	5.0	26.0	38.0
Stack Exit Velocity (ft/sec)	60.6	70.0	28.3	30.0
Stack Exit Flow Rate (ft^3/min)	182,898.0	82,465.0	901,720.0	2,044,018.0

Table 2-2.c Stack Parameters at Minimum Operating Conditions
(4 turbines @ 100% load, 2 turbines @ 50% load, and 2 engines @50% load)

Inputs	Combustion Turbines/ HRSG (100%)	Combustion Turbines/ HRSG (50%)	Reciprocating Gas Engines/ HRSG (50%)	Steam Turbine Cooling Tower (CT1)	Chiller Tower (CT2)
Temperature (°F)	345	345	345	98	98
Stack Height (ft)	140	140	140	45	45
Stack Inside Diameter (ft)	8.0	8.0	5.0	26.0	38.0
Stack Exit Velocity (ft/sec)	60.6	53.9	33.0	28.3	30.0
Stack Exit Flow Rate (ft^3/min)	182,898.0	162,474.0	38,913.0	901,720.0	2,044,018.0

As with all combustion processes, firing of natural gas in the gas combustion turbines and reciprocating gas engines will result in minor amounts of incomplete combustion products. A few of these compounds are classified as HAPs. Emissions of HAPs were estimated and compared with the 112(g) thresholds. Table B-4 of Appendix B presents details on emissions of each species of HAP. These estimates were based on factors taken from AP-42, Section 3.1, dated April 2000, for combustion turbines; and AP-42, Section 3.2, dated July 2000, for the reciprocating gas engines. Individual and total annual HAPs emissions were found to be below the 112(g) thresholds (i.e., total HAP less than 25 tpy and individual HAP less than 10 tpy).

Total dissolved solids (TDS) contained in cooling water drift droplets (liquid water entrained in the cooling tower exhaust air stream) are considered PM emissions. Table 2-3 provides PM emissions from the cooling towers. Conservatively, PM was assumed to be equivalent to both PM_{10} and $PM_{2.5}$. As documented in

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Appendix B, the combined estimated PM emissions rate from the wet mechanical draft cooling towers is 0.79 lb/hr. Assuming continuous operation, the maximum potential annual emissions of $PM/PM_{10}/PM_{2.5}$ would be 3.46 tpy.

Table 2-3. PM Emissions from Cooling Towers

	Steam Turbine Cooling Tower (CT1)	**Chiller Tower (CT2)**
Recirculating Water Flow Rate (gpm)	37,500	170,010
$PM/PM_{10}/PM_{2.5}$ emissions (lbs/hr) *[with drift eliminator]*	0.14	0.65
	0.79	

2.4 ANNUAL POTENTIAL EMISSIONS

Annual emissions from the Wolf 1 CHP are based on 8,760 hours per year (hr/yr) of operation for six of the seven gas combustion turbines and approximately 8,580 hr/yr of operation for each of the three reciprocating gas engines after accounting for maintenance down time. The estimated annual emissions are based on six of the gas combustion turbines and all three reciprocating gas engines operated at 100% load, which may occur after the data center is fully operational. The seventh gas turbine is anticipated to be held in reserve for use in the event that one of the other combustion based units is shut down for maintenance or malfunctions.

When the demand for electricity is reduced, combinations of turbines and engines may operate at a reduced load, but will always be operated in a manner that satisfies the N+2 operating requirements for uninterruptable power for the data center. The combustion turbine manufacturer guarantees emission concentrations from 50%-100% of the operating load. Aside from periods of startup or shutdown, the combustion turbines will not be operated at less than 50% load. The reciprocating engines produce the highest pound per hour emissions at 100% operating load. Reduced loads for the reciprocating engines produce fewer emissions. The annual emission estimates for the reciprocating gas engines were based on 8,580 hours per year of operation at 100% operating load.

Use of these assumptions provides a worst-case estimate of annual emissions shown in Table 2-4.

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Table 2-4. Annualized Emissions Rates (tpy)

Pollutant	Combustion Turbine/HRSG (6 Units)	Reciprocating Gas Engine/ HRSG (3 units)	Cooling Towers (2 units)	Facility Totals (tpy)
NO_x	42.2	31.9	-	74.1
CO	9.6	69.1	-	78.7
VOC	12.2	69.1	-	81.3
SO_2	8.2	1.1	-	9.3
H_2SO_4	6.1	1.9	-	8.0
GHG (as CO_{2e})	Facility-wide			901,6134
Ammonia	55.5	17.1	-	72.6
$PM/PM_{10}/PM_{2.5}$	38.2	17.8	3.5	59.5

2.5 ESTIMATES OF EQUIPMENT SHUTDOWNS AND STARTUPS

Based on information provided by the gas turbine manufacturer, GE, the first scheduled maintenance requiring shutdown of a gas combustion turbine will occur at 4,000 hours with an outage time of approximately 100 hours. To be conservative, the minimal reduction in operating time due to maintenance of the gas combustion turbines has not been accounted in the yearly emissions or hours of operation. Based on the maintenance schedule, each turbine is anticipated to operate under start-up conditions at most three times per year (three maintenance events), yielding 18 total start-ups. The seventh turbine in the group is anticipated to have more frequent (13 events estimated) start-ups, since it will be used to provide power when the other turbines and the engines are sequentially shut down for maintenance. Start-up emission concentrations for NO_x and CO will be higher during turbine start-ups since the add-on controls (discussed later in this report) will not be operating at their optimum efficiency. GE has indicated that start-up time for the turbines is approximately 10 minutes. The increased emissions of NO_x and CO from the gas combustion turbines during the start-up period are discussed below.

N+2 operating requirements for the CHP means six turbines will be producing power at all times. The seventh turbine likely will operate only when one of the other turbines or a reciprocating gas engine is shutdown intentionally for maintenance or shutdown due to malfunction. As such, the seventh turbine will have more startups and shutdowns than the other six turbines. Startups that occur within 2 to 6 hours of shutdown would be considered "warm starts," where temperatures within the HRSG (including the oxidation catalyst and selective catalytic reduction (SCR) pollution control units) rapidly reach normal operating conditions and emissions reach operating levels. However, for purposes of this analysis, few warm starts are anticipated to occur. "Cold starts", where the HSRG and air pollution control units will need time to heat before being able to treat emissions, likely will be the typical condition. Therefore, startup emissions are based on "cold start" conditions.

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To provide a conservative estimate of down time, Duffield Associates assumed that turbine shutdowns last 100 hours rather than 24 hours, for maintenance, insuring that restarts would be "cold". Balancing equipment maintenance cycles with N+2 operating conditions and anticipated power output requirements, yielded an estimated 31 total shutdowns per year for the seven turbines. According to GE, the proposed combustion turbines will reach 100% loading within 10 minutes from a cold start. Estimated emissions during the 10 minute startup are quoted at 1.7 pounds of NO_x and 1.4 pounds of CO. At 10 minutes per startup times 31 starts per year, startup conditions are anticipated to exist for a total time of 310 minutes or 5.2 hours per year out of an estimated combined operating time of 53,436 hours. Therefore, turbine startup conditions are anticipated to occur during approximately 0.01% of the total annual runtime of the turbines. Currently unforeseen operating conditions or mechanical issues may necessitate additional shutdowns of individual turbines. To illustrate the truly minor nature of turbine startup emission conditions, the turbines could be shut down and restarted up to 320 times during the year without the startup period contributing more than 0.1% of total operating time for the turbines. Startup conditions for the turbines will be an intermittent operating circumstance.

Operations planning forecasts that all of the reciprocating gas engines will be operated, when not shut down for maintenance or to stagger maintenance timing. The manufacturer estimates that each engine will need to be shut down for an average of 15 days per year over a 12 year time period, based on the forecast to operate these engines more than 8,000 hours per year. Each year, maintenance shutdown durations likely will vary between a total of 8 days and 26 days, reflecting the extent of required maintenance. The following estimate of startups and shutdowns is based on the 15 average days of maintenance and an estimated duration of three days (72 hours) per maintenance event, which yields an estimated five shutdowns and startups per year per engine for maintenance. Under these assumptions, all restarts would be considered "cold" starts, where the APC units would need time to heat before being able to treat emissions. According to Wartsila, the reciprocating gas engines will reach 100% loading operation within 30 minutes of a cold start and produce an estimated 17.4 pounds of NO_x and 16.5 pounds of CO during that 30 minute period. Based on an analysis similar to the one prepared for the turbines, TDC anticipates a maximum of 20 startups per year for the combined three reciprocating gas engines and a total of 21,960 operating hours. At 30 minutes per startup, the time period when reciprocating gas engines would be operating under startup conditions amounts to an estimated 10 hours (600 minutes) per year when reciprocating gas engines would be operating in startup mode. This time equates to less than 0.046% of the total yearly operation. The engines could be restarted up to 44 times per year before the startup operating conditions amounted to more than 0.1% of total operating time. Startup conditions for the reciprocating gas engines will be an intermittent operating circumstance.

Manufacturer's experience with HRSG maintenance is that their availability/reliability is approximately 95-98% of the time. Additional

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startups/shutdowns would not result from maintenance requirement for the HRSGs. HRSG maintenance is anticipated to occur during periods when the associated gas combustion turbine or reciprocating gas engine is being maintained.

Cold start emissions from both the combustion turbines and reciprocating gas engines are shown below.

Table 2-5. Cold Start Emissions per Event

Pollutant	**Cold Start Emissions (lb/event)**	**Number of Events**	**Cold Start Emissions (tpy)**
GE LM2500 (10 minute start-up)			
NO_x	1.7	31	0.026
CO	1.4	31	0.022
Wartsila 18V50SG (30 minute start-up)			
NO_x	17.4	20	0.174
CO	6.5	20	0.065
VOC as CH_4 equivalent	11.0	20	0.110
PM_{10}	2.9	20	0.029
$PM_{2.5}$	2.9	20	0.029

Note: Emissions @ ref 15% O2

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3.0 NEW SOURCE REVIEW REQUIREMENTS

3.1 NATIONAL AND STATE AAQS

As a result of the CAA, EPA has enacted primary and secondary NAAQS for six air pollutants (40 CFR 50). Primary NAAQS are intended to protect the public health with an adequate margin of safety, and secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects associated with the presence of pollutants in the ambient air. Delaware has also adopted ambient air quality standards (AAQS) (7 DE Admin. Code 1103). Table 3-1 presents the current national and Delaware AAQS.

Areas of the country in violation of AAQS are designated as nonattainment areas and new sources to be located in or near these areas may be subject to more stringent air permitting requirements. The Wolf 1 CHP site is located in New Castle County, which presently is designated in 40 CFR 81.308 as better than national standards for total suspended particulates (TSPs) and SO_2, unclassifiable/attainment for CO, unclassifiable or better than national standards for NO_2, and nonattainment for 8-hour ozone, 1-hour ozone, and $PM_{2.5}$. New Castle County is not designated for PM_{10} and lead.

Delaware also has a 3-hour AAQS for hydrocarbons, exclusive of methane, of 160 micrograms per cubic meter ($\mu g/m^3$) not to be exceeded more than once per year. This concentration is measured over a 3-hour period from 6 to 9 a.m. local time. In addition, Delaware has an AAQS for hydrogen sulfide of 0.06 part per million (ppm) not to be exceeded over any consecutive 3-minute period and 0.03 ppm not to be exceeded over any 1-hour period.

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Table 3-1. National and Delaware Ambient Air Quality Standards
([μg/m^3] unless otherwise stated)

Pollutant	Averaging Periods	National Standards		Delaware Standards μg/m^3
		Primary	Secondary	
SO_2	1-hour *	196		
	3-hour †		1,300	1,300
	24-hour †	365		365
Suspended PM	24-hour †			260
	Annual ‡			75
PM_{10}	24-hour §	150	150	150
	Annual ¥	50	50	50
$PM_{2.5}$	24-hour #	35	35	65 **
	Annual ††	15	15	15
CO	1-hour †	40,000		40,000
	8-hour †	10,000		10,000
Ozone (ppmv)	1-hour ‡‡			0.12
	8-hour §§	0.08	0.08	0.08
NO_2	1-hour	188 ¥¥	188	
	Annual ##	100	100	100
Lead				1.5**
	Rolling 3-month average	0.15	0.15	

Note: ppmv = part per million by volume.

* Standard based on 3-year average of the 99th percentile of the annual distribution of 1-hour daily maximum SO_2 concentrations.
† Not to be exceeded more than once per calendar year.
‡ Geometric mean.
§ The standards are attained when the expected number of days per calendar year with a 24-hour average concentration above 150 μg/m^3, as determined in accordance with 40 CFR 50 Appendix K, is equal to or less than one.
¥ The standards are attained when the expected annual arithmetic mean concentration, as determined in accordance with 40 CFR 50 Appendix K, is less than or equal to 50 μg/m^3.
98th percentile concentration, as determined in accordance with 40 CFR 50 Appendix N.
** Delaware has not yet incorporated 24-hour $PM_{2.5}$ or rolling 3-month average lead NAAQS into their regulations.
††Arithmetic mean concentration, as determined in accordance with 40 CFR 50 Appendix N.
‡‡Standard attained when the expected number of calendar days per calendar year with maximum hourly average concentrations above the standard is equal to or less than 1, as determined by 40 CFR 50, Appendix H.
§§Standard attained when the average of the annual 4th highest daily maximum 8-hour average concentrations over a 3-year period are less than or equal to the standard, as determined by 40 CFR 50, Appendix I.
¥¥Standard based on 3-year average of the 98th percentile of the annual distribution of 1-hour daily maximum NO_2 concentrations.
##Arithmetic mean.

Sources: 40 CFR 50.
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3.2 NONATTAINMENT NSR APPLICABILITY

The Wolf 1 CHP site is located in New Castle County, which presently is designated as a nonattainment area for the 8-hour ozone standard and $PM_{2.5}$. Ozone concentrations are elevated in the summer months when the more intense sunlight interacts with NO_x and VOCs to form photochemical oxidants, including ozone.

Nonattainment pollutants which exceed major source thresholds in a nonattainment area are subject to NNSR requirements as defined in 7 DE Admin. Code 1125 Section 2.0. Table 3-2 presents projected annual facility emissions for TDC and major source thresholds. Due to the projected annual facility NO_x and VOC emissions exceeding the major stationary source thresholds of 25 tpy in an ozone nonattainment area, the Wolf 1 CHP facility will be subject to NNSR requirements for NO_x and VOCs.

Table 3-2. NSR Major Source Thresholds

Pollutant	Estimated PTE Annual Emissions (tpy)	Major Source Threshold (tpy)
NOx	**74.11**	**25**
VOC	**81.36**	**25**
CO	78.83	100
SO_2	20.73	100
PM Total	59.29	100
PM_{10}	59.29	100
$PM_{2.5}$	59.29	100
HAPs (Individual / Aggregate)	9.81/13.44	10/25
H_2SO_4	8.0	100
Greenhouse Gases (GHG) in CO2e*	**901,697**	**100,000**

Values that exceed Major Source Thresholds are shown in bold font

The Wolf 1 CHP facility will **not** be subject to NNSR requirements for $PM_{2.5}$ since the projected emissions do not exceed the major source threshold of 100 tpy as shown in Table 3-2. $PM_{2.5}$ is addressed in accordance with State of Delaware Minor New Source Review requirements (see section 3.5).

General NNSR requirements for NO_x are enumerated in 7 DE Admin. Code 1125 Section 2.0, Emissions Offset Provisions. In summary, the special requirements applicable to this project are as follows:

- Each other major facility in Delaware "owned or operated by the applicant, or any entity controlling, controlled by, or under common control with the

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applicant," must be in compliance with applicable emissions limitations and standards or have a federally enforceable plan for compliance;

- Emissions sources will comply with LAER;
- Facility potential NO_x and VOC emissions must be offset with emissions reductions at a ratio of 1.3 to 1 to provide a positive net air quality benefit. Such NO_x and VOC emissions reduction credits (ERCs) must be procured prior to facility startup; and
- An analysis must be conducted of "alternative sites, sizes, production processes, and environmental control techniques;" the alternatives analysis must demonstrate that the "benefits of the proposed source significantly outweigh the environmental and social costs imposed as a result of its location, construction, or modification."

The proposed facility will not be able to commence operation until the required NO_x offsets (ERCs) are procured. Based on the facility's potential NO_x emissions of 74.11 tons and applying the 1.3-to-1 ratio, Wolf 1 CHP will need to secure up to 96.34 tons of NO_x offsets. Based on the facility's potential VOC emissions of 81.36 tons and applying the 1.3-to-1 ratio, Wolf 1 CHP will need to secure up to 105.77 tons of VOC offsets. Offsets generally are acceptable if obtained within the same nonattainment area as the new or modified emissions unit. In accordance with 7 DE Admin. Code 1125 Section 2.5.6, offsets may also be obtained from any area with an equal or higher nonattainment classification than the area in which the emissions unit is located, provided the emissions from the other area have been demonstrated to contribute to a violation in the area in which the new emissions unit is located. Wolf 1 CHP will obtain the required, properly certified, offsets in accordance with these criteria.

3.3 PSD NSR APPLICABILITY

Facilities with potential emissions that exceed the major source thresholds in Table 3-2 are considered major stationary sources and are subject to PSD requirements as defined in 7 DE Admin. Code 1125 Section 3.0. Pollutants which are considered "significant" are subject to PSD review. "Significant" pollutants are those pollutants that exceed the PSD significant emission rates (SERs) listed in 7 DE Admin. Code 1125 Section 3.0. Table 3-3 presents projected facility emissions and SER levels to identify significant pollutants subject to PSD review. Effective July 1, 2011, GHG became subject to PSD requirements at a facility that is a new stationary source that will have the potential to emit 100,000 tpy or more CO_{2e}.

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Table 3-3. PSD SER Comparison

Pollutant	Estimated PTE Annual Emissions (tpy)	Significant Emission Rate (SER) (tpy)	Prevention of Significant Deterioration (PSD)
NOx*	**74.11**	**25**	**No***
VOC*	**81.36**	**25**	**No***
CO	78.83	100	No
SO_2	20.73	40	No
PM Total	**59.29**	**25**	**Yes**
PM_{10}	**59.29**	**15**	**Yes**
$PM_{2.5}$*	**59.29**	**10**	**No***
HAPs (Individual / Aggregate)	9.81/13.44	no SER	N/A
H_2SO_4	**8.0**	**7**	**Yes**
Greenhouse Gases (GHG)	**901,697**	**100,000**	**Yes**

Values that exceed Major Source Thresholds are shown in bold font

*Note: These pollutants exceed the SER. However, since New Castle County is nonattainment for these pollutants, PSD does not apply.

NO_x, VOC, PM/PM_{10}/PM2.5, H_2SO_4 mist, and GHG are each projected to exceed the applicable PSD SER level. New Castle County is located in a nonattainment zone for NO_x, VOC, and $PM_{2.5}$. As such, PSD regulations do not apply to these pollutants. PM/PM_{10}, H_2SO_4, and GHG are subject to the PSD NSR requirements as defined in 7 DE Admin. Code 1125 Section 3.0. Information included in Appendix B of this application provides detailed facility emissions rate estimates.

3.4 PSD REQUIREMENTS

3.4.1 CONTROL TECHNOLOGY REVIEW

An analysis of BACT is required for each pollutant proposed to be emitted in amounts equal to or greater than the PSD SER levels. BACT is defined as: "an emissions limitation, including a visible emissions standard, based on the maximum degree of reduction of each pollutant emitted which the Administrator, on a case by case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable…. through application of production processes or available methods, systems and techniques (including fuel cleaning or treatment or innovative fuel combustion techniques) for control of each such pollutant."

BACT determinations are made on a case-by-case basis as part of the NSR process and apply to each pollutant that exceeds the PSD SER thresholds shown in Table 3-3. Emissions units that emit or increase emissions of the

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applicable pollutants involved in a major modification or a new major source must undergo BACT analysis. Because each applicable pollutant must be analyzed, particular emissions units may undergo BACT analysis for more than one pollutant.

BACT is defined in terms of a numerical emissions limit. This numerical emissions limit can be based on the application of air pollution control equipment; specific production processes, methods, systems, or techniques; fuel cleaning; or combustion techniques. BACT limitations may not exceed applicable federal NSPS, national emissions standard for hazardous air pollutants (NESHAPs), or other emissions limitation established by state regulations.

BACT analyses must be conducted using the following five step top-down approach:

1. Available control technology alternatives are identified based on knowledge of the particular industry of the applicant, control technology vendors, technical journals and reports, and previous control technology permitting decisions for other identical or similar sources.

2. The identified available control technologies are evaluated for technical feasibility. If a control technology has been installed and operated successfully on the type of source under review, it is considered demonstrated and technically feasible. An undemonstrated control technology may be considered technically feasible if it is available and applicable. A control technology is considered available if it can be obtained commercially (i.e., the technology has reached the licensing and commercial sales phase of development). An available control technology is applicable if it can reasonably be installed and operated on the source type under consideration. Undemonstrated available control technologies that are determined to be technically infeasible, based on physical, chemical, and engineering principals, are eliminated from further consideration.

3. The technically feasible technology alternatives are rank-ordered by stringency into a control technology hierarchy.

4. The hierarchy is evaluated starting with the top or most stringent alternative to determine economic, environmental, and energy impacts and assesses the feasibility or appropriateness of each alternative as BACT, based on site- specific factors. If the top control alternative is accepted as BACT from an economic and energy standpoint, evaluation of energy and economic impacts of the other alternative technologies is not required since the only reason for conducting these assessments is to document the rationale for rejecting a more stringent alternative

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technology as BACT. Instead, the applicant proceeds to evaluate the top case control technology for impacts of unregulated air pollutants or impacts in other media (i.e., collateral environmental impacts). If there are no issues regarding collateral environmental impacts, the BACT analysis is complete, and the top case control technology alternative is proposed as BACT. If the top control alternative is not applicable due to adverse energy, environmental, or economic impacts, it is rejected as BACT, and the next most stringent control alternative is considered.

5. This evaluation process continues until an applicable control alternative is determined to be both technologically and economically feasible, thereby defining the emissions level corresponding to BACT for the evaluated pollutant.

Chapter B of EPA's Draft New Source Review Manual, dated October 1990 describes in detail this five-step procedure for conducting a BACT analysis.

3.4.2 AMBIENT AIR QUALITY MONITORING

In accordance with the PSD requirements of 7 DE Admin. Code 1125 Section 3.0, an application for a PSD permit must contain, for each pollutant subject to review, an analysis of ambient air quality data in the area affected by the proposed major stationary source or major modification. The affected pollutants are those that the new or modified source would potentially emit in significant amounts (i.e., those that exceed the PSD SER thresholds shown in Table 3-3).

Preconstruction ambient air monitoring for a period of up to 1 year is generally required. Existing data from the vicinity of the proposed source may be used if the data meet certain quality assurance requirements; otherwise, additional data may need to be gathered. Guidance in designing a PSD monitoring network is provided by EPA's Ambient Monitoring Guidelines for Prevention of Significant Deterioration (1987a).

7 DE Admin. Code 1125 Section 3.0 provides an exemption that excludes or limits the pollutants for which an air quality monitoring analysis is conducted. This exemption states that a proposed facility will be exempt from the preconstruction ambient air monitoring requirements with respect to a particular pollutant if the emissions increase of the pollution from the new source would cause, in any area, air quality impacts less than the PSD *de minimis* ambient impact levels presented in Table 3-4. In addition, an exemption may be granted if the air quality impacts due to existing sources in the area of concern are less than the PSD *de minimis* ambient impact levels.

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Section 8.2 discusses the applicability of the PSD preconstruction ambient monitoring requirements to the proposed Wolf 1 CHP facility.

Table 3-4. PSD *De Minimis* Levels

Pollutant	**Averaging Time**	***De Minimis* Level (μg/m^3)**
NO_2	Annual	14
SO_2	24-Hour	13
CO	8-Hour	575
PM_{10}	24-Hour	10
Lead	Quarterly	0.1
Fluorides	24-Hour	0.25
Total Reduced Sulfur	1-Hour	10
H_2S	1-Hour	0.2
Reduced Sulfur Compounds	1-Hour	10

3.4.3 AMBIENT IMPACT ANALYSIS

An air quality or source impact analysis must be performed for a proposed major stationary source subject to PSD for each pollutant for which the increase in emissions exceeds the SERs (see Table 3-3) with the exception of GHG and H_2SO_4 mist. There currently are no AAQS for GHG or H_2SO_4 mist. Therefore, an ambient air quality impact analysis under PSD rules is not required for those pollutants. The PSD regulations specifically require the use of applicable EPA atmospheric dispersion models in determining conservative estimates of predicted ground level ambient air quality concentrations. Guidance for the use and application of dispersion models is presented in the EPA Guideline on Air Quality Models (GAQM) as published in Appendix W to 40 CFR 51. Full source impact analysis of criteria pollutants is not required typically when modeling results indicate that the net addition of criteria pollutants from new or modified sources are below the applicable PSD significant impact levels (SILs) presented in Table 3-5.

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Table 3-5. PSD SILs

Pollutant	Averaging Time	Significant Impact Level ($\mu g/m^3$)
NO_2	Annual	1
	1-Hour	7.5
SO_2	Annual	1
	24-Hour	5
	3-Hour	25
	1-Hour	7.8
CO	8-Hour	500
	1-Hour	2,000
PM_{10}	Annual	1
	24-Hour	5
PM2.5	Annual	0.3
	24-Hour	1.2
Lead	Quarterly	0.03

Ozone is one pollutant for which a source impact analysis typically is not required. Ozone is formed in the atmosphere on hot, sunny, summer days as a result of complex photochemical reactions. Models for ozone generally are applied to entire urban areas.

Various lengths of record for meteorological data can be used for impact analyses. A 5-year period can be used with corresponding evaluation of the highest of the second- highest (HSH) short-term concentrations for comparison to AAQS or PSD increments. The term highest, second-highest refers to the highest of the second-highest concentrations at all receptors (i.e., the highest concentration at each receptor is discarded). The second-highest concentration is significant because short-term PSD increments specify the standard should not be exceeded at any location more than once per year. If less than 5 years of meteorological data are used, the highest concentration at each receptor must be used.

In promulgating the 1977 CAA Amendments, Congress specified that certain increases above an air quality baseline concentration level for SO_2 and total suspended particulates (TSP) would constitute significant deterioration of air quality. The magnitude of the increment that cannot be exceeded depends on the classification of the area in which a new source (or modification) will have an impact. Three classifications were designated based on criteria established in the 1977 CAA Amendments. Initially, Congress promulgated areas as Class I (international parks, national wilderness areas, and memorial parks larger than 2,024 hectares [5,000 acres], and national parks larger than 2,428 hectares [6,000 acres]) or Class II (all other areas not designated as Class I). No Class III areas, which

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would be allowed greater deterioration than Class II areas, were designated. However, the states were given the authority to redesignate any Class II area to Class III status, provided certain requirements were met. EPA then promulgated, as regulations, the requirements for classifications and area designations.

On October 17, 1988, EPA promulgated PSD increments for NO_2. The effective date of the new regulation was October 17, 1989. However, the baseline date for NO_2 increment consumption was set at February 8, 1988. New major sources or modifications constructed after that date will consume NO_2 increments.

On June 3, 1993, EPA promulgated PSD increments for PM_{10}. The effective date of the new regulation was June 3, 1994. The increments for PM_{10} replaced the original PM increments that were based on TSP. Baseline dates and areas previously established for the original TSP increments remained in effect for the new PM_{10} increments. Revised NAAQS for PM, which include revised NAAQS for PM_{10} and $PM_{2.5}$, became effective on October 17, 2006. PSD increments, SILs and significant monitoring concentration levels for $PM_{2.5}$ PSD requirements became finalized effective December 20, 2010 (Federal Register, Volume 75, No. 202, October 20, 2010). Table 3-6 presents current PSD allowable increments. Section 8.2 discusses the applicability of the PSD allowable increments requirements to the proposed Wolf 1 CHP facility.

Table 3-6. PSD Allowable Increments

Pollutant	**Averaging Time**	**PSD Allowable Increment (μg/m^3)**		
		Class I	Class II	Class III
PM_{10}	Annual arithmetic mean	4	17	34
	24-Hour maximum*	8	30	60
$PM_{2.5}$	Annual arithmetic mean	1	4	8
	24-Hour maximum*	2	9	18
SO_2	Annual arithmetic mean	2	20	40
	24-Hour maximum*	5	91	182
	3-Hour maximum*	25	512	700
NO_2	Annual arithmetic mean	2.5	25	50

*Maximum concentration not to be exceeded more than once per year at any one location.

Sources: 40 CFR 52.21.

The term "baseline concentration" evolved from Federal and state PSD regulations and denotes a concentration level corresponding to a specified baseline date and certain additional baseline sources. By definition in the

PSD regulations, as amended, baseline concentration means the ambient concentration level that exists in the baseline area at the time of the applicable minor source baseline date. A baseline concentration is determined for each pollutant for which a baseline date is established based on:

- The actual emissions representative of sources in existence on the applicable minor source baseline date.
- The allowable emissions of major stationary sources that commenced construction before the major source baseline date but were not in operation by the applicable minor source baseline date.

The following will not be included in the baseline concentration and will affect the applicable maximum allowable increase(s) (i.e., allowed increment consumption):

- Actual emissions from any major stationary source on which construction commenced after the major source baseline date.
- Actual emissions increases and decreases at any stationary source occurring after the minor source baseline date.

Determination of the baseline concentration is not necessary to determine the amount of PSD increment consumed. Instead, increment consumption calculations need only reflect the ambient pollutant concentration change attributable to emissions sources that affect an increment. Major source baseline date means January 6, 1975, for PM (TSP/PM_{10}) and SO_2 and February 8, 1988, for NO_2. Minor source baseline date means the earliest date after the trigger date on which the first complete application was submitted by a major stationary source or major modification subject to the requirements of 40 CFR 52.21. The trigger dates are August 7, 1977, for PM (TSP/PM_{10}) and SO_2 and February 8, 1988, for NO_2.

In this report, Sections 7.0 (Air Quality Impact Analysis Methodology) and 8.0 (PSD Class II Air Quality Impact Analysis Results) provide the ambient impact analyses for the Wolf 1 CHP facility.

3.4.4 ADDITIONAL IMPACT ANALYSES

PSD regulations require additional impact analyses for three topics: associated growth, soils and vegetation impact, and visibility impairment. The level of analysis for each area should be commensurate with the scope of the project. A more extensive analysis would be conducted for projects having large emissions increases than those that will cause a small increase in emissions.

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The growth analysis generally includes:

- A projection of the associated industrial, commercial, and residential growth that will occur in the area;
- An estimate of the air pollution emissions generated by the permanent associated growth; and
- An air quality analysis based on the associated growth emissions estimates and the emissions expected to be generated directly by the new source or modification.

The soils and vegetation analysis typically is conducted by comparing projected ambient concentrations for the pollutants of concern with applicable susceptibility data from the air pollution literature. For most types of soils and vegetation, ambient air concentrations of criteria pollutants below the NAAQS will not result in harmful effects. Sensitive vegetation and emissions of toxic air pollutants could necessitate a more extensive assessment of potential adverse effects on soils and vegetation.

The visibility impairment analysis pertains particularly to Class I area impacts and other areas where good visibility is of special concern. A quantitative estimate of visibility impairment is conducted, if warranted by the scope of the project. Section 9.0 of this report provides the additional impact analyses for the Wolf 1 CHP facility.

3.5 DELAWARE MINOR NEW SOURCE REVIEW PROGRAM

Delaware regulates non-major sources under their minor new source review program contained in 7 DE Admin. Code 1125 Section 4.0 *Minor New Source Review*. This regulation applies to new stationary sources with the potential to emit 5 tpy or more of NO_x, VOC, sulfur oxides, $PM_{2.5}$, and aggregate HAPs.

Therefore, pollutants that are identified as <u>not</u> subject to PSD <u>or</u> NNSR, may be subject to Minor New Source Review, if emissions exceed the MNSR thresholds. Table 3-7 lists the pollutants that were exempt from PSD and NNSR. Based on the estimated emissions, CO, SO_2, $PM_{2.5}$ and HAPs are subject to MNSR.

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Table 3-7. New Source Review Permitting Track

Pollutant	Estimated Annual Emissions (tpy)	PSD	NNSR	MNSR
NO_x	74.11		X	
CO	78.83			X
VOC	81.36		X	
SO_2	20.73			X
PM Total	59.29	X		
PM_{10}	59.29	X		
$PM_{2.5}$	59.29			X
HAPs (Individual/Aggregate)	9.81/13.44			X
H_2SO_4	8.02	X		
Greenhouse Gases (GHG) CO_{2e}	901,697	X		

MNSR includes installing and operating emissions control technology that limits emissions to the atmosphere by meeting the BACT, LAER, or control technologies approved either in advance by DNREC or on a case-by case basis. NO_x and VOCs are subject to NNSR and Wolf 1 CHP will be required to install the most stringent control technology equivalent to LAER for these pollutants. CO, SO_2, $PM_{2.5}$, and HAPs from the Wolf 1 CHP exceed the 5-tpy threshold, and the facility will be subject to the Delaware MNSR program. Section 5.0 of this report provides the BACT assessment for those substances.

3.6 DELAWARE CO_2 BUDGET TRADING PROGRAM

The Wolf 1 CHP is not subject to 7 DE Admin. Code 1147 (Delaware's component of the CO_2 Budget Trading Program). None of the proposed power units will serve an electricity generator with a nameplate capacity equal to or greater than 25 MW_e.

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4.0 STATE AND FEDERAL EMISSIONS STANDARDS

4.1 NEW SOURCE PERFORMANCE STANDARDS

Section 111 of the CAA, Standards of Performance of New Stationary Sources, requires EPA to establish Federal emissions standards for source categories that cause or contribute significantly to air pollution. These standards are intended to promote use of the best air pollution control technologies, taking into account the cost of such technology and any other non-air quality, health, and environmental impact and energy requirements. These standards apply to sources that have been constructed or modified since the proposal of the standard. Since December 23, 1971, EPA has promulgated more than 75 standards. NSPS are codified in 40 CFR 60. NSPS regulations are also addressed in 7 DE Admin. Code 1120.

The Wolf 1 CHP facility's air emissions sources include seven dry, low NO_x, gas combustion turbines with HRSGs to support combined cycle operation, three lean-burn, spark-ignition, reciprocating gas engines with HRSGs to support combined cycle operation, and two cooling towers. The following subsections discuss those NSPS that potentially are applicable to the Wolf 1 CHP facility emission sources.

4.1.1 NSPS SUBPART JJJJ - STATIONARY SPARK IGNITION INTERNAL COMBUSTION ENGINES

Subpart JJJJ establishes emissions limits for spark ignited, reciprocating gas engine units rated at 500 Hp or more that commence construction after July 1, 2010. The Wolf 1 CHP facility reciprocating gas engines will be subject to the requirements of Subpart JJJJ.

NSPS Subpart JJJJ specifies emissions limitations, monitoring, reporting, and record- keeping requirements for NO_x, CO, and VOC. Applicable NSPS Subpart JJJJ emissions standards for each of the reciprocating gas engine units are summarized as follows:

NO_x – 82 ppmvd at 15% O_2

CO – 270 ppmvd at 15% O_2

VOC – 60 ppmvd at 15% O_2

The Wolf 1 CHP facility's lean-burn, spark ignition, four stroke reciprocating natural gas-fired engine units will have emissions well below the NSPS Sub- part JJJJ emissions standards and will comply with the applicable requirements of NSPS Subpart JJJJ.

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4.1.2 NSPS SUBPART KKKK—STATIONARY GAS COMBUSTION TURBINES

Subpart KKKK establishes emissions limits for natural gas combustion turbine units that commenced construction after February 18, 2005, and have a heat input at peak load equal greater than 50 MMBtu per hour HHV but less than or equal to 850 MMBtu per hour HHV. The gas turbines proposed for the Wolf 1 CHP will be in this category and will be subject to the requirements of Subpart KKKK.

NSPS Subpart KKKK specifies emissions limitations, monitoring, reporting, and record- keeping requirements for NO_x and SO_2. Applicable NSPS Subpart KKKK emissions standards for each of the proposed gas combustion turbine units are summarized as follows:

NO_x – 25 ppmvd at 15% O2
SO_2 – 0.90 lb/MWh gross energy output or
0.060 lb/MMBtu of heat input sulfur content for the fuel.

The proposed dry low NO_x, gas-fired combustion turbine units have NO_x emission rates well below the NSPS Sub-part KKKK emissions standard and the fuel supplied by Eastern Shore has a sulfur content that is less than the Subpart KKKK fuel requirement, based on monthly records provided by Eastern Shore (Williams Transo) which will be a source of the gas distributed to the proposed Wolf 1 CHP.

4.2 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS

The provisions of the CAA that address the control of HAP emissions, or air toxics, are found in Section 112. Section 112 of the CAA includes provisions for the promulgation of NESHAPs, or maximum achievable control technology (MACT) standards, as well as several related programs to enhance and support the NESHAPs program. Section 112 requires EPA publish and regularly update (at least every 8 years) a list of the categories and subcategories of major and area sources that emit HAPs. The Section 112(c) list of source categories was initially published in the Federal Register on July 16, 1992, and has been periodically revised thereafter. EPA must promulgate regulations establishing emissions standards (NESHAPs) for each category or subcategory of major sources and area sources of HAPs that are listed pursuant to Section 112(c). The standards must require the maximum degree of emissions reduction that EPA determines to be achievable by each particular source category. Different criteria for MACT apply for new and existing sources. Less stringent standards, known as generally available control technology standards, are allowed at the EPA Administrator's discretion for area sources.

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On March 29, 2005, EPA issued a final agency action delisting electric utility steam generating units from the CAA Section 112(c) source category list.

In general, the 40 CFR 63 NESHAPs are only applicable to major HAP sources (i.e., facilities that have potential emissions of an individual HAP of 10 tpy or more, and potential emissions of total HAPs of 25 tpy or more). The Wolf 1 CHP facility will have potential HAP emissions rates below these thresholds and, therefore, is a minor, or area, source of HAPs.

4.3 ACID RAIN PROGRAM (CCA TITLE IV)

The Wolf 1 CHP is not an affected unit subject to the requirements of the Acid Rain Program. 40 CFR 72.6(b)(4)(ii) offers the following exemption from the requirements of the Acid Rain Program:

> "(b) The following types of units are not affected units subject to the requirements of the Acid Rain Program. (4) A cogeneration facility which: (ii) For units which commenced construction after November 15, 1990, supplies equal to or less than one-third its potential electrical output capacity or equal to or less than 219,000 MWe-hrs actual electric output on an annual basis to any utility power distribution system for sale (on a gross basis)."

The Wolf 1 CHP has an electricity generation capacity of approximately 279 MW. If operated at that capacity for a year (8,760 hours), it would produce 2,444,040 MWe-hrs. TDC anticipates providing approximately 50 MW of power to the City of Newark through DMEC, a power distribution utility. If they provide an average of 50 MW of power over the course of a year, 438,000 MWe-hrs would be provided, which is approximately 17.90% of the Wolf 1 CHP capacity. Within the "equal to or less than one third of its potential capacity" provision of the Acid Rain Program exemption, the Wolf 1 CHP could provide up to 806,533 MWe-hrs to DMEC annually.

4.4 DELAWARE EMISSIONS STANDARDS

Delaware's air quality regulations are contained in Title 7, Natural Resources and Environmental Control, DE Admin. Code. The following is a brief description of the Delaware emissions regulations that are relevant to the Wolf 1 CHP:

- 7 DE Admin. Code 1104, *Particulate Emissions from Fuel-Burning Equipment* – Section 1104.2.0 limits PM from fuel-burning equipment to no more than 0.3 lb/MMBtu determined as the maximum 2-hour average. Due to the use of natural gas as the sole fuel source, the maximum PM emissions will be approximately 0.0066 lb/MMBtu for the combustion turbines and 0.0099 lb/MMBtu for the reciprocating gas turbines. Therefore, the Wolf 1 CHP will meet the requirements of this rule;

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- 7 DE Admin. Code 1105, *Particulate Emissions from Industrial Process Operations* – Section 1105.2.0 limits the potential PM emissions of cooling towers to 0.2 grains per standard cubic foot. Wolf 1 CHP's PM emissions will be less than 0.00001 grains per standard cubic foot. Section 1105.7.0 states that the concentration of potentially hazardous PM should be listed. Only negligible amounts of such substances (e.g., silica) are expected to be emitted from the cooling towers. Therefore, the Wolf 1 CHP will meet the requirements of this rule;
- 7 DE Admin. Code 1108, *Sulfur Dioxide Emissions from Fuel Burning Equipment* – Section 1108.2.2 and 2.3 specify maximum allowable sulfur contents for fuels prior to July 2016 and after July 2016, respectively. For natural gas, the specified sulfur content does not change. The maximum sulfur content is 1.0% by weight. Compliance with this requirement rests with Eastern Shore, the fuel vendor (supplier) for the Wolf 1 CHP. SO_2 Emissions from Fuel Burning Equipment—Section 1108.2.2 states that no person shall purchase or use fuel containing sulfur greater than 0.3% by weight. The sulfur content of the fuels used by Wolf 1 CHP will be well below the emissions limit of this rule. The natural gas will have a maximum sulfur content of 0.5 grains or less per 100 standard cubic feet (i.e., less than or equal to 0.0015% sulfur by weight);
- 7 DE Admin. Code 1112, *Control of NO_x Emissions* – Section 1112.3.2.2 addresses Reasonably Available Control Technology (RACT) for fuel burning equipment. In Section 1112.3.2.2.1, low NO_x burner technology is identified as RACT. Per section 1112.3.4, the reciprocating engines will have pre-ignition chamber technology where a rich mixture of fuel will be ignited by spark. The ignited rich mixture will flow into the combustion chamber where it will ignite a compressed lean fuel mixture. A similar two stage rich/lean combustion process (Dry Low NO_x system) will be used in the combustion turbines in compliance with the requirement for low NO_x burner technology. In accordance with Section 1112.3.2.4.3, the combustion turbines and reciprocating engines will have a Continuous Emissions Monitoring System (CEMS). Therefore, the Wolf 1 CHP will meet the requirements of this rule;
- 7 DE Admin. Code 1114, *Visible Emissions*—Section 1114.2.1 states that no more than 20% opacity for 3 minutes in 1 hour or 15 minutes in 24 hours shall occur. Wolf 1 CHP will comply with this rule;
- 7 DE Admin. Code 1116, *Sources Having an Interstate Air Pollution Potential* – Section 1116.3.2 states that "all new sources of air contaminants, whose emissions are carried into a neighboring state, shall control their emissions to such an extent as to not substantially affect the ambient air quality of the receptor state." Wolf 1 CHP's emissions will comply with this regulation; and
- 7 DE Admin. Code 1119, *Control of Odorous Air Contaminants* – Section 1119.2.0 states that "no person shall cause or allow the emissions of an odorous air contaminant such as to cause a condition of air pollution." Wolf 1 CHP will comply with this rule. This is a Delaware enforceable requirement only.

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5.0 CONTROL TECHNOLOGY ANALYSES

The proposed Wolf 1 CHP is subject to review with respect to the following control technology requirements:

- LAER for NO_x, $PM_{2.5}$ and VOCs. New Castle County is classified as nonattainment for ozone and $PM_{2.5}$. NO_x and VOCs are ozone precursors. The potential facility emissions of these substances exceed the applicable NNSR thresholds;
- BACT for PM_{10} and H_2SO_4, which exceeds the PSD significant emissions rate thresholds specified in 40 CFR 52.21(b)(23). New Castle County is classified as being in attainment or not listed for those pollutants;
- BACT for complying with minor new source review requirements of 7 DE Admin. Code 1125 for pollutants, including CO, SO_2, and HAPs, that have potential to be emitted at rates equal to or greater than 5 tpy; and
- BACT for GHG emissions if the total facility CO_{2e} potential emissions exceed 75,000 tpy and the facility is subject to PSD review for a regulated non-GHG pollutant or if the total facility CO_{2e} potential emissions exceed 100,000 tpy (per the "Tailoring Rule").

BACT and LAER requirements apply to each air emissions source at the facility that emits that particular pollutant. These analyses are discussed in the following subsections.

5.1 LOWEST ACHIEVABLE EMISSIONS RATE (LAER)

5.1.1 POLLUTANT APPLICABILITY

New Castle County retains the legacy designation of severe ozone nonattainment for the 1-hour ozone standard. Due to the projected annual facility NO_x and VOC emissions exceeding the major stationary source thresholds of 25 tpy in a severe ozone nonattainment area, as defined in 7 DE Admin. Code 1125 Section 2.0, the Wolf 1 CHP facility will be subject to NNSR requirements for NO_x and VOCs and a LAER analysis is required for these substances.

New Castle County is designated as nonattainment for $PM_{2.5}$. The projected annual emissions of $PM_{2.5}$ from the Wolf 1 CHP do not exceed 100 tpy. Therefore, a LAER assessment for $PM_{2.5}$ is not required, but a BACT analysis is applicable due to the MNSR requirement.

5.1.2 METHODOLOGY

LAER is defined in 7 DE Admin. Code 1101 Section 2.0, as: "The more stringent rate of emissions based on the following:

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(i) The most stringent emissions limitation which is contained in the implementation plan of any State for such class or category of source, unless the owner or operator of the proposed source demonstrates that such limitations are not achievable; or

(ii) The most stringent emissions limitation which is achieved in practice by such class or category of source.

In no event shall the application of this term permit a proposed new or modified facility to emit any pollutant in excess of the amount allowable under the new source standards of performance."

Sources of information that were used to identify the potential LAER alternatives include:

- EPA's Reasonably Available Control Technology (RACT)/BACT/LAER Clearinghouse [RBLC] database;
- Vendor information; and
- Experience with similar projects.

The following LAER analysis for NO_x and VOCs describes the available control technologies and discusses the most stringent emissions limitations that have been achieved in practice. The LAER assessment is discussed separately per stationary source beginning with the gas combustion turbines followed by reciprocating gas engines.

5.1.3 GAS COMBUSTION TURBINE EMISSIONS

Gas combustion turbines emit criteria pollutants including NO_x, CO, VOCs, and lesser amounts of PM, and SO_x as a byproduct of combustion or as a direct result of incomplete combustion. This LAER assessment is limited to the emissions of NO_x and VOCs.

NO_x emissions from gas combustion turbines consist of two components: oxidation of atmospheric nitrogen in combustion air (thermal NO_x and prompt NO_x) and conversion of chemically bound fuel nitrogen (FBN or fuel NO_x). Essentially all NO_x emissions originate as nitric oxide (NO). NO generated by combustion processes subsequently are further oxidized in the atmosphere to the more stable NO_2 molecule.

Thermal NO_x results from the oxidation of atmospheric nitrogen under high temperature combustion conditions. The amount of thermal NO_x formed is primarily a function of combustion temperature and residence time, air/fuel ratio, and, to a lesser extent, combustion pressure. Thermal NO_x increases

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exponentially with increases in temperature and linearly with increases in residence time as described by the Zeldovich mechanism.

Prompt NO_x is formed near the combustion flame front from the oxidation of intermediate combustion products. Prompt NO_x comprises a small portion of total NO_x in conventional near-stoichiometric combustors, but increases under fuel-lean conditions. Therefore, prompt NO_x is an important consideration with respect to low-NO_x combustors that use lean fuel mixtures. Prompt NO_x levels may also become significant with ultra-low- NO_x burners.

Fuel NO_x arises from the oxidation of non-elemental nitrogen contained in the fuel. The conversion of FBN to NO_x depends on the bound nitrogen content of the fuel. In contrast to thermal NO_x, fuel NO_x formation does not vary appreciably with combustion variables such as temperature or residence time. Presently, there are no combustion processes or fuel treatment technologies available to control fuel NO_x emissions. For this reason, the regulations typically contain an allowance for FBN directly or inherently (i.e., part of the emissions limit). Typically, natural gas contains a negligible amount of FBN. As such, fuel NO_x typically does not contribute significantly to total NO_x emissions from gas-fired turbines.

In general, VOC emissions from combustion turbines inherently are very low and largely dependent on the fuel source. Factors affecting VOC emissions include firing temperatures, residence time in the combustion zone, and combustion chamber mixing characteristics. VOC emissions generally are produced at the lowest rate when combustion turbines are operating at full load and combustion temperatures are high. Conversely, emissions of VOC generally increase during turbine partial load conditions, when combustion temperatures are lower.

Emissions of NO_x and VOC can be inversely related (i.e., decreasing NO_x emissions will result in an increase in VOC emissions). Accordingly, combustion turbine vendors have had to consider the competing factors involved in NO_x and VOC formation to develop units that achieve acceptable emissions levels for both pollutants. For instance, decreased combustion zone temperature due to the injection of water or steam for NO_x control leads to increases in VOC emissions. An increase in combustion zone residence time and improved mixing of fuel and combustion air will increase oxidation rates and cause a decrease in VOC emissions rates, but can produce more NO_x emissions.

The LAER assessment below begins with a discussion of applicable combustion turbine control technologies for NO_x, followed by a discussion of applicable control technologies for VOCs.

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5.1.3.1 Potential Control Technologies - NO_x

Available technologies for controlling NO_x emissions from combustion turbines include combustion process modifications and post-combustion exhaust gas treatment systems. A listing of available technologies for each of these categories follows:

Combustion Process Modifications:

- Water or steam injection and standard combustor design;
- Water or steam injection and advanced combustor design;
- Dry low-NO_x combustor design; and
- Catalytic combustion controls.

Post-Combustion Exhaust Gas Treatment Systems:

- Selective non-catalytic reduction (SNCR);
- Non-selective catalytic reduction (NSCR);
- Selective Catalytic Reduction (SCR); and
- SCONOx™.

A description of each of the listed control technologies is provided in the following subsections.

Water or Steam Injection and Standard Combustor Design

Injection of water or steam into the primary combustion zone of a combustion turbine reduces the formation of thermal NO_x by decreasing the peak combustion temperature. Water injection decreases the peak flame temperature by diluting the combustion gas stream and acting as a heat sink by absorbing heat necessary to vaporize the water (latent heat of vaporization) and raise the vaporized water temperature to the combustion temperature. High purity water must be employed to prevent turbine corrosion and deposition of solids on the turbine blades. Steam injection employs the same mechanisms to reduce the peak flame temperature with the exclusion of heat absorbed due to vaporization since the heat of vaporization has been added to the steam prior to injection. Accordingly, a greater amount of steam, on a mass basis, is required to achieve a specified level of NO_x reduction in comparison to water injection. Typical injection rates range from 0.3 to 1.0 and 0.5 to 2.0 pounds of water and steam,

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respectively, per pound of fuel. Water or steam injection will not reduce the formation of fuel NO_x.

The maximum amount of steam or water that can be injected depends on the combustor design. Excessive rates of injection will cause flame instability, combustor dynamic pressure oscillations, thermal stress (cold-spots), and increased emissions of CO and VOCs, due to combustion inefficiency. Accordingly, the efficiency of steam or water injection to reduce NO_x emissions also depends on turbine combustor design. For a given turbine design, the maximum water to fuel ratio (and maximum NO_x reduction) will occur up to the point where cold-spots and flame instability adversely affect safe, efficient, and reliable operation of the turbine. The use of water or steam injection and standard turbine combustor design generally can achieve NO_x exhaust concentrations of 42 ppmvd for gas-firing.

Water or Steam Injection and Advanced Combustor Design

Water or steam injection functions in the same manner for advanced combustor designs as described previously for standard combustors. However, advanced combustors are designed to generate lower levels of NO_x and tolerate greater amounts of water or steam injection. The use of water or steam injection and advanced turbine combustor design typically can achieve NO_x exhaust concentrations of 25 ppmvd for gas-firing.

Dry Low-NO_x Combustor Design

Dry low-NO_x combustors are designed to premix turbine fuel and air prior to combustion in the primary zone. The use of a premix burner results in a homogeneous air/fuel mixture without an identifiable flame front. This allows a lower flame temperature in the combustion zone, causing a decrease in thermal NO_x emissions.

Currently, premix burners are limited in application to natural gas and loads above approximately 35 to 50% of baseline due to flame stability considerations.

In addition to lean premixed combustion, dry low-NO_x combustors typically incorporate lean combustion and reduced combustor residence time to reduce the rate of NO_x formation. Dilution air is added to the combustion chamber which leans the fuel mixture and cools the hot combustor gases rapidly to temperatures below those needed for NO_x formation. Reduced residence time combustors

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add dilution air sooner than do standard combustors. The amount of thermal NO_x is reduced because the combustion gases are at a high temperature for a short period of time.

Current dry low-NO_x combustor technology typically can achieve NO_x exhaust concentrations of approximately 9 ppmvd or less using natural gas fuel, depending on the combustion turbine vendor.

Catalytic Combustion Controls (XONON™)

Another technology that is potentially capable of reducing gas turbine NO_x emissions to less than 3.5 ppmvd is catalytic combustion. Catalytica, Inc. was the first entity to commercially develop catalytic combustion controls for certain (mostly smaller) turbine engines and markets this system under the name XONON™. In October 2006, this technology was sold to Kawasaki Heavy Industries Ltd. It is not commercially available for larger combustion turbines. Therefore, catalytic combustion does not represent an available control option for the proposed GE LM2500 DLE combustion turbines.

Selective Non-Catalytic Reduction

The SNCR process involves the gas phase reaction, in the absence of a catalyst, of NO_x in the exhaust gas stream with injected ammonia or urea to yield nitrogen and water vapor. The two commercial applications of SNCR include the Electric Power Research Institute's NOxOUT™ and Exxon's Thermal DeNOx™ processes. The two processes are similar in that either ammonia (Thermal DeNOx™) or urea (NOxOUT™) is injected into the hot exhaust gas stream at a location specifically chosen to achieve the optimum reaction temperature and residence time. Simplified chemical reactions for the Thermal DeNOx™ process are as follows:

Reaction (1): $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

Reaction (2): $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

The NOxOUT™ process is similar with the exception that urea is used in place of ammonia. The critical design parameter for both SNCR processes is the reaction temperature. At temperatures below 1,600 degrees Fahrenheit (°F), rates for both reactions decrease allowing unreacted ammonia to exit with the exhaust stream. Temperatures between 1,600 and 2,000°F will favor

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reaction (1), resulting in a reduction in NO_x emissions. Reaction (2) will dominate at temperatures above approximately 2,000°F, causing an increase in NO_x emissions. Due to reaction temperature considerations, the SNCR injection system must be located at a point in the exhaust duct where temperatures are consistently between 1,600 and 2,000°F.

Non-Selective Catalytic Reduction

The NSCR process uses a platinum/rhodium catalyst to reduce NO_x to nitrogen and water vapor under fuel-rich (less than 3% oxygen [O_2]) conditions. NSCR technology has only been applied to automobiles and stationary reciprocating engines.

Selective Catalytic Reduction

In contrast to SNCR, SCR reduces NO_x emissions by reacting ammonia with exhaust gas NO_x to yield nitrogen and water vapor in the presence of a catalyst. Ammonia is injected upstream of the catalyst bed where the following primary reactions take place:

Reaction (3): $4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$

Reaction (4): $4NH_3 + 2NO_2 + O_2 \rightarrow 3N_2 + 6H_2O$

The catalyst serves to lower the activation energy of these reactions, which allows the NO_x conversions to take place at a lower temperature than the exhaust gas. The optimum temperatures can range from 350°F to 1,100°F, but typically is designed to occur between 600°F and 750°F, depending on the catalyst. Typical SCR catalysts include metal oxides (titanium oxide and vanadium), noble metals (combinations of platinum and rhodium), zeolite (alumino-silicates), and ceramics. Water vapor and elemental nitrogen are released to the atmosphere as part of the exhaust stream.

Factors affecting SCR performance include space velocity (volume per hour of flue gas divided by the volume of the catalyst bed), ammonia/NO_x molar ratio, and catalyst bed temperature. Space velocity is a function of catalyst bed depth. Decreasing the space velocity (increasing catalyst bed depth) will improve NO_x removal efficiency by increasing residence time, but will also cause an increase in catalyst bed pressure drop. The reaction of NO_x with ammonia theoretically requires a 1:1 molar ratio. Ammonia/NO_x molar ratios greater than 1:1 are necessary to achieve high NO_x removal efficiencies, due to imperfect mixing and other reaction

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limitations. Typically, ammonia/NO_x molar ratios are maintained at 1:1 or lower to prevent excessive unreacted ammonia (ammonia slip) emissions. As was the case for SNCR, reaction temperature is critical for proper SCR operation. Below the minimum temperature, reduction reactions (3) and (4) will not proceed. At temperatures exceeding the optimal range, oxidation of ammonia will take place resulting in an increase in NO_x emissions. NO_x removal efficiencies for SCR systems typically range from 80 to 90%.

SCR catalyst can be subject to deactivation by a number of mechanisms. Loss of catalyst activity can occur from thermal degradation, if the catalyst is exposed to excessive temperatures over a prolonged period of time. Catalyst deactivation can also occur due to chemical poisoning. Principal poisons include arsenic, sulfur, potassium, sodium, and calcium. Another consideration with the application of SCR technology is the possibility of "fouling" (i.e., formation of sticky ammonium sulfates and plugging the catalyst bed surfaces over time). This condition is caused by the use of high sulfur fuels and is especially problematic for combined-cycle operations using HRSGs.

EMx™ (SCONOx™)

EMx™ (formerly referred to as SCONOx™) is a multi-pollutant reduction catalytic control system offered by EmeraChem. EMx™ is a complex technology that is designed to reduce NOx, VOC, and CO simultaneously through a series of oxidation/absorption catalytic reactions.

The EMx™ system employs a single catalyst to oxidize CO to CO_2 and NO to NO_2, simultaneously. NO_2 formed by the oxidation of NO is absorbed subsequently onto the catalyst surface through the use of a potassium carbonate absorber coating. The EMx™ oxidation/absorption cycle reactions are:

Reaction (5): $CO + \frac{1}{2} O_2 \rightarrow CO_2$

Reaction (6): $NO + \frac{1}{2} O_2 \rightarrow NO_2$

Reaction (7): $2NO_2 + K_2CO_3 \rightarrow CO_2 + KNO_2 + KNO_3$

CO_2 produced by reactions (5) and (7) is released to the atmosphere as part of the exhaust stream. Due to absorption of NO_2 on the catalyst coating, the catalyst must be regenerated periodically. Following regeneration, the EMx™ catalyst has a

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fresh coating of potassium carbonate, allowing the oxidation/absorption cycle to begin again. Since the regeneration cycle must take place in an oxygen-free environment, the section of catalyst undergoing regeneration is isolated from the exhaust gas stream using a set of louvers.

The EMx™ operates at a temperature range of 300 to 700°F and, therefore, must be installed in the appropriate temperature section of a HRSG. For installations below 450°F, the EMx™ system uses an inert gas generator for the production of hydrogen and CO_2. For installations above 450°F, the EMx™ catalyst is regenerated by introducing a small quantity of natural gas with a carrier gas, such as steam, over a steam reforming catalyst and then to the EMx™ catalyst. The reforming catalyst initiates the conversion of methane to hydrogen, and the conversion is completed over the EMx™ catalyst. Water vapor (from the steam) and CO_2 would be released to the atmosphere during regeneration.

Consumable materials needed for the operation of the EMx™ control system include ambient air, natural gas, water, steam, and electricity. The primary consumable is natural gas used for regeneration gas production. Steam is used as the carrier/dilution gas for the regeneration gas. Electricity is required to operate the computer control system, control valves, and louver actuators.

Commercial experience to date with the EMx™ control system is based upon several small combined-cycle power plants located in California. Representative of these small power plants is a GE LM2500 turbine, owned by Sunlaw Energy Corporation, equipped with water injection to control NO_x emissions to approximately 25 ppmvd. The low temperature SCONOx™ control system (i.e., located downstream of the HRSG where the exhaust gas temperature is between 300 and 400°F) was retrofitted to the Sunlaw Energy facility in December 1996 and has achieved a NO_x exhaust concentration of 3.5 ppmv, resulting in an approximate 85% NO_x removal efficiency. This facility is no longer operating due to market factors. A high-temperature application of EMx™ (i.e., control system located within the HRSG at an exhaust gas temperature between 600 and 700°F) has been in service since June 1999 on a small, 5-MW solar combustion turbine located at the Genetics Institute in Massachusetts. Although considered commercially available for natural gas-fired combustion turbines, there currently are no known combined-cycle units of similar scale to those proposed for the Wolf 1 CHP that have demonstrated successful application of the EMx™ control technology.

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5.1.3.2 Technical Feasibility

Water/steam injection and standard combustor design, water/steam injection and advanced combustor, and dry low-NO_x combustor design would be feasible combustion process modifications for the project combustion turbines. The GE LM2500 DLE is equipped with dry low-NO_x burner technology for natural gas firing. By definition, this technology is feasible.

Of the post-combustion exhaust gas treatment technologies, SNCR is not feasible because the temperature required for this technology (between 1,600 and 2,000°F) exceeds that which will be found in the combustion turbine gas streams (less than 1,500°F). NSCR was also determined to be technically infeasible because the process must take place in a fuel-rich (less than 3% oxygen) environment. The oxygen content of the proposed combustion turbine exhaust gases is in excess of 12%.

SCR units have been used successfully in combined-cycle gas turbine and HRSG applications. Therefore, it is technically feasible for use in the proposed Wolf 1 CHP. The proposed GE LM2500 DLE combustion turbines will be fueled by pipeline-quality natural gas, which has inherently low metal and sulfur contents. Therefore, catalyst poisoning is unlikely to occur. Ammonia slip can be limited to 7 ppmvd (3-hour average) under all operating conditions. To ensure optimal performance of the catalyst, NO_x emissions can be monitored, periodic ammonia slip testing can be performed, ammonia inventory can be maintained, ammonia flow rate monitoring can be implemented, and periodic physical inspections of the catalyst bed can be done through the placement of "coupons" in the bed that can be visually checked and analyzed to assess catalyst life.

EMx™ is desirable in that it, unlike SCR, does not require ammonia. This technology appears to provide a rate of NO_x removal that is similar to the rate achievable using SCR. However, as discussed previously, there are many complex technical issues associated with this technology and there are few operating examples to view for treatment reliability and effectiveness, when compared to SCR technology. The installation of EMx™ technology would likely result in an increase in the back pressure in the exhaust system amounting to twice that of an SCR system, which might reduce the operating efficiency of the gas turbines and HRSG. The EMx™ technology will consume additional resources to support the regeneration process, adding to both capital and operating costs.

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5.1.3.3 Proposed NO_x LAER Emissions Limit for Combustion Turbines

To determine the most stringent NO_x emissions limit for the combustion sources, the EPA's RBLC database was queried for combined-cycle gas combustion turbines rated at less than 25 MW. BACT and LAER determinations were obtained for units combusting pipeline-quality natural gas for the past 10 years and are summarized in Appendix E, Table E-1. As shown, the lowest NO_x emissions limits are in the range of 2 to 2.5 ppmvd (3-hour average) at 15% oxygen for natural gas-fired combustion turbines, depending on the manufacturer and operating case. The typical control system used to achieve these emissions limits includes dry low-NO_x combustors and SCR units.

The proposed NO_x LAER emissions rate for the Wolf 1 CHP gas turbines is 2 ppmvd at 15% oxygen, based on a 3-hour average for base load operating cases. These proposed NO_x LAER emissions rates are consistent with the results of previous LAER and BACT determinations. Table 5-1 provides a summary of the proposed NO_x LAER emissions limit for all operating cases. The proposed control system to achieve these emissions limits is dry low-NO_x combustors and SCR. In all operating cases, ammonia slip will be limited to 7 ppm (3-hour average) at 15% oxygen.

Table 5-1 Proposed NO_X LAER Emissions Limits

Emissions Source	Proposed NO_x LAER Emissions Limit (3-hour average)	
Gas Combustion Turbines	2 ppmvd*	1.6 lb/hr†

*Corrected to 15% oxygen
†Maximum hourly emissions rate, excluding startup and shutdown emissions.

5.1.3.4 Potential Control Technologies - VOCs

There are two known available technologies for controlling VOC from gas turbines: combustion process design and oxidation catalyst.

Combustion Process Design

Combustion process controls involve combustion chamber designs and operation practices that improve the oxidation process and minimize incomplete combustion. Due to the high combustion

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efficiency of gas combustion turbines, approximately 99%, VOC emissions inherently are low. Additionally, burner control technologies, such as the Dry low-NO_x system proposed for control of NO_x formation, also promote complete combustion through use of a well-designed combustion sequence. Complete combustion reduces VOC formation or pass-through of VOCs contained in natural gas.

Oxidation Catalyst

Noble metal (commonly platinum or palladium) oxidation catalysts are used to promote oxidation of VOC to CO_2 and water at temperatures lower than would be necessary for oxidation without a catalyst. The design operating temperature range for oxidation catalysts is between 650 and 1,150°F.

Removal efficiency of VOC oxidation processes vary with inlet temperature. Removal efficiency increases with increasing temperature up to a temperature of approximately 1,100°F, with significant VOC oxidation occurring at temperatures above roughly 900°F. Inlet temperature must be maintained below 1,350 to 1,400°F to prevent thermal aging of the catalyst, which will reduce catalyst activity and pollutant removal efficiencies. Removal efficiency also increases with increased gas residence time, which is a function of catalyst bed depth. Increasing bed depth will increase removal efficiencies, but will also cause an increase in pressure drop across the catalyst bed.

VOC removal efficiency will vary with the species of hydrocarbon. In general, unsaturated hydrocarbons such as ethylene are more reactive with oxidation catalysts than saturated species such as ethane. A typical VOC control efficiency using oxidation catalyst is in the range of 30 to 50%.

Oxidation catalysts are susceptible to deactivation due to impurities present in the exhaust gas stream. Arsenic, iron, sodium, phosphorous, and silica (typically present in fuel oil) will all act as catalyst poisons causing a reduction in catalyst activity and pollutant removal efficiencies. Oxidation catalysts are also non-selective and will oxidize other compounds in addition to VOC. The non-selectivity of oxidation catalysts is important in assessing applicability to exhaust streams containing sulfur compounds. Sulfur compounds that have been oxidized to SO_2 in the combustion process will be further oxidized by the catalyst to SO_3. Higher SO_3 concentrations increase the potential for formation of ammonia salt particles and H_2SO_4 mist. These

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substances may condense and adhere to the ductwork and stack, resulting in corrosion and increased maintenance. Due to the oxidation of sulfur compounds and excessive formation of H_2SO_4 mist emissions, oxidation catalysts are not considered appropriate for combustion devices fired with fuels containing appreciable amounts of sulfur. The exclusive use of low-sulfur pipeline quality natural gas is proposed for the Wolf 1 CHP project.

5.1.3.5 Technical Feasibility

Both combustion process design and oxidation catalysts are considered technically feasible for the Wolf 1 CHP facility's combustion turbines. The application of both technologies represents the top level of control and, therefore, LAER for the control of VOCs.

5.1.3.6 Proposed VOC LAER Emissions Limit for Combustion Turbines

To determine the most stringent VOC emissions limit for the combustion turbines, the EPA's RBLC database was queried for combined cycle combustion turbines with capacities less than 25 MW firing natural gas. BACT and LAER determinations were obtained for the past 10 years and are summarized in Appendix E, Table E-2. As shown, the lowest VOC emissions limits are for natural gas-fired, combined-cycle, combustion turbines operating with good combustion practices and an attached oxidation catalyst. LAER emission rates for turbines operating with a similar exhaust flow rate are listed as 2 ppmvd (assumed to be based on 15% O_2) and 2.9 lb/hr. Another listed turbine of similar size posed a VOC emission rate of 0.6 lb/hr, but neither the technology used nor the basis of determination were listed in the database.

The proposed VOC LAER emissions limit for the Wolf 1 CHP gas combustion turbines is 2 ppmvd (3-hour average) or 0.46 lb/hr for all operating cases when firing natural gas (see Table 5-2). This proposed VOC LAER emissions limit is consistent with typical emissions limits for a GE LM2500 DLE combustion turbines operating with good combustion practices and equipped with an oxidation catalyst unit to treat the exhaust stream. Compliance will be demonstrated through good combustion practices and emissions monitoring. TDC plans to inspect the catalyst on a periodic basis and to place "coupons" in the catalyst bed to assess and ensure its functionality and performance. These proposed VOC LAER emissions rates are consistent with the results of previous LAER and BACT determinations.

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Table 5-2 Proposed VOC LAER Emissions Limit

Emissions Source	Proposed VOC LAER Emissions Limit (3-hour average)	
Gas Combustion Turbines	2 ppmvd*	0.46 lb/hr†

*Corrected to 15% oxygen
†Maximum hourly emissions rate, excluding startup and shutdown emissions.

5.1.4 RECIPROCATING GAS ENGINE EMISSIONS

This LAER assessment is limited to the emissions of NO_x and VOCs. CO emissions are addressed in the BACT analysis, Section 5.2 of this report.

The reciprocating gas engines proposed for the facility are categorized as 4-stroke, lean burn, with spark ignition. The primary emission pollutants of reciprocating engines include NO_x, CO, VOCs. Production of other emission pollutants such as oxides of sulfur (SO_x) and PM primarily is dependent on the fuel used. For instance, the sulfur content of the fuel determines emissions of sulfur compounds, primarily SO_2. As a result, SO_x and PM emissions from reciprocating gas-fired engines are low when compared to engines fired by other fuels, such as petroleum distillates.

NO_x emissions are usually the primary subject for reciprocating natural gas engines. NO_x emissions are essentially a mixture of NO and NO_2. As discussed in Section 5.1.3 above for gas turbines, there are three mechanisms that form NO_x: thermal NO_x, prompt NO_x, and fuel-bound NO_x. The predominant NO_x formation mechanism in reciprocating gas engines is thermal NO_x. Early reactions of nitrogen molecules in the combustion air and hydrocarbon radicals from the fuel can form prompt NO_x. Fuel-bound NO_x forms when the fuel contains nitrogen as part of the hydrocarbon structure. Natural gas has negligible chemically bound nitrogen. Therefore, Fuel-bound NO_x is not a significant component of total NO_x formed by reciprocating gas engines.

Volatile hydrocarbons or VOCs, include a wide range of organic compounds, some of which are also hazardous air pollutants. VOCs from reciprocating gas engines are emitted when some portion of the fuel remains unburned or partially burned (oxidized).

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The LAER assessment below begins with a discussion of applicable reciprocating gas engine control technologies for NO_x, followed by discussion of technologies available for controlling VOCs.

5.1.4.1 Potential Control Technologies – NO_x

Similar to combustion turbines, available technologies for controlling NO_x emissions from RGEs/HRSGs include combustion process modifications and post-combustion exhaust gas treatment systems. A listing of available technologies for each of these categories follows:

Combustion Process Modifications:

- Rich Burn;
- Lean Burn; and
- Clean Burn.

Post-Combustion Exhaust Gas Treatment Systems:

- Non-Selective Catalytic Reduction (NSCR);
- Selective Catalytic Reduction (SCR);
- Catalytic Absorption; and
- Lean-NO_x Catalysts.

A description of each of the listed control technologies is provided in the following subsections.

Rich Burn

Rich burn engines have a lower air-to-fuel ratio that limits the oxygen availability in the cylinder and results in lower NO_x emissions. This technology has a limitation of producing more CO and hydrocarbon emissions. This method also requires the installation of an automatic air to fuel ratio controller.

Lean Burn

Lean burn technology increases the air to fuel ratio resulting in decreased NO_x emissions due to lower combustion temperatures in the combustion chamber. Extra air is added to the combustion chamber, which dilutes the combustion gas, thus lowering peak flame temperature and thermal NO_x formation. This technology generally is coupled with use of a turbocharger that increases

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combustion air to the engine. Lean burn technology can increase VOC and CO emissions, if air-to-fuel ratios become too high to support complete combustion or result in temperatures becoming too low in the combustion chamber.

Clean Burn

Clean Burn or low emission combustion (LEC) is combustion of a very fuel lean mixture. The fuel mixture acts as a heat sink, lowering cylinder temperatures and reducing NO_x formation. Turbochargers and after coolers are added to provide the additional, cooled combustion air, which services to maintain the rated power output of the engine.

Non-Selective Catalytic Reduction (NSCR)

This post-combustion technology uses three-way catalysts to promote reduction of NO_x to nitrogen and water. The exhaust passes over a catalyst, such as a noble metal (platinum, rhodium or palladium) to non-selectively transform NO_x, CO and VOCs to N_2, CO_2 and H_2O. NSCR is only applicable to rich burn engines.

Selective Catalytic Reduction (SCR)

SCR is based on a catalyzed reduction of NO_x in combination with injected ammonia or urea solution. This technology is only applicable to lean burn engines (i.e., engines with greater than about 1% exhaust oxygen, since oxygen is a reagent in the selective reduction reaction). A drawback to SCR use is unreacted ammonia (slip) and monitors are necessary to provide correct control of ammonia injection rates to minimize slip. The SCR reduction chemistry was discussed previously in the LAER NO_x section for combustion turbines.

Catalytic Adsorption

Catalytic Adsorption includes the use of a single catalyst and hydrogen regeneration to remove carbon monoxide and nitrogen oxides. A precious metal oxidation catalyst simultaneously oxidizes CO to CO_2 and NO to NO_2.

Lean-NO_x Catalyst

A lean NO_x catalyst uses a reducing agent (diesel fuel) to facilitate catalytic conversions. Hydrocarbons in diesel fuel act as a

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reducing agent to facilitate the conversion of NO_x to nitrogen and water vapor.

5.1.4.2 Technical Feasibility

All of the listed technologies have been implemented and are commercially available. As such they are feasible technologies for consideration.

5.1.4.3 Proposed NO_x LAER Emissions Limit for Reciprocating Gas Engines

To determine the most stringent NO_x emissions limit for the reciprocating gas engines, the EPA's RBLC database was queried for internal combustion engines greater than 500 horsepower (hp) firing natural gas. BACT and LAER determinations were obtained for the past 10 years and are summarized in Appendix E, Table E-3. No reciprocating gas engines of comparable output (approximately 25,000 hp) were listed in the database and no LAER determination was posted. A 2003 BACT determination for one of the two largest engines listed in the database (4,730 hp), described the emission control technology as "Clean Burn" and provided a NO_x emission rate of 2.07 lb/MWh. Another large engine (4,735 hp) was listed as a case-by-case determination in 2005 and no technology was described. The listed NO_x emission rate for that engine was 2.95 lb/MWh. BACT determinations in 2004 for two relatively small engines listed lean burn as the technology used and provided a NO_x emission rate of 2.36 lb/MWh for both engines. A 2011 BACT determination for a small (550 kW) engine listed the technology as SCR and the NO_x emission rate as 0.62 lb/MWh. Other BACT determinations listed the applied technologies as turbochargers, intercoolers and good combustion practices. The NO_x emission rates for these engines were larger than the rates cited above.

The database listings suggest that a combination of combustion control technologies and post-combustion technologies would yield LAER. The lowest listed NO_x emission rate, 0.62 lb/MWh, was associated with use of SCR for post-combustion treatment. Lean burn technology apparently yielded the lowest NO_x emission rate of combustion technologies at 2.36 lb/MWh. However, the applicability of that rate to a much larger engine is not known. Wartsila, the manufacturer of the engines proposed for use in the Wolf 1 CHP, has indicated that their engine uses lean burn technology and can achieve a NO_x emission rate of 3.3 lb/MWh at full (100%) loading. Discussions with SCR equipment providers

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and Wartsila indicate that post-combustion treatment of the exhaust could lower the NO_x emission rate to 0.132 lb/MWh at full loading, which is a lower rate of emissions than the BACT rates found in the RBLC database. Based on this analysis, a rate of 0.132 lb/MWh is LAER for a natural gas-fired reciprocating engine.

The proposed NO_x LAER emissions limit for the Wolf 1 CHP reciprocating gas engines is 0.132 lb/MWh [5 ppmvd (3-hour average)] for all operating cases (see Table 5-3). This proposed NO_x LAER emissions limit is consistent with controlled emissions rates provided by Wartsila for an 18V50SG reciprocating engine with add-on emission controls, such as the proposed SCR units. Compliance will be demonstrated through good combustion practices and continuous emissions monitoring. This proposed NO_x LAER emissions rate is an improvement over emission rates listed as BACT in the RBLC database.

Table 5-3 Proposed NO_X LAER Emissions Limit

Emissions Source	Proposed NO_x LAER Emissions Limit (3-hour average)	
Reciprocating Gas Engines	5 ppmvd*	0.132 lb/MWh†

*Corrected to 15% oxygen
†Maximum hourly emissions rate, excluding startup and shutdown emissions.

5.1.4.4 Potential Control Technologies – VOCs

Parallel to gas combustion turbines, available technologies for controlling VOC emissions from reciprocating gas engines include combustion process modifications to promote complete combustion of fuel and post-combustion exhaust gas treatment systems. Lean burn technologies that incorporate use of pre-combustion chamber and spark induced ignition tend to promote complete fuel combustion in the main combustion chamber, as long as good combustion practices, such as maintenance and tuning are implemented. Oxidation catalysts can be used to reduce post-combustion emissions of CO and VOC in the same manner described in Section 5.1.3.4 for combustion turbines. For effective reduction of CO and VOC, the flue gas must be lean to promote the conversion of CO to CO_2 and hydrocarbon VOCs to H_2O and CO_2.

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5.1.4.5 Technical Feasibility

Both combustion process design and oxidation catalysts are considered technically feasible for controlling reciprocating gas engine VOC emissions. The application of lean burn technology and oxidation catalysts represents the top level of control. Therefore, these technologies are expected to produce LAER for the reciprocating gas engines.

5.1.4.6 Proposed VOC LAER Emissions Limit for the Reciprocating Gas Engines

To determine the most stringent VOC emissions limit for the reciprocating gas engines, the EPA's RBLC database was queried for internal combustion engines greater than 500 horsepower (hp) firing natural gas. BACT and LAER determinations were obtained for the past 10 years and are summarized in Appendix E, Table E-4. No LAER determinations were listed in the database. All of the engines listed in the RBLC database had smaller output ratings than the proposed Wartsila 18V50SG engines (25,000 hp). As such, the technologies presented in the database may not be applicable to engines in the large output class.

A 2009 BACT determination for a much smaller engine (875 hp) indicated that a "catalytic converter" was specified. The BACT emissions for that engine were 2.7 lb/hr, which translates to 4.135 lb/MWh. Several 2005 case-by-case determinations were listed, but had no technology descriptions were provided. These engines ranged in output between 440 hp and 3,105 hp. Listed emission rates varied with the listed output, ranging from 0.48 lb/hr (1.462 lb/MWh) for the 440 hp engine to 10.94 lb/hr (4.721 lb/MWH) for the 3,105 hp engine, but the variability of the emission rates was not linked in a one to one ratio to the rated output. A 2005 BACT determination for a 4,735 hp engine listed as incorporating an oxidation catalyst for exhaust treatment had a listed VOC emission rate of 7.1 lb/hr (2.009 lb/MWh). This engine had the largest rated output of the database entries. Two other small engines were listed as using oxidation catalysts for exhaust treatment to achieve VOC emission rates of 0.886 lb/MWh, per 2004 BACT analyses. As such, minimal definitive information was derived from the RBLC database that was useful for determination of LAER VOC emissions from reciprocating gas engines.

However, the database review suggests that LAER likely would be linked to a combined use of technology supporting complete

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combustion and post-combustion treatment by oxidation catalyst units. Wartsila indicates that the 18V50SG engine has an emphasize VOC emission rate of 1.39 lb/MWh at 100% load. That rate is less than the rates listed for BACT determinations in the RBLC database. Wartsila further indicates that when emissions are controlled through use of an oxidation catalyst, a VOC emission rate of 0.286 lb/MWh can be achieved at 100% loading. This emission rate is less than the emission rates listed in in the RBLC database as BACT. Based on the preceding analysis, a VOC emission rate of 0.286 lb/MWh is proposed as LAER for the Wolf 1 CHP reciprocating gas engines (see Table 5-4).

This proposed VOC LAER emissions limit is consistent with the information provided by Wartsila for an 18V50SG reciprocating engine with add-on emission controls. Compliance will be demonstrated through good combustion practices and continuous emissions monitoring. TDC plans to inspect the catalyst on a periodic basis and to place "coupons" in the catalyst bed to assess and ensure its functionality and performance. These proposed VOC LAER emissions rates are consistent with the results of previous LAER and BACT determinations.

Table 5-4. Proposed VOC LAER Emissions Limit

Emissions Source	Proposed VOC LAER Emissions Limit (3-hour average)	
Reciprocating Gas Engines	26 ppmvd*	0.286 lb/MWh†

*Corrected to 15% oxygen
†Maximum hourly emissions

5.2 BEST AVAILABLE CONTROL TECHNOLOGY

5.2.1 POLLUTANT APPLICABILITY

Pursuant to 40 CFR 52.21(j)(2), an analysis of BACT is required for each pollutant that will be emitted by the proposed project in amounts equal to or greater than the PSD significant emissions rates (SER). In addition, BACT is also required for facilities in Delaware when potential emissions exceed 5 tpy in accordance with 7 DE Admin. Code 1125. The proposed Wolf 1 CHP project has the potential to emit H_2SO_4, and PM_{10} in amounts that exceed the PSD SER. Potential NO_x and VOC emissions have been addressed through the LAER analysis summarized in Section 5.1. LAER emissions limitations for NO_x and VOC are required to be at least as stringent as those determined through BACT analysis. A separate BACT

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analysis for NO_x and VOC is not necessary (i.e., the LAER control technology analyses also serves as the BACT analyses for NO_x and VOC). Therefore, H_2SO_4 and $PM/PM_{10}/PM_{2.5}$, are addressed in this section of the report through BACT analysis. CO and SO_2 potential emissions will exceed 5 tpy. As a result, controls for those substances also are subject to an assessment of BACT. Lastly, the proposed Wolf 1 CHP project has the potential to emit GHG emissions (calculated as CO_{2e}) in amounts greater than 100,000 tpy. Therefore, GHG emissions will be subject to an assessment of BACT.

5.2.2 METHODOLOGY

BACT is defined in 7 DE Admin. Code 1125 Section 1.9, as:

> "…an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each pollutant subject to regulation under CAA which would be emitted from any proposed major stationary source or major modification which the Department, on a case-by-case basis, takes into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 7 DE Admin. Code 1120 and 1121. If the Department determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results."

BACT analyses were performed in accordance with the EPA top-down method as previously described in Section 3.4.1. The first step in the top-down BACT procedure is the identification of available control technologies. Alternatives considered included process designs and operating practices that reduce the formation of emissions, post-process exhaust controls that reduce emissions after they are formed, and combinations of these two control categories. Like the LAER analyses, sources of information used to identify control alternatives include:

- EPA's RBLC database;
- Vendor information; and

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- Experience from similar projects.

Following the identification of available control technologies, the next step in the analysis is to determine which technologies may be infeasible technically. Technical feasibility was evaluated using the criteria contained in Chapter B of the draft EPA NSR Workshop Manual (EPA, 1990). The third step in the top-down BACT process is the ranking of the remaining technically feasible control technologies from high to low in order of control effectiveness.

An assessment of energy, environmental, and economic impacts is then performed. The economic analysis employed the procedures found in the Office of Air Quality Planning and Standards Control Cost Manual (EPA, 1996). The fifth and final step is the selection of a BACT emissions limitation or a design, equipment, work practice, operational standard, or combination thereof corresponding to the most stringent, technically feasible control technology that was not eliminated based on adverse energy, environmental, or economic grounds.

If the most stringent or top control technology is selected, an assessment of energy and economic impacts is not required. In this case, a review of collateral environmental impacts is conducted to determine if selection of a less stringent alternative control technology is warranted. If there are no issues regarding collateral environmental impacts, the top control technology is proposed as BACT, and the BACT analysis is concluded.

Sections 5.2.3 through 5.2.8 provide control technology analyses using the five-step top- down BACT method for $PM/PM_{10}/PM_{2.5}$, CO, SO_2, H_2SO_4, and GHG emissions, respectively.

5.2.3 BACT ANALYSIS FOR $PM/PM_{10}/PM_{2.5}$ FROM GAS COMBUSTION TURBINES AND RECIPROCATING GAS ENGINES

Emissions of $PM/PM_{10}/PM_{2.5}$ from the proposed project will occur due to the combustion of natural gas in the turbines and the reciprocating engines. The choice of exclusively using pipeline quality natural gas ensures that the least amount of particulate matter will be produced by combustion. Combustion of any other fuel would result in the emission of more particulate matter to the atmosphere. The relative absence of suspended solids is the primary reason for the low emission of particulates from natural gas combustion. The second most significant reason is that natural gas combustion products are gases that, with the exception of water vapor, generally do not condense into liquids or solids at common atmospheric temperatures.

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A query and review of the EPA's RBLC database for BACT and LAER determinations for the past 10 years pertaining to PM control from natural gas-fired combustion turbines and reciprocating gas engines yielded no control practices or equipment that could be added to natural gas-fired turbines with rated capacities less than 25 MW or reciprocating gas engines with rated capacities greater than 500 hp, to lower particulate matter emissions, other than the implementation of good combustion practices. The results of the query are provided in Appendix E, Tables E-5 and E6. Good combustion practices, such as equipment maintenance and combustion equipment tune-ups, help to insure that the least amount of particulate matter is emitted. The conclusion to be drawn from this assessment is that the use of pipeline quality natural gas as a fuel and the implementation of good combustion practices is BACT for particulate matter emitted by combustion equipment, as summarized in Table 5-5 below. No further analysis is required for this topic.

Table 5-5
Proposed PM/PM10/PM2.5 BACT Emissions Limits for Gas Combustion Turbines and Reciprocating Gas Engines

Emissions Source	Proposed PM/PM10/PM2.5 BACT Emissions Limit (3-hour average)
Gas Combustion Turbines	Exclusive use of pipeline-quality natural gas and good combustion practices
Reciprocating Gas Engines	Exclusive use of pipeline-quality natural gas and good combustion practices

5.2.4 BACT ANALYSIS FOR PM/PM_{10}/$PM_{2.5}$ FROM COOLING TOWERS

Operation of the cooling towers will also be a source of PM emissions. PM/PM_{10}/$PM_{2.5}$ emissions from operation of the cooling towers will be particles formed by crystallization of the dissolved solids carried in water droplets discharged to the atmosphere. The water droplets evaporate causing the dissolved solids to coalesce and become particulate matter. The size of the particulates directly reflects the dissolved solid content of the water at the time of droplet formation. Large concentrations of dissolved solids tend to produce larger particulates after evaporation of the water, whereas small concentrations of dissolved solids tend to produce smaller particulates.

5.2.4.1 Potential Control Technologies for Cooling Tower PM

High efficiency drift eliminators are a potential control technology for PM/PM_{10}/$PM_{2.5}$ emissions from cooling towers. High efficiency drift eliminators control PM/PM_{10}/$PM_{2.5}$ emissions by

capturing water droplets from the cooling tower exhaust using inertial separation principles and returning the captured water to the water basin for the cooling tower. A high efficiency drift eliminator can provide a drift rate (water loss rate) of 0.0005% of the total recirculating cooling water rate.

5.2.4.2 Technical Feasibility for Cooling Tower PM Control

A query and review of the EPA's RBLC database for BACT and LAER determinations for the past 10 years pertaining to PM control from cooling towers indicates that drift eliminators have been used for applications similar to those proposed for the Wolf 1 CHP. The results of the query are provided in Appendix E, Table E-7. Drift eliminators are by definition feasible technology.

5.2.4.3 Proposed PM/PM10/PM2.5 BACT Emissions Limit for Cooling Towers

The only control system to control $PM/PM_{10}/PM_{2.5}$ emissions from wet mechanical draft cooling tower is high efficiency drift eliminators. Wolf 1 CHP proposes to use high efficiency drift eliminators with a drift rate of 0.0005% as $PM/PM_{10}/PM_{2.5}$ BACT for the cooling towers. Based on the anticipated dissolved solids content of the cooling water following five cycles of concentration, the $PM/PM_{10}/PM_{2.5}$ emission rate would be 0.79 lb/hr.

A summary of the proposed $PM/PM_{10}/PM_{2.5}$ BACT emissions limit for cooling towers is provided in Table 5-6.

Table 5-6.
Proposed $PM/PM_{10}/PM_{2.5}$ BACT Emissions Limit for Cooling Towers

Emissions Source	Proposed PM/PM10/PM2.5 BACT Emissions Limit (3-hour average)
Cooling Towers	0.0005% drift rate†

†Maximum hourly emissions

5.2.5 BACT ANALYSIS FOR CO

CO emissions result from the incomplete combustion of carbon and organic compounds in the proposed gas combustion turbines and reciprocating gas engines. The general factors affecting the formation of VOC described previously in Section 5.1.3 also apply to CO emissions.

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5.2.5.1 Potential Control Technologies

Two technologies are potentially available for controlling CO emissions. Combustion process design can be used to control the formation of CO emissions and oxidation catalysts can be used to destroy CO in the exhaust from combustion processes. Combustion process design technologies are oriented to promote complete combustion of fuel through crafting air-to-fuel mixtures, staging the combustion process and ensuring adequate residence time for the complete oxidation of the fuel. As discussed in Section 5.1.3, oxidation catalysts support the transformation of CO to CO_2. Temperatures on the order of 500°F are needed to maximize the oxidation of CO to CO_2.

5.2.5.2 Technical Feasibility

Both control technologies are commercially available and have been used to control CO emissions. These technologies are technically feasible to apply to the proposed gas combustion turbines and reciprocating gas engines. The use of an oxidation catalyst represents top control technology. Therefore, detailed energy and economic impact analyses are not necessary.

No significant adverse energy or environmental impacts are associated with the use of good combustor designs and operating practices to minimize CO emissions. However, the use of oxidation catalysts will promote the conversion of a portion of the SO_2 in the exhaust to H_2SO_4 mist.

The oxidation catalyst does not remove CO. The catalyst promotes oxidation of CO to CO_2. This conversion has been considered a good, health-based, trade-off historically. CO is a chemical asphyxiant that reacts with hemoglobin in animals and starves the effected animals of oxygen, whereas CO_2 does not react with hemoglobin. However, CO_2 is a greenhouse gas.

5.2.5.3 Proposed CO BACT Emissions Limit

To determine the most stringent CO emissions limit for the gas combustion turbines and reciprocating gas engines, the EPA's RBLC database was queried for combustion turbines less than 25 MW firing natural gas and reciprocating engines > 500 hp. BACT and LAER determinations were obtained for the past 10 years and are summarized in Appendix E, Tables E-8 and E9.

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The proposed CO BACT emissions limit for the gas combustion turbines is 0.75 ppmvd at 15% oxygen (3-hour average) at 100% load and for the reciprocating gas engines load is 15 ppmvd at 15% oxygen (3-hour average) at 100% load (see Table 5-7). These proposed CO BACT emissions limits are consistent with typical emissions for a GE LM2500 DLE and Wartsila 18V50SG, following exhaust treatment by oxidation catalyst. Compliance will be demonstrated through good combustion practices and oxidation catalyst inspections. As is the case for VOC, TDC plans to inspect the catalyst on an as-needed basis and will place "coupons" in the catalyst bed to facilitate analysis of the catalyst functionality and ensure the performance of the catalyst.

Table 5-7 Proposed CO BACT Emissions Limits

Emissions Source	Proposed CO BACT Emissions Limit (3-hour average)	
Gas Combustion Turbines	0.75 ppmvd*	0.4 lb/hr†*
Reciprocating Gas Engines	15 ppmvd*	5.37 lb/hr†

*Corrected to 15% oxygen.
†Maximum hourly emissions rate for CT/HRSG based on base load at 20°F.

Sources: GE, 2011.
Wartsila, undated

5.2.6 BACT ANALYSIS FOR SO_2

Emissions of SO_2 from the proposed project will occur due to the combustion of natural gas in the gas combustion turbines and reciprocating gas engines. SO_2 emissions resulting from the combustion of natural gas will be low due to the inherently low sulfur content of the fuel. The turbines and reciprocating engines will be fueled with "pipeline-quality natural gas" obtained from Eastern Shore Natural Gas Company, containing no more than 0.5 grains of total sulfur per 100 standard cubic feet (gr S/100 scf).

5.2.6.1 Potential Control Technologies

Control is accomplished by limiting the fuel to pipeline quality natural gas. There are no post-combustion control systems, such as scrubbers or duct sorbent injection, for SO_2 emissions that have been applied to natural gas-fired combustion turbines or reciprocating engines.

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There are no post-combustion control systems that are technically feasible to control SO_2 emissions from natural gas-fired combustion turbines or reciprocating engines.

5.2.6.2 Technical Feasibility

Limiting the fuel to pipeline quality natural gas is feasible. To limit the potential for disruption of gas supply to the CHP, two gas service lines will be extended to the facility, each connected to separate transcontinental pipelines.

5.2.6.3 Proposed SO_2 BACT Emissions Limit for Gas Combustion Turbines and Reciprocating GAS Engines

SO_2 emissions from natural gas-fired combustion turbines and reciprocating engines are dependent on the sulfur content of the fuel. The sulfur content of pipeline-quality natural gas can vary slightly depending on the area of the country and the natural gas supplier. As summarized in Table 5-8, Wolf 1 CHP proposes the exclusive use of pipeline- quality natural gas as the sole fuel in the gas combustion turbines and reciprocating gas engines as BACT for SO_2.

Table 5-8 Proposed SO_2 BACT Emissions Limits

Emissions Source	Proposed SO_2 BACT Emissions Limit
Gas Combustion Turbines	Exclusive use of pipeline-quality natural gas
Reciprocating Gas Engines	Exclusive use of pipeline-quality natural gas

5.2.7 BACT ANALYSIS FOR H_2SO_4

Emissions of H_2SO_4 from the proposed project potentially will occur due to the use of oxidation catalyst to treat VOC and CO emissions. H_2SO_4 emissions could result from oxidation of SO_2 to SO_3 through the catalyst and subsequent reaction of SO_2 with water vapor H_2O to form H_2SO_4. The emission rate of H_2SO_4 will be low due to the low sulfur content of the natural gas fuel supply, which limits the formation of SO_2 and subsequent formation of H_2SO_4.

5.2.7.1 Potential Control Technologies

Control is accomplished by limiting the fuel to pipeline quality natural gas. There are no post-combustion control systems, such as

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scrubbers or duct sorbent injection, for H_2SO_4 emissions that have been applied to natural gas-fired combustion turbines or reciprocating engines.

5.2.7.2 Technical Feasibility

Limiting the fuel to pipeline quality natural gas is feasible. To limit the potential for disruption of gas supply to the CHP, two service lines will be extended to the facility, each connected to separate transcontinental pipelines.

There are no post-combustion control systems that are technically feasible to control H_2SO_4 emissions from gas combustion turbines or reciprocating gas engines.

5.2.7.3 Proposed H_2SO_4 BACT Emissions Limit for Gas Combustion Turbines and Reciprocating Gas Engines

As summarized in Table 5-9, Wolf 1 CHP proposes the exclusive use of pipeline-quality natural gas as the sole fuel in the gas combustion turbines and reciprocating gas engines as BACT for H_2SO_4.

Table 5-9 Proposed H_2SO_4 BACT Emissions Limits

Emissions Source	Proposed H_2SO_4 BACT Emissions Limit
Gas Combustion Turbines	Exclusive use of pipeline-quality natural gas
Reciprocating Gas Engines	Exclusive use of pipeline-quality natural gas

5.2.8 BACT FOR GHGs

Since Wolf 1 CHP will be a new major stationary source for a NSR pollutant other than GHG and will have CO_{2e} emissions greater than 75,000 tpy, Wolf 1 CHP is subject to PSD review for GHG including a BACT analysis. CO_{2e} emissions are defined as the sum of the mass emissions of each individual GHG adjusted for the respective global warming potential (GWP) of the substance using Table A-1 of the Greenhouse Gas Reporting Program (40 CFR 98, Subpart A). The anticipated GHG that will be emitted by combustion units in the Wolf 1 CHP are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Sulfur hexafluoride (SF_6) is another GHG that may be emitted from the facility. Unlike the other GHG, SF_6 is not a product of combustion. Sulfur hexafluoride is used as a gaseous dielectric medium (insulator) in

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pressurized high voltage electrical switches. Emissions to the atmosphere of SF_6 would be associated with possible leaks from this electrical equipment.

In March 2011, EPA published an updated version of the guidance document entitled PSD and Title V Permitting Guidance for Greenhouse Gases (EPA, 2011). This guidance document, which was originally published in November 2010, provides guidance on performing BACT analyses for GHG emissions. EPA's guidance affirms that a BACT analysis for GHG emissions must be conducted using the same five-step, top-down approach used for other NSR pollutants. Per EPA's guidance, the GHG BACT analyses should lead to implementing energy efficiency measures, in most cases.

Carbon dioxide is a product of complete combustion of fuel containing carbon. Complete combustion is the objective in any power generation technology using fossil fuel. The basic theoretical combustion equation for methane (CH_4) is:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

Carbon dioxide emissions are the product of the chemical reaction between the fuel and the oxygen, not a byproduct caused by imperfect combustion. Therefore, CO_2 emissions cannot be reduced by improving the combustion efficiency, and there is no technology available that can reduce CO_2 generation during combustion of carbon-based fuels without reducing combustion efficiency and producing other unwanted products, like carbon monoxide (CO). In fact, improvements in combustion efficiency always increase the production of CO_2, while decreasing the production of unwanted byproducts. The only effective means to minimize the amount of CO_2 generated by a fuel-burning power plant is through high-efficiency use of the heat energy released by the combustion reaction, which leads to lower fuel consumption. The reduced fuel consumption is the source of the reduced CO_2 emissions. Minimizing the amount of fuel required (in units of British thermal units) to produce a given amount of power output (in units of kilowatt-hours) results in the least amount of CO_2 generated per output power produced.

For natural gas-fired combustion units, methane emissions result from incomplete combustion of the fuel and can be reduced, but not eliminated, by improved combustion efficiency. Methane is a more potent GHG than carbon dioxide. As such, improvements in combustion efficiency do improve GHG emissions by converting more methane to the less potent GHG carbon dioxide.

The other GHG anticipated to be emitted by the combustion units is nitrous oxide (N_2O). Nitrous oxide is a byproduct of combustion that is formed in the combustion chamber. Natural gas combustion tends to produce less

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nitrous oxide than combustion of most other fuels due to the low nitrogen content of natural gas. As discussed in Section 5.1.3, most of the nitrogen oxide compounds, including nitrous oxide, are formed by the reaction of atmospheric nitrogen and oxygen as thermal NO_x and prompt NO_x in the elevated temperature of the combustion chamber. Unfortunately, combustion temperature controls that reduce NO and NO_2 formation tend to increase N_2O formation and vice versa. By example, the dry low NO_x and lean burn technologies that are being applied to the turbines and reciprocating engines to reduce NO and NO_2 emissions by lowering combustion temperatures will increase the amount of N_2O produced.

5.2.8.1 Potential Control Technologies

Technologies that formed the basis of an applicable NSPS must be considered in the BACT analysis, since a BACT emissions limit cannot be less stringent than an applicable NSPS emissions limit. The reciprocating gas engines are subject to the NSPS for Stationary Spark Ignition Internal Combustion Engines, 40 CFR 60, Subpart JJJJ. The gas combustion turbines are subject to the NSPS for Stationary Combustion Turbines, 40 CFR 60, Subpart KKKK.

Available control technologies or techniques that have a practical application to the control of GHG emissions include:

- Use of low emission fuels;
- Use of energy efficient equipment;
- Incorporation of energy efficient processes;
- Incorporation of add-on controls; and
- Good operating practices.

Low Emission Fuels

Of the fossil fuels available for combustion processes, natural gas produces the fewest number of GHG substances and the least concentrations of those substances. Use of natural gas as a fuel instead of other carbon-based fossil fuels (coal or petroleum) reduces GHG production for a given amount of power production.

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Energy Efficient Equipment

Use of energy efficient equipment reduces the amount of fuel consumed, which results in lower GHG emissions for the amount of power produced. Energy efficiency takes many forms. Those of principle interest in the case of the Wolf 1 CHP include:

- High efficiency combustion equipment; and
- High energy efficiency of equipment using the energy provided by the CHP.

Energy efficiency in the CHP equipment includes such items as completeness of combustion, maximization of heat energy transfer to mechanical energy, maximization of mechanical energy to electrical energy, reduction of friction losses and reduction of heat losses. In the data center, energy efficiency the primary focus is on the electrical and thermal efficiency of electronic equipment and building systems.

Energy Efficient Processes

Like the use of energy efficient equipment, employment of energy efficient processes lowers fuel consumption and results in lower emissions of GHG. Processes such as combined heat and power and combined-cycle operations of energy conversions are examples of energy efficient processes.

Add-on Controls

Add-on controls for addressing GHG emissions take several forms and are dependent (specific) to the substances being controlled. There are no known controls that can be applied to destroy CO_2 emissions. Technological control of CO_2 emissions are based on capture and either reuse or sequestration of that substance. These technologies are progressing from theoretical to pilot testing. Sequestration technologies appear to be dependent on geologic and geographic conditions, as they rely on the presence of geologic formations capable of storing and retaining CO_2 or large deep bodies of water that can retain CO_2 in dissolved form, under pressure. CO_2 is a useful gas in several industries. Capture and direct reuse of CO_2 from combustion sources is a promising technology for control of GHG if it displaces other technologies that form or liberate CO_2 from other sources (i.e., result in an overall minimization of release to the atmosphere). If capture and direct reuse replaces CO_2 technology that obtains CO_2 from the atmosphere, it would not result in a direct reduction of atmospheric

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CO_2 concentrations. Such a process likely would improve the energy efficiency to the CO_2 capture process due to the higher concentration of CO_2 in exhaust streams than in the atmosphere. The logical outcome of lower energy usage is a reduction of fuel consumption, which would result in a reduction of CO_2 emissions at a power source.

Technologies are being developed to destroy methane through the use of oxidation catalysts, based on a review of patent descriptions. The product of methane oxidation would be the same as for combustion, CO_2 and H_2O, at a ratio on one part CH_4 to 2 parts CO_2. Methane is 27 times more potent than CO_2 as a GHG. The trade-off of lower methane emissions for higher CO_2 emissions, assuming 100% removal efficiency, would be a 2,700% reduction of GHG effect for the environment.

Like CO_2, no add-on control technologies apparently exist for destroying N_2O. Most reaction-based technologies would result in the formation of NO or NO_2.

Good Operating Practices

Good Operating practices for combustion equipment include monitoring the efficiency of combustion and equipment operation to support identification of performance deterioration. Maintenance and tuning can then be scheduled and accomplished to re-establish high efficiency. Similarly, other heat transfer equipment can be monitored and maintained to retain high thermal efficiency throughout heat transfers in the HRSG, steam turbine, chiller, heat exchanger and cooling tower units. Good operating practice for processes includes inspection of equipment for indications of insulation breaches and open values or leaks in steam lines. Noted breaches, open values or leaks can be repaired (or closed) to maintain the heat retention of the process system. Similarly, switchgear can be inspected for leaks of SF_6 and action can be taken to reduce loss of SF_6 to the atmosphere.

5.2.8.2 Technical Feasibility

It is technically feasible to operate the proposed CHP solely using natural gas and this technology has been adopted. CHP is an energy efficient technology. It is technically feasible to operate a CHP facility in an even more energy efficient manner by combining cogeneration of heat and electricity with combined-cycle production of electricity. It is technically feasible to use energy efficient combustion equipment. The proposed GE LM2500 DLE gas

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combustion turbines and Wartsila 18V50SG reciprocating gas engines are very efficient combustion devices within the rated capacity classes for these types of engines. TDC will install inlet air chiller units to maintain combustion efficiency during conditions when warm ambient air temperatures exist.

Current operational planning indicates that the CHP plant should achieve a heat rate of 5,710 British thermal units per kilowatt-hour (Btu/kWh). This heat rate is appropriate for the proposed combinations of equipment and power produced, based on the higher heat value (HHV) of natural gas. This heat rate is equivalent to a net CHP plant efficiency of 59.8%. The net heat rate reflects the production of electricity and steam in the CHP during summer operating conditions and assumes electricity is supplied to the power grid and steam is supplied to the University of Delaware. A lower net heat rate (i.e., more efficient power production) is anticipated to be achieved during winter operating conditions. During operation of the CHP, the proposed efficiency condition will be maintained through good operating practices.

The applicant has proposed to pursue LEED accreditation for the data center and other supporting buildings. A guiding principle of LEED is energy efficiency. The data centers and supporting buildings will demonstrate energy efficiency in excess of current international building code requirements in pursuit of LEED accreditation. These energy efficiency measures in combination will minimize GHG emissions.

TDC is exploring incorporating a CO_2 capture and reuse technology. If that technology proves feasible for reducing CO_2 emissions, TDC will submit a separate construction permit application to DNREC before proceeding with application of the technology.

Carbon dioxide sequestration is not feasible at the proposed facility location. Neither geologic conditions nor large bodies of deep water are present.

The add-on oxidation catalyst system for CO and VOC control may have some capability to also oxidize CH4 to CO_2.

Good operating practices are feasible to implement.

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5.2.8.3 Proposed GHG BACT

Analysis has determined that BACT for GHG emissions consists of maintaining a high-efficiency plant design inherent to this type of gas-fired power plant. Wolf 1 CHP proposes a GHG BACT emissions limit of 901,697 short tons of CO_{2e} per year. This numerical GHG BACT emissions limit is based on the exclusive use of pipeline-quality natural gas. Compliance with this numerical GHG BACT emissions limit will be demonstrated by measuring and recording the total heat input from the combustion sources expressed in million British thermal units per year. CO_2 emissions will be calculated using the methodology for calculating CO_2 emissions under the ARP in accordance with 40CFR75, Equation G-4, as described in the following:

$$W_{CO2} = \frac{(F_c \text{ x } H_f \text{ x } U_f \text{ x MW } CO_2)}{(2{,}000)}$$

Where:

W_{CO2} = CO_2 emitted from combustion, tons/hr

MW CO_2 = Molecular weight of carbon dioxide, 44.0 lb/lb-mole

F_c = Carbon based F-factor, 1040 scf/MMBtu for natural gas, according to the procedures in Section 3.3.5 of Appendix E to 40CFR75 for other gaseous fuels

H_f = Hourly heat input in MMBtu, as calculated using the procedures in section 5 of Appendix E

U_f = 1/385 scf CO_2/lb-mole at 14.7 psia and 68 °F

Methane and nitrous oxide emissions will be calculated using emissions factors as defined in the Mandatory Greenhouse Gas Reporting Rule, Table C-2. CO_2e emissions will then be calculated using each GHG pollutant's respective global warming potential as defined in the Mandatory Greenhouse Gas Reporting Rule, Table A-1. Example CO_2e emissions calculations are provided in Appendix B.

5.2.9 BACT DURING STARTUP

BACT must be met at all times including during periods of startup. Pollutants subject to BACT analysis and review must address BACT emissions limits not only during normal operation, but also during startup.

NO_x and CO emissions are expected to have higher hourly emissions rates during periods of startup. This is due, in general, to the following two factors. One factor is that these pollutants are the products of incomplete combustion and complete combustion will not occur during periods of startup. The other factor is that NO_x and CO emissions are controlled by SCR and oxidation catalyst, respectively. When gas combustion turbine and reciprocating gas engine exhaust gas temperatures cannot heat the catalysts to the minimum activation temperature, such as during a cold startup, the SCR control system will not permit the flow of ammonia into the exhaust gas stream. Therefore, the SCR system will not function to reduce NO_x emissions. Below the minimum catalyst temperature, the oxidation catalyst will not function at peak efficiency to lower CO emissions.

Other pollutants, such as $PM/PM_{10}/PM_{2.5}$, SO_2, H_2SO_4, and VOCs, have lower emissions during startup as these emissions are directly proportional to the amount of fuel flow. Since fuel flow is lower during startup as compared to normal operation, emissions of these pollutants during startup will be lower when compared to normal operating conditions. Therefore, the BACT emissions limits proposed for these pollutants will be valid during periods of normal operation as well as during periods of startup.

The proposed BACT emissions limits for NO_x and CO during cold startup provided in Table 5-10:

Table 5-10. Proposed BACT Emissions Limits during Cold Startup

Status	**Cold Start**	
Equipment	**Emissions (lb./event)**	**Duration (minutes)**
Gas Turbines		
NO_x	1.7	10
CO	1.4	10
Reciprocating Engines		
NO_x	17.4	30
CO	6.5	30

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5.2.10 SUMMARY

Table 5-11 provides a summary of BACT control technologies proposed for the Wolf 1 CHP project.

Table 5-11. Summary of BACT Control Technologies

Equipment	Pollutant	Control Technology
A. Combustion Turbines and Reciprocating Gas Engines		
	VOC	Efficient combustion
		Oxidation catalyst
	PM/PM10/PM2.5	Exclusive use of pipeline-quality natural gas as primary fuel
	CO	Efficient combustion
		Oxidation catalyst
	SO2	Exclusive use of pipeline-quality natural gas as primary fuel
	H2SO4	Exclusive use of pipeline-quality natural gas as primary fuel
	GHG	Annual CO2e emissions limit expressed in tons per year
B. Cooling Tower		
	PM/PM10/PM2.5	High-efficiency drift eliminators

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6.0 PROJECT ALTERNATIVES ANALYSIS

In accordance with 7 DE Admin. Code 1125 Section 2.4.4, the application for a construction permit shall include "an analysis of alternative sites, sizes, production processes, and environmental control techniques for the proposed source which demonstrates that benefits of the proposed source significantly outweigh the environmental and social costs imposed as a result of its location, construction, or modification." The following subsections provide the analyses to satisfy this regulatory requirement.

This section is not intended to address specific control of pollutants. Section 5.0 provides a detailed discussion of the air emissions control system alternatives considered as part of the New Source Review.

6.1 SITE AND DESIGN ALTERNATIVES

This section highlights TDC's efforts to minimize or mitigate environmental impacts associated with the selected site and the equipment selected for the Wolf 1 CHP and Data Center facility. The entire facility development effort, from inception, has been driven by TDC's energy and environmental consciousness as exhibited by their pursuit of US Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certification for the project. This section presents some of the considerations included in TDC's decision to locate their facility at the STAR Campus, in the City of Newark, New Castle County, Delaware.

The concept of uninterruptable power has become industry standard for electronic data storage to assure reliable client access to stored data. This uninterruptible power requirement cannot be met through even multiple connections to a power supply grid alone. For instance, a failure of a transmission line, blackout or brownout in the grid would cause failure of a data storage center. At other data storage facilities, typified by those existing in New Castle County, Delaware, uninterruptible electrical power has been achieved through a combination of purchased, dual feed electricity from the regional supply grid, installation of large capacity emergency generating equipment capable of meeting the electricity demand of the data storage facility, and installation of large battery systems sized to instantaneously handle data center electrical loads in the event of grid power failure for a short period of time, while the emergency generator units are brought up to full power production. This typical system necessitates large investments in equipment that is seldom used (stranded assets) and results in: inefficient use of land, production of air emissions with no net benefit from emergency generator engine testing, and less than desirable energy efficiency, in part due to transmission system energy losses associated with obtaining electricity from remote locations. Such a system does not result in the generation of fewer air emissions in the region - it merely separates the locations of emission generation from the location where the electricity is used.

The proposed Wolf Technology Center 1 eliminates the negative aspects of typical

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uninterruptable power systems. The CHP generates the base power, including electricity and thermal, required to support the data center. It meets the uninterruptable power requirement by insuring that enough power generating equipment is operating so that, in the event any two primary power units fail, the remaining operating equipment could support the data center power load. Satisfaction of this requirement necessitates the production of more electricity than is demanded by the data center. This excess electricity will be supplied to the City of Newark for use, under routine operating conditions.

The number of power production units necessary to assure uninterruptable power is defined as N+2+1, where N is the number of power production units (by type) required to power the facility (produce base load), +2 is the number of additional power production units that are required to assure operational requirements are met if base load units fail, and +1 is the number of additional production units that are available for use when units are non-operational for maintenance. This requirement results in a strong preference for multiple, moderate capacity, power production units as opposed to fewer, large power units. In a system designed to provide uninterruptable power, multiple moderate capacity units result in a more efficient matching of power production to demand and less generation of excess electricity, resulting in fewer air emissions than would be the case if fewer, large capacity power production units were used.

The requirement for uninterruptable power also factors into the selection of the types of electrical power generating equipment for the facility. A combination of natural gas-fired turbines, reciprocating engines, and condensing steam turbines has been selected to produce electricity. Gas turbines have been selected as the principle power producing machines. Gas turbines are very efficient at converting fuel combustion heat to power and produce fewer criteria pollutants emissions per unit of heat compared to other combustion technologies when operated near full power capacity. The design of the CHP is based on the turbines operating at full power capacity. However, since gas turbines respond poorly to changing power demand, reciprocating engines were selected to meet varying loads. Reciprocating engines produce more criteria pollutants per unit of heat and require more maintenance than gas turbines, but produce power more efficiently under varying loads. The use of condensing steam turbines improves the overall thermal efficiency of the CHP, and through that improved efficiency, contributes to reducing air emissions per unit of power produced over simply cycle power generation facilities.

TDC selected natural gas over other fossil fuels (primarily petroleum and coal) due to the inherently lower air emissions that result from utilizing natural gas. Additionally, natural gas use requires less storage and handling space on site than would be necessary for use of other fossil fuels, which contributes to efficient land use.

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To maximize energy efficiency, and in turn reduce the amount of air emissions being produced for electrical power generation, heat exiting from the primary combustion units (gas turbines and reciprocating engines) will be used to generate steam (cogeneration). The steam will be used to power steam turbines in combined-cycle operation and absorption inlet air chillers. Three steam turbines in the Wolf 1 CHP will drive electrical generators to produce electrical power. A steam turbine will also drive a chiller that provides cooling for the data center. The combination of design features will make the proposed CHP thermally energy efficient. In addition, surplus steam will be exported to the University of Delaware for use thereby offsetting a portion of their need to generate steam to meet thermal loads.

The excess electricity generated by the CHP will be supplied to the City of Newark's power system under a power purchase agreement (PPA), replacing a portion of the current importation of electrical power from the regional PJM (Pennsylvania-Jersey-Maryland) power grid. The transmission of the Wolf 1 CHP electricity is more efficient than PJM-supplied electricity transmission due to the close proximity of the power plant to the end users (the data center and the City of Newark), which reduces line losses associated with long distance power transmission. To the extent that the CHP-supplied electricity offsets PJM electricity generated by simple cycle plants or plants fired by a coal or petroleum, fewer air emissions will be released during the production of the electricity. These aspects of the proposed system will benefit regional air quality by ensuring a more efficient transfer of electricity to end users, ultimately resulting in the production of less electricity, and fewer emissions to the region.

6.1.1 SELECTED SITE

TDC sought to redevelop a previously developed property rather than construct at a "greenfield" location. TDC's selection of the STAR Campus location was first and foremost based on the criteria it satisfied:

- The STAR Campus is a former industrial site, properly zoned for the proposed use, with an adequate amount of previously developed land available for siting the Wolf Technology Center 1; and
- STAR Campus is located in a mature, urbanized environment that has adequate public and private infrastructure to support most needs that will be imposed by the proposed facility. The location, and the entities present in the neighboring community, will support efficient use of the electrical and steam energy that will be produced by the proposed facility, which serves to conserve natural resources and realize that maximum benefits are derived from the air emissions produced.

STAR Campus is located within the City of Newark and close to a major user of electrical power and steam, the University of Delaware. The site is located in a portion of Delaware where there is no local production of base

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load electricity. This circumstance will support the efficient use of the energy released from the combustion of fossil fuel and serve to minimize the production of air emissions associated with energy use. Electricity generated in excess of the immediate demand of the Wolf Technology Center 1 will be transmitted to the City of Newark for distribution to City residents and businesses, offsetting the need to import electricity from more remote locations. Steam in excess of the demands within the Wolf Technology Center 1 will be transmitted to the University of Delaware for use in their distribution system, partially offsetting the need to generate that quantity of steam in the University's power plant to meet their demand. The overall thermal efficiency of the proposed CHP combined-cycle and cogeneration operation is anticipated to be approximately 60%, due in part to the site location selected. A more remotely located site for the CHP would not support this level of efficiency and would result in the wasting of heat generated by fossil fuel combustion, as commonly occurs in most existing electricity generating stations in the region. For instance, a site location that did not offer an outlet for steam would likely limit the energy efficiency of the plant to approximately 40%, a typical efficiency rating for a modern combined-cycle power plant. Few other locations in Delaware or neighboring states would support this efficiency benefit. Among the many benefits of higher energy efficiency is the corresponding reduction of air emissions produced for the same amount of power produced.

The STAR Campus location offered an additional benefit. The property is a DNREC Certified Brownfield and the project will bring jobs back into a location where many prior jobs of similar character have been lost. The proposed facility will generate approximately 370 fulltime equivalent jobs and 90 indirect jobs in a community that lost thousands of direct and indirect jobs with the closure of the former Chrysler Newark Assembly Plant during December 2008 and other nearby industrial and distribution facilities over the last decade. No other available location could provide a similar benefit.

The proposed site location should serve to minimize air emissions associated with future employee commuting. Bus and commuter rail service are available at STAR Campus. Few other locations in the State of Delaware could offer the combination of appropriate zoning and commuter rail service. The Delaware Department of Transportation (DelDOT), in conjunction with area commuter rail systems (DART, SEPTA and MART), is planning an expansion of existing commuter rail service and constructing a new railroad station adjacent to the STAR Campus. Future employees and clients of the proposed Wolf Technology Center 1 will be able to utilize that commuter rail service, which will suppress the generation of air emissions from vehicles. Commuting distances from existing residential areas are short enough to support a portion of the future work force walking or biking to work. STAR Campus is bounded by two state highways (DE Route 896 and DE Routes 2 and 4) and is located close to a major interstate highway (I-95). The state

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highways in the vicinity of the proposed project location previously handled the commuter traffic associated with the large number of employees at the former Chrysler Newark Assembly Plant. The vehicle loading associated with the fewer employees of the proposed Wolf Technology Center 1 will not burden the existing highway infrastructure and is not anticipated to lead to congestion and needless air emissions from idling vehicles.

The STAR Campus is located along the Northeast Corridor Railroad which provides freight service as well as the previously mentioned passenger service. The freight aspect of operations will facilitate the energy efficient delivery of large equipment and construction materials to the project site.

Water service is provided to the site by an existing utility system operated by United Water Delaware. That water system previously provided water to meet the demands of the Chrysler Newark Assembly Plant prior to closure of that facility. The water supply system has adequate capacity to supply the demand of the proposed Wolf 1 CHP and that demand is not a new burden for the utility. For water efficiency, the Wolf 1 CHP will incorporate closed-cycle steam production and closed-cycle cooling water systems. Steam condensate is collected and reused in steam production and cooling water is reused by circulating it through cooling towers. Both systems serve to minimize the water demand of power production and in turn, lessen the demand on the potable water system. The data center is anticipated to use gray water (rain water and chiller condensate) for flushing water closets and urinals and to irrigate landscape, which also lessens the demand on the potable water delivery system.

Wastewater service is provided by a public sewage collection system. A trunk sanitary sewer interceptor sewer is located along the southern side of the site, which has the capacity to convey the projected wastewater load from the Wolf Technology Center 1, which is anticipated to include condensate blow-down, cooling tower blow-down and sanitary wastewater. That sanitary sewer interceptor previously conveyed the wastewater load of the Former Chrysler Newark Assembly Plant. The anticipated wastewater load from the Wolf Technology Center 1 will not be a new or expanded burden on the existing municipal sewerage system.

The site currently is paved (nearly 100% impervious surface cover) and construction of the proposed Wolf Technology Center 1 offers the opportunity to reduce the quantity and quality of storm water runoff from the property. Currently, there is no management of storm water quantity or quality. There are no wetlands on site and there is no wildlife habitat on site. Therefore, adaptively reusing the property for the Wolf Technology Center 1 will not impact wetlands or impact local wildlife through habitat destruction.

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The site does not have natural gas service with sufficient capacity for the demand of the Wolf 1 CHP. TDC is in discussions with Eastern Shore Gas to secure delivery of an adequate, dual feed, gas supply. The dual feed will necessitate construction of high pressure/high volume gas mains from transmission pipelines located near Hockessin, Delaware and Elkton, Maryland.

6.2.2 DESIGN ALTERNATIVES

Alternative technologies and designs were considered by TDC for the Wolf 1 CHP equipment and are discussed in the following:

- Alternative generation technologies; and
- Air emissions control system alternatives.

The process of selecting natural gas as the fuel was a relatively straightforward choice – there is no fossil fuel that produces fewer emissions or waste products and the current supply of natural gas is abundant. Natural gas use is more energy efficient than other fossil fuels when considered holistically, which serves to conserve natural resources and lead to the production of energy at the least amount of air pollution feasible for the energy produced. According to Federal Department of Energy reports, less energy is required to extract, refine and transport natural gas than for oil or coal. The choice to couple cogeneration and combined-cycle technology with the natural gas-fired combustion equipment selected for the Wolf 1 CHP is also straightforward. The fuel and power technologies selected offer the following advantages over other fuels and technologies:

- Higher efficiency of electrical generation (as represented by heat rate in terms of Btu/kWh);
- Lower environmental impacts with regard to air emissions from use, fuel production (exploration, extraction and refining), and transport;
- Lower operation and maintenance costs; and
- Less acreage needed for plant footprint.

The facility's design will minimize pollution in a number of ways which will result in lower environmental impacts when compared to alternate power generating technologies. The facility will be cleaner and more efficient than many of the existing fossil fuel-fired electrical power generating plants in the ozone transport region. Therefore, the regional power generation that the Wolf 1 CHP displaces from other plants consuming coal, petroleum products or natural gas, which generally utilize single-cycle technology, or older combustion or emission control equipment, will provide local air quality improvements as well as general regional improvements. The high efficiency

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of the facility will also prevent pollution by requiring the combustion of less fuel per unit of energy produced. Construction of the facility will enable management of storm water quantity and storm water treatment to improve the quality of runoff in comparison to existing site conditions.

Specific systems within the facility have been conceived and designed to minimize pollution. Primary examples include:

- The use of natural gas as the sole fuel source for power generation, which will result in fewer air emissions, less solid waste generation and lower dust emissions than with the use of coal or petroleum;
- The selection of gas turbines and reciprocating engines that incorporate advanced low-NO_x combustion technology in the primary mode of operation to reduce emissions of NO_x, while improving the efficiency of combustion, which reduces the production of CO, VOC and PM at the same time;
- The incorporation of cogeneration and combined-cycle power generation that results in more efficient energy extraction per unit of fossil fuel burned, which lowers the quantity of pollutants emitted per unit of electricity and thermal energy produced;
- The use of an SCR system to control the emissions of NO_x from the combustion units;
- The use of an oxidation catalyst to control the emissions of CO and VOC from the combustion units; and
- Incorporation of storm water quantity and quality management.

In summary, the design alternatives selected, which utilize advanced technology and pipeline quality natural gas, along with LAER and BACT emission controls, contribute to minimization of the WOLF 1 CHP impact on the environment and make it compatible with the STAR Campus location site in the City of Newark. These decisions will make the Wolf 1 CHP cleaner and more efficient than most other existing or planned fossil fuel-fired power plants in Delaware or in the ozone transport region. The proposed Wolf Technology Center 1 will be an asset for the community as it will achieve positive economic benefits, makes use of existing developed land and infrastructure, support resource conservation through efficient use of energy in exchange for minimized emissions to the atmosphere, which, through the purchase of emission credits and offsetting power production at other regional facilities, will result in a net local improvement in air quality.

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6.2 BENEFIT-COST ANALYSIS

Construction and operation of the Wolf 1 CHP facility will result in economic and social effects. This subsection describes the socioeconomic benefits and costs.

6.2.1 PROJECT BENEFITS

A primary benefit to the region will be the introduction of a new forward looking economic development project that will create hundreds of good sustainable jobs, an even greater number of construction jobs and construction spending as well as significant investment in regional gas infrastructure and fiber optics while also providing a clean, and reliable energy power source and improvement of regional air quality. These project benefits are further discussed in the following paragraphs.

The near term construction impacts on local employment opportunities will be significant. This project will likely be the largest construction project that Delaware has seen in many years. Construction employment, likely to last approximately 2 years, will be a positive socio-economic benefit to the region and locality. TDC estimates that approximately 1,000 construction jobs (over the life of construction) will be generated as a direct result of the proposed project. Additional, indirect employment in the local area will occur primarily in retail and wholesale trade, business services, health services, and eating and drinking establishments. In addition, the local purchase of construction materials will have a significant beneficial impact to area supply companies.

Duffield Associates anticipates that New Castle County companies and residents, will receive a majority of the construction wages. Another local economic benefit from construction will be the use of local subcontractors and vendors to provide labor and goods.

Once operational, the Wolf 1 CHP and Data Center will create approximately 370 direct fulltime job equivalents and 90 indirect jobs. Additional contractor jobs to support ongoing plant maintenance are also anticipated. These jobs most likely will be filled by people who reside in Newark, New Castle County and nearby areas of Cecil County, Maryland and Chester County, Pennsylvania – the same area economically impacted by the closure of the Chrysler Newark Assembly Plant. The "ripple effect" of good paying jobs is well documented and will occur as a result of the Wolf Technology Center 1 project.

Construction of the facility will also generate significant public revenues through corporate and individual income taxes. Current forecasts prepared for TDC project that the State of Delaware would receive approximately $21.18 million from taxes and equipment purchases. Purchased services for

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wastewater conveyance and treatment will restore a portion of the City of Newark's revenue that was lost as a result of the closure of the former Chrysler Plant. Similarly, revenues to United Water Delaware, lost when Chrysler closed, will be restored. This restored revenue will aid with system maintenance expenses.

6.2.2 PROJECT SOCIO-ECONOMIC COSTS

No significant traffic problems are expected during the construction period. Much of the heavy equipment and materials for the Wolf Technology Center 1 is anticipated to arrive at the site by railroad, rather than by over the road transport. The road network around the proposed construction was developed to handle the employee traffic of the former Chrysler Newark Assembly Plant. The number of people traveling to or from the site during construction or when the facility becomes operational will be significantly less than the number of employees that formerly traveled daily to and from the site when the vehicle assembly plant was operational. Simultaneous construction of the adjoining Bloom Energy manufacturing plant and the College of Health Sciences building on STAR Campus has not resulted in noticeable traffic congestion. Construction of both of those currently ongoing projects is anticipated to be substantially complete before construction starts at the Wolf Technology Center 1.

Nearby neighborhoods adjacent to the site may experience minimal impacts during construction of the Wolf Technology Center 1. These impacts might include intermittent temporary construction noise and visual impacts. Noise levels during construction and from plant operations will be controlled to ensure compliance with applicable City of Newark noise standards. The facility design is intended to minimize long-term aesthetic impacts through the incorporation of architectural features and site screening. The proposed screening techniques should render most daily operational activities at the site invisible to nearby residents, with the possible exception of visible water vapor emanating from the cooling towers during specific atmospheric conditions. The site is located in an area that currently receives transportation noise from Christina Parkway (Delaware Routes 2 and 4) and the Northeast Corridor railroad, one of the most active railroads in the United States, serving Amtrak, SEPTA and Norfolk Southern, currently. In addition to through train noise, Norfolk Southern operates a switching yard adjacent to the site.

Rental properties and hotels will benefit during construction and long-term operation, to provide construction workforce temporary residence for construction workers, vendors, and transient employees. Construction of the proposed facility will have a beneficial impact on housing market by improving employment and stemming foreclosures that have resulted from the economic downturn of the local economy. Similarly, no negative

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impacts are expected on local restaurants and lodging/hotel properties.

Construction and post-construction impacts related to public services and facilities such as police, fire, and medical services and water, wastewater, and solid waste disposal (related to housing) are not expected to be significant. Those services were provided to the larger employment base of the former Chrysler Newark Assembly Plant.

Following construction, benefits associated with the operation of the facility are anticipated to be significant. Projections prepared for TDC forecast that the State of Delaware should receive approximately $3.54 million in annual revenue from the Wolf Technology Center 1 operations. Similarly, the City of Newark should receive approximately $0.35 million, New Castle County should receive approximately $0.22 million, and Christina School District should receive approximately $2.84 million annually. Adverse impacts associated with facility operations are expected to be marginal and localized. The following summarizes some of these potential minor impacts.

The improved employment condition anticipated to occur as a result of the Wolf Technology Center 1 should help support real estate values in the local community. While the number of permanent employees is not anticipated to generate a large demand for new housing construction, employment at the facility likely will improve demand for local resale housing, which in turn, should serve to stabilize or increase the value of local residential real estate.

Adverse impacts to aesthetic quality of the area will be minimal. While the Wolf Technology Center 1 project will be visible from the surrounding area, the appearance of the facility is intended to blend with the other entities being built at STAR Campus, such as the Bloom Energy factory. The proposed site is not located near national or state parks or designated scenic views. Screening devices (berms and vegetation) are planned for installation along the railroad tracks to the north of the facility. These features should reduce the visible presence of the facility for the closest residents, who are located to the north of the existing railroad. Motorists driving along Christina Parkway, the closest road, may briefly view (in passing the facility) portions of the Wolf Technology Center 1 buildings, but that view will not be incongruous with the new Bloom Energy factory that is being constructed between the proposed facility and Christina Parkway or the prior Chrysler Newark Assembly Plant. Existing woodlands on the DelDOT property to the west of proposed site location should contribute to the screening of the facility from drivers traveling on Christina Parkway. The site is approximately one mile west of South College Avenue (DE Route 896) and should be unobtrusive to drivers traveling along that road.

Operation of the proposed Wolf Technology Center 1 will not affect essential services or facilities negatively. While the facility will rely on local

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police and fire protection, the facility will be equipped with Fire Marshall approved fire protection systems, and the site will be secured with controlled, fenced access and manned around the clock.

In summary, the Wolf Technology Center 1 will directly employ an estimated 370 fulltime (or equivalent) workers and is anticipated to create approximately 90 indirect jobs. Most of these future workers should be drawn from the existing population of the area. Employment at the facility, or created in support of the facility, should not affect provision of services, schools, or degrade traffic along local roadways materially. Such services previously were adequate to handle the much larger employment and infrastructure of the former Chrysler Newark Assembly Plant. In the unlikely event of medical emergency, existing local medical facilities are available and previously were adequate to support the need for such services at the former Chrysler Newark Assembly Plant.

In summary, the Wolf Technology Center 1 facility is a Brownfield Redevelopment project of an abandoned heavy industrial site including large antiquated electrical substations, a wastewater treatment plant and a massive assembly plant, a very large painting facility, and a regional parts warehouse. The Wolf Technology Center 1 project is an adaptive re of this former heavy industrial site and is following recommended land use practices including seeking LEED Certification. Further, the project is not anticipated to displace residents, adversely impact property values, or place an unmanageable burden on public infrastructure. The site will also not displace visually impact or otherwise impair scenic, recreational, or ecologically sensitive lands.

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7.0 AIR QUALITY IMPACT ANALYSIS METHODOLOGY

7.1 GENERAL APPROACH

As previously noted in Subsection 3.1, the Wolf 1 CHP facility site is located in an area designated as attainment or unclassifiable for criteria pollutants except ozone and $PM_{2.5}$. All areas of Delaware are designated as PSD Class II areas. PSD Class I areas located within 300 km of the Wolf 1 CHP include Brigantine National Wilderness Area (NWA) in New Jersey and Shenandoah National Park (NP) in Virginia. This section focuses on the methodology used to determine project air quality impacts with respect to the PSD Class II increments and NAAQS.

The approach to assessing air quality impacts for a new or modified emissions source generally begins by determining the impacts of only the proposed facility. If facility impacts are below the PSD SILs, no further analysis is required. The PSD Class II SILs were presented previously in Table 3-5. If the impacts of a proposed facility are found to exceed a particular PSD SIL, an additional cumulative analysis considering other existing sources and background pollutant concentrations is required for that pollutant and averaging time.

The approach used to analyze the potential impacts from the facility, as described in detail in the following subsections, was developed in accordance with accepted practice. Guidance contained in EPA manuals and user's guides was followed. In addition, an air dispersion modeling protocol was submitted to DNREC on August 13, 2013, for review and comment, followed by subsequent discussions of specific modeling options and scenarios. The air quality impact analyses conducted for the facility incorporate comments and suggestions received from DNREC, EPA and United States Fish and Wildlife Service (USFWS) regarding the modeling protocol. Appendix C contains the modeling protocol, and Appendix D contains responses to the comments regarding the modeling protocol received from DNREC, EPA, and USFWS. The relevant agency comments have been incorporated into air quality analyses and the modeling approach described in this section for assessing the impacts of the Wolf 1 CHP facility emissions.

7.2 POLLUTANTS EVALUATED

Table 3-2 previously presented the estimated potential annual emissions rates for the facility. As shown in that table, potential emissions of NO_x, VOCs, H_2SO_4, and PM/ PM_{10}/$PM_{2.5}$ and GHGs, are each projected to exceed the applicable PSD SER threshold. Potential emissions from the facility are below the applicable PSD SER levels for the other PSD-regulated pollutants. Accordingly, the facility is subject to the PSD NSR air quality impact analysis. As Table 3-2 indicates, NO_x and VOCs are regulated under NNSR, while $PM_{2.5}$ is regulated under MNSR. Although projected facility GHG and H_2SO_4 emissions will exceed the PSD applicability threshold, an air quality impact analysis is not required, due to the absence of an

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EPA established NAAQS for those pollutants. Therefore, PM_{10} and NO_2 will be the only pollutants modeled as part of the PSD NSR air quality impact analysis.

7.3 MODEL SELECTION AND USE

For this air quality analysis, the current version of the American Meteorological Society (AMS)/EPA regulatory model (AERMOD) modeling system (Version 11103 – April 13, 2011), together with 5 years of hour-by-hour National Weather Service meteorology, was used to obtain predictions of both short-term periods (i.e., periods equal to or less than 24 hours) and annual average air quality impacts. In the November 9, 2005, Federal Register, EPA approved the use of AERMOD as a GAQM Appendix A preferred model, effective December 9, 2005. Lakes Environmental's AERMOD View user interface program was used to facilitate the use of AERMOD software.

The highest heat rate input to the facility combustion equipment has been predicted to occur during the winter and would result in the largest discharge of emissions to the atmosphere. Therefore, annual and hourly emission rates used for modeling were based on winter operating conditions. Modeled scenarios included:

- Operations based on the projected minimum power output of CHP, which conceivably would occur only when the CHP and data center are operating under "island" conditions. That condition would occur when the power grid could not accept electrical power from the CHP such as when the power grid is disrupted by weather events. This scenario is based on four gas combustion turbines operating at 100% load, two gas combustion turbines operating at 50% load, and two reciprocating gas engines operating at 50% load. The combination of equipment cited would provide sufficient power to run the CHP and data center and conforms to N+2 operating requirements. This scenario assessed emissions impacts associated with lowest expected exhaust temperatures and exhaust velocities;
- Operations based on projected "normal" operating conditions, where the CHP would be supplying power to the data center, exporting steam to the University of Delaware and supplying approximately 50 MW of electricity to the City of Newark through the distribution grid. This scenario is based on six combustion gas turbines operating at 100% load and three reciprocating gas engines operating near 100% load. This scenario should assess typical operating conditions; and
- Operations based on all of the combustion equipment running at 100% loads (i.e., seven gas combustion turbines and three reciprocating gas engines at 100% load). This scenario is not anticipated to represent standard operating. However, it did provide an assessment of emission impacts associated with operating the available CHP combustion equipment at the maximum rated capacity.

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7.4 MODEL OPTIONS

Procedures applicable to the AERMOD modeling system specified in the latest version of the User's Guide for the AMS/EPA Regulatory Model—AERMOD (September 2004) and EPA's November 9, 2005, revisions to the GAQM were followed. Also guidance from the EPA AERMOD Implementation Guide (September 27, 2005, and October 19, 2007) was applied.

The facility will be located in an area of New Castle County that includes a mix of residential, commercial and industrial land use. Per guidance provided by DNREC and USEPA, the AERMOD option to model rural conditions was selected, based on the land use percentages calculated for the surrounding area within 3 km of the site location.

7.5 NO_2 AMBIENT IMPACT ANALYSIS

On January 22, 2010, the EPA announced a new 1-hour average NO_2 NAAQS. The 1-hour NO_2 NAAQS was set at 100 ppb for the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour concentrations. This 1-hour NO_2 NAAQS became effective April 12, 2010.

A memorandum issued by the EPA on March 1, 2011 titled, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" described modeling parameters for assessing compliance with the new NO_2 NAAQS. Based upon this memorandum the following conditions/parameters were used:

- Ambient air quality modeling was conducted using the current version of AERMOD;
- NO_2 impact was estimated using the Tier 2 ratio of 0.80 as the ratio of NO_2/NO, which is a conservative assumption since at stack exit conditions, NO typically comprises 90% or more of total NO_x;
- For each receptor, the daily 1-hour maximum NO_2 concentrations was averaged over the 5-year modeling period;
- The predicted averages were compared to the EPA recommended interim SIL of 7.5 $\mu g/m^3$; and
- Cumulative NO_2 modeling was performed using nearby NO_x sources identified by DNREC along with background data from an appropriate monitoring station.

In selecting an NO_2 background monitoring site, Duffield Associates contacted DNREC for appropriate background concentrations. DNREC indicated that there are two NO_2 monitoring sites in New Castle County, Delaware including one in the City of Wilmington, and one in Brandywine State Park. According to DNREC, the monitor in the City of Wilmington is not representative of an appropriate background concentration and the Brandywine monitor does not have sufficient

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data to approximate yearly averages. DNREC recommended using data from a nearby monitoring station located at 600 Dorsey Avenue, Essex, Maryland (ID 240053001). The 98th percentile of the daily maximum 1-hour NO_2 concentrations obtained from the Maryland Department of the Environment for the Dorsey Avenue monitoring station, 43 parts per billion (80.85 $\mu g/m^3$), was used as the NO_2 background value for the 1-hour NO_2 modeling demonstration. This concentration was based on the concentrations monitored in 2012.

7.6 TERRAIN CONSIDERATION

The GAQM defines: "flat terrain" as terrain equal to the elevation of the stack base, "simple terrain" as terrain lower than the height of the stack top, and "complex terrain" as terrain exceeding the height of the stack being modeled. The project site elevation is approximately 90 feet above mean sea level (ft-msl). The combustion equipment exhaust stacks will each have a height of approximately 140 feet above ground level (ft-agl) and the cooling towers will have discharge heights of approximately 45 ft-agl. Accordingly, terrain elevations above approximately 200 ft-msl (for the combustion equipment stacks) and 135 ft-msl for the cooling towers discharges would be classified as complex terrain.

U.S. Geological Survey (USGS) National Elevation Dataset (NED) terrain data was examined for terrain features within the expected Wolf 1 CHP impact area (see Figure 4). As shown in Figure 4, the general topography in the area surrounding Wolf 1 CHP was found to rise to the north of the site. A number of local high points were found to the south of Wolf 1 CHP, one of which (Iron Hill) approaches approximately 310 feet above sea level. Based on this examination, terrain in the vicinity of the Wolf 1 CHP site was classified as complex terrain, and AERMOD was run accordingly.

7.7 BUILDING WAKE EFFECTS

The CAA Amendments require that stack height not exceed the limit established by good engineering practice (GEP) as a means of achieving compliance with NAAQS. On July 8, 1985, EPA promulgated final stack height regulations (40 CFR 51). GEP stack heights for the facility emissions sources will comply with EPA promulgated final stack height regulations (40 CFR 51). GEP stack height is defined as the highest of 65 meters, or a height established by applying the formula:

$$Hg = H + 1.5\ L$$

where:

Hg = GEP stack height.
H = height of the structure or nearby structure.
L = lesser dimension (height or projected width) of the nearby structure.

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Nearby is defined as a distance up to five times the lesser of the height or width dimension of a structure or terrain feature, but not greater than 800 meters. GEP stack height regulations require that stack height used in modeling for determining compliance with NAAQS and PSD increments not exceed the GEP stack height. Guidelines for determining GEP stack height have been issued by EPA (1985).

The anticipated maximum building height at the proposed facility is approximately 75 ft-agl, which is the lesser of the structure descriptive dimension. Application of the above formula yielded a stack height of 188 ft-agl. The stack height proposed for the combustion equipment stacks, 140 ft-agl is less than the GEP stack height of 188 feet or the maximum allowable stack height of 65 meters (213 feet).

Since the stack heights for the facility emissions sources will comply with the EPA promulgated final stack height regulations, the proposed facility stack heights were used in the modeling analyses. According to EPA, stacks with heights lower than GEP stack height could potentially result in higher downwind concentrations of criteria pollutants, due to building downwash effects. Therefore, the use of a less than GEP stack height in air dispersion modeling should yield a conservative assessment of atmospheric concentrations of those pollutants at receptor locations. AERMOD evaluates the effects of building downwash based on the PRIME building downwash algorithms. For the ambient impact analysis, the complex downwash analysis implemented by AERMOD was performed using the current version of EPA's BPIP for PRIME (BPIPPRM) (Version 04274 [September 30, 2004]). The EPA BPIP program was used to determine the area of influence for each building, whether a particular stack is subject to building downwash, the area of influence for directionally dependent building downwash, and finally to generate the specific building dimension data required by the model. BPIP output consists of an array of 36 direction-specific (10 to 360 degrees) building heights (BUILDHGT keyword), lengths (BUILDLEN keyword), widths (BUILDWID keyword), and along-flow (XBADJ keyword) and across-flow (YBADJ keyword) distances for each stack suitable for use as input to AERMOD.

Table 7-1 provides dimensions of the buildings/structures evaluated for wake effects. The building/structure dimensions were determined from the concept-level design documents for the facility. Figure 7-1 shows the facility buildings/structures in three-dimension.

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Table 7-1. Building Structure Dimensions Used in Downwash Analysis

		Height		Length		Width	
Building/Structure	**Modeling ID**	**feet**	**meters**	**feet**	**meters**	**feet**	**meters**
Phase 1 Data Center	ADMIN_BLD	75	22.8	480		490	
Phase 2 Data Center	ADMIN_BLD	75	22.8	480		490	
Power Conditioning Equipment Building		25	7.62				
Switch Gear Buildings		25	7.62	48	14.6	18	5.5
Gas Turbine and HRSG Power Block		60	18.3	180	54.8	75	22.8
Gas Engine Power Block		60	18.3	120	36.5	90	27.4
Steam Turbine Building		25	7.62	170	51.8	85	25.9
Water Treatment Building		32	9.75	75	22.8	55	16.7
Control/Admin Building		17	5.2	150	45.7	90	27.4
Warehouse/Maintenance Building		25	7.62	185	56.4	90	27.4
Steam Turbine Cooling Tower		45	13.7				
Chiller Cooling Tower	CLG_TWR	45	13.7				
Air Liquide Building	ADMIN_BLD	20	6.09				

7.8 RECEPTOR GRIDS

The latest version of AERMAP, the terrain pre-processor for AERMOD, was utilized to provide a terrain elevation for each receptor used in modeling. NED 1/3 arc second data was not available for the entire modeling area. Therefore, NED 1 arc second terrain data was used to determine facility and receptor elevations.

A receptor grid was prepared to identify those points at which the ambient air quality was modeled. Ambient air is identified by the EPA as "that portion of the atmosphere, external to buildings, to which the general public has access." Therefore, the nearest locations of general public access were determined to be at and beyond the Wolf 1 CHP facility fence line. The ambient air receptor grid was prepared with the following constraints, which are illustrated in Figure 5:

- Fence Line Receptors – Receptors placed at 25 meter intervals along the Wolf 1 CHP facility fence line;
- Close Receptors – Receptors placed at 50-meter intervals on the x and y axes starting at the fence line and extending outward to a minimum of 1 km;
- Medium Receptors – Receptors placed at 100-meter intervals on the x and y axes starting at approximately 1 km and extending outward to a minimum of 5 km; and

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- Far Receptors – Receptors placed at 1,000-meter intervals on the x and y axes starting at approximately 5 km and extending outward to a minimum of 10 km.

This receptor grid spacing was chosen to ensure a high density of modeling points in areas closest to the points of discharge, where substance dispersion has had less time and distance to provide dilution of discharged substance concentrations.

Figure 7-2 provides a graphical representation of the fence line receptors. Figure 7-3 provides a graphical representation of the near- and mid-field receptor grids. Figure 7-4 provides a graphical representation of the far-field receptor grid.

7.9 METEOROLOGICAL DATA

AERMET is the meteorological preprocessor for AERMOD. AERMET uses a collection of inputs including weather observations, land use inputs from the AERSURFACE preprocessor, and wind inputs from the AERMINUTE preprocessor to produce a meteorological input for AERMOD. The latest version of AERMET (Version 12345) was utilized to develop the meteorological inputs for AERMOD.

AERMET requires input data regarding upper air soundings and hourly surface weather data. Upper air soundings data is collected at a limited number of locations throughout the country. The nearest upper air data stations include Aberdeen Phillips Field Station in Aberdeen, Maryland, and Wallops Flight Facility on Wallops Island, Virginia. Under close inspection during modeling, Duffield Associates determined that the upper air data from Aberdeen Phillips Field Station was missing more than 10% of the data. At this level of missing data, the modeling results would not be considered valid. In order to obtain valid modeling results, upper air data from Wallops Flight Facility was used. Data were obtained for the 5-year period from January 1, 2008 to December 31, 2012 from http://www.esrl.noaa.gov/raobs/.

Hourly surface data is available at a greater number of locations compared to upper air data including New Castle Airport (NCA), Aberdeen Phillips Field Station, Philadelphia International Airport, Dover Air Force Base, and Millville Municipal Airport. The closest location to the proposed Wolf 1 CHP facility is NCA, and hourly surface data is available at NCA consistently from January 1, 1973, to the present day. Data were obtained for the 5-year period from January 1, 2008 to December 31, 2012, from ftp://ftp.ncdc.noaa.gov/pub/data/noaa.

AERMINUTE is an AERMET preprocessor that factors in wind speed and direction to complement the reported surface weather data. AERMINUTE uses 1-minute automated surface observing station (ASOS) data. The latest version of AERMINUTE was used (Version 11325) to supplement AERMET. Nearby 1-minute ASOS locations include NCA, Sussex County Airport, and Millville Municipal Airport. NCA is the closest location to the proposed Wolf 1 CHP facility, and 1-minute ASOS data is available for NCA from January 2000 to the

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date of this report. Data were obtained for the 5-year period from January 1, 2008 to December 31, 2012, from ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/.

AERMET requires information on surface roughness length, albedo, and Bowen ratio to determine the effect of surface conditions on weather patterns. AERSURFACE was developed to calculate surface roughness length, albedo, and Bowen ratio from information on land cover for input to AERMET. The latest version of AERSURFACE was used (Version 13016). National Land Cover Database's (NLCD's) land cover data from 1992 was used in AERSURFACE. The land cover was obtained for NCA according to GAQM guidance, which recommends that land cover data be collected for the site where weather information is collected. As shown in Figure 6, the land cover at NCA has not varied significantly since 1992. Therefore, the 1992 land use data is still applicable.

7.10 MODELED EMISSIONS INVENTORY

7.10.1 ON-PROPERTY SOURCES

Emissions sources in the air quality impact analysis include the proposed facility combustion units, and the cooling towers.

There are three different Wolf 1 CHP operating scenarios considered in the air quality impact analysis. The modeled emission rates associated with those operating conditions have been summarized in Table B-2. The stack parameters for each operating scenario have been summarized in Tables 2-2.a through 2-2.c. The modeled emissions rates and discharge parameters for the cooling towers also have been summarized in 2-2.a through 2-2.c. The impacts for NO_2, and PM_{10} were assessed using these parameters and emission rates.

In their March 2011 guidance memorandum for 1-hour NO_2 air quality compliance demonstrations, EPA indicates emissions sources that operate intermittently do not need to be included in the modeled emissions inventory. Similarly, startup/shutdown emissions are also addressed in the memorandum and can be omitted if they can be considered an intermittent source. As summarized in Section 2.5 of this report, individual combustion units in the Wolf 1 CHP will be shut down or restarted as necessary to perform maintenance, and to meet varying power demands. However, the turbines could be shut down and restarted 310 times per year before cold start-up conditions would amount to 0.1% of annual operating time and the engines could be similarly cycled 44 times per year before cold startup conditions would amount to 0.1% of annual operating time. Both of these shutdown/startup frequencies far exceed the anticipated number of events that would occur for maintenance or load matching. The cold startup mode is not considered a continuous operating mode or to occur frequently enough to impact daily emission rates, but could

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disproportionally impact daily 1-hour maximum values if included in air dispersion modeling. Therefore, the emissions associated with cold startups were not modeled.

7.10.2 OFF-PROPERTY SOURCES

Initial modeling results for all three operating conditions indicated a need to perform cumulative modeling, where ambient air quality monitoring concentrations and emissions from other, off-property sources of NO_2 and PM_{10} are taken into consideration. After consultation with DNREC, Duffield Associates contacted PADEP, MDE, and DNREC-AQM for a list of major sources of NO_x and PM_{10} within10 km of the Wolf 1 CHP facility. PADEP indicated that there are no such facilities in Pennsylvania within that radius. MDE and DNREC-AQM provided a list of multiple facilities which met those criteria. After further consultation with DNREC, the list of Maryland and Delaware facilities were narrowed to those listed in Table 7-2.

Table 7-2. Off-Site Sources

Facility Name	State	UTM Coordinates (meters)	Source Type
Christiana Care	Delaware	442,574.00, 4,393,411.00	Point Source
DuPont Stine-Haskell	Delaware	432,571.00, 4,390,658.00	Point Source
FMC Biopolymers	Delaware	437,831.00, 4,393,171.00	Area Source
Rohm & Haas	Delaware	440,945.00, 4,389,169.00	Point Source
University of Delaware	Delaware	435,612.00, 4,392,665.00	Point Source
W.L. Gore – Cherry Hill Plant	Maryland	426,422.00, 4,391,429.00	Point Source

DNREC-AQM provided permitted emission rates and stack parameters for the Delaware facilities, while MDE provided actual annual emission rates and facility locations. Delaware facilities with multiple stack parameters were averaged, while stack parameters for the Maryland facility were estimated using similar facility data. The emission rates of the off-site sources are listed in Table 7-3 and stack parameters are provided in Table 7-4. Due to the number and variations of stacks a FMC Biopolymers, that site was modeled as an area source.

Table 7-3. Off-Site Sources Emission Rates

Facility Name	NO_x Emissions (lb/hr)	PM_{10} Emissions (lb/hr)
Christiana Care	3.42	0.027
DuPont Stine-Haskell	2.16	0.12
FMC Biopolymers	7.10	5.37
Rohm & Haas	0.76	0.089
University of Delaware	4.29	0.073
W.L. Gore – Cherry Hill Plant	2.86	0.24

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Table 7-4. Off-Site Sources Stack Parameters

Facility Name	Stack Height (feet)	Stack Diameter (feet)	Exhaust Temperature (°F)	Exhaust Velocity (ft/s)
Christiana Care	142	9.0	480	2.1
DuPont Stine-Haskell	60	2.5	490	57.0
FMC Biopolymers	50*	1443.5**	N/A	N/A
Rohm & Haas	45	2.0	500	40.1
University of Delaware	70	6.0	600	60.0
W.L. Gore – Cherry Hill Plant	60	5.0	500	50.0

*FMC Biopolymers was modeled as an area source with a release height of 50 feet
**FMC Biopolymers was modeled as an area source with a release area of 1,443.5 feet by 1,443.5 feet

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8.0 PSD CLASS II AIR QUALITY IMPACT ANALYSIS RESULTS

8.1 AIR QUALITY IMPACT ANALYSIS RESULTS

The AERMOD dispersion model was used to assess the impacts for each of the three operating cases for each pollutant and averaging period subject to PSD review (i.e., NO_2 and PM_{10}). Each of the three operating cases was assessed for a 5-year meteorological data period (2008 through 2012). The specific emissions rates, stack exit exhaust temperature, and exhaust gas velocity appropriate for each operating case was modeled.

The following four separate pollutants/averaging periods were analyzed:

- PM_{10} annual averaging period.
- PM_{10} 24-hour averaging period.
- NO_2 annual averaging period.
- NO_2 1-hour averaging period.

The two PM_{10} averaging periods were combined in the same AERMOD input file as were the two NO_2 averaging periods. As noted below, some operating conditions failed SILs, and additional cumulative source modeling was required to show compliance with the NAAQS.

8.2 MAXIMUM FACILITY IMPACTS

The modeling performed to compare the predicted impacts of the Wolf 1 CHP sources to the SILs is discussed in this section. Tables 8-1 through 8-3 summarize the maximum AERMOD results for each pollutant and averaging period for the three operating cases.

Table 8-1. Normal Operating Conditions

Assessment Summary of Maximum Predicted Concentrations

Pollutant	Averaging Period	Predicted Maximum Concentration ($\mu g/m^3$)	SIL ($\mu g/m^3$)	*de minimis* ($\mu g/m^3$)	Allowable Increase ($\mu g/m^3$)
PM_{10}	Annual	0.32	1.0	---	17
	24-Hour	3.71	5.0	10	25
NO_2	Annual*	0.47	1.0	14	25
	1-Hour*	8.50	7.5	---	---

*Tier 2 values assuming an 80% conversion rate of NO_x to NO_2

Under projected normal operating conditions, the maximum 1-hour NO_2

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concentration is predicted to exceed the SIL value. None of the PM_{10} or NO_2 concentrations are predicted to exceed *de minimis* or allowable increase levels.

Table 8-2. Full Capacity Output Assessment

Summary of Maximum Concentrations

Pollutant	Averaging Period	Predicted Maximum Concentration ($\mu g/m^3$)	SIL ($\mu g/m^3$)	*de minimis* ($\mu g/m^3$)	Allowable Increase ($\mu g/m^3$)
PM_{10}	Annual	0.60	1.0	---	17
	24-Hour	6.23	5.0	10	25
NO_2	Annual*	0.64	1.0	14	25
	1-Hour*	12.37	7.5	---	---

*Tier 2 values assuming an 80% conversion rate of NO_x to NO_2

Under projected full capacity operating conditions, 24-hour PM_{10} and 1-hour NO_2 concentrations are predicted to exceed the SIL values. None of the PM_{10} or NO_2 concentrations are predicted to exceed *de minimis* or allowable increase levels.

Table 8-3. Minimum Output (Island Mode) Assessment

Summary of Maximum Predicted Concentrations

Pollutant	Averaging Period	Predicted Maximum Concentration ($\mu g/m^3$)	SIL ($\mu g/m^3$)	*de minimis* ($\mu g/m^3$)	Allowable Increase ($\mu g/m^3$)
PM_{10}	Annual	1.21	1.0	-	17
	24-Hour	16.99	5.0	10	25
NO_2	Annual*	0.51	1.0	14	25
	1-Hour*	8.90	7.5	-	-

*Tier 2 values assuming an 80% conversion rate of NO_x to NO_2

Under projected minimum output (during island mode), annual PM_{10}, 24-hour PM_{10}, and 1-hour NO_2 concentrations are predicted to exceed the SIL values. The 24-hour PM_{10} concentration is predicted to exceed the applicable *de minimis* value, but none of the other PM_{10} or NO_2 concentrations are predicted to exceed *de minimis* or allowable increase levels.

Cumulative modeling was performed for each of the substances where maximum predicted concentrations exceeded a SIL under normal operating conditions and full capacity conditions. Cumulative modeling was not performed for island mode conditions. Island mode operating condition

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would be intermittent. Island mode operations would only occur during unplanned incidences when DEMEC could not receive electricity due to disruption of the power distribution grid. In this circumstance, island mode operations would be analogous to emergency generator operations at other facilities. Therefore, island mode has been treated as an intermittent condition, similar to emergency generator usage at other facilities.

8.2.1 PM_{10} RESULTS

Table 8-4 presents the maximum annual PM_{10} concentrations for the three operating conditions averaged across the five years of meteorological data and presents a summary with a comparison to the PSD SIL value. The distance to the maximum concentration from the center of the Wolf 1 CHP facility is also provided.

Table 8-4. Maximum Annual PM_{10} Concentrations

Operating Condition	Max Concentration ($\mu g/m^3$)	Location (UTM)	Distance (meters)	PSD SIL ($\mu g/m^3$)	Above SIL?
Normal	0.32	434398.10, 4390401.90	2361.18	1.0	No
Full Capacity	0.60	434398.10, 4390401.90	2361.18	1.0	No
Island Mode	1.21	434374.47, 4390393.73	2385.55	1.0	Yes

Table 8-5 presents the maximum 24-hour PM_{10} concentrations for the three operating conditions across the five years of meteorological data and presents a summary with a comparison to the PSD SIL value. The distance to the maximum concentration from the center of the Wolf 1 CHP facility is also provided.

Table 8-5. Maximum 24-Hour PM_{10} Concentrations

Operating Condition	Max Concentration ($\mu g/m^3$)	Location (UTM)	Distance (meters)	Date (M/D/Y)	PSD SIL ($\mu g/m^3$)	Above SIL?
Normal	3.71	434411.22, 4390568.03	2336.29	12/10/09	5.0	No
Full Capacity	6.23	433971.13, 4390552.64	2776.65	11/12/09	5.0	Yes
Island Mode	16.99	433971.13, 4390552.64	2776.65	10/16/09	5.0	Yes

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As a result of these findings, cumulative modeling was performed for PM_{10} emissions during a 24-hour averaging time under the full capacity operating condition.

8.2.2 NO_2 RESULTS

Table 8-6 presents the maximum annual NO_2 concentrations for the three operating conditions averaged across the five years of meteorological data and presents a summary with a comparison to the PSD SIL value. The distance to the maximum concentration from the center of the Wolf 1 CHP facility is also provided.

Table 8-6. Maximum Annual NO_2 Concentrations

Operating Condition	Tier	Max Concentration ($\mu g/m^3$)	Location (UTM)	Distance (meters)	PSD SIL ($\mu g/m^3$)	Above SIL?
Normal	Tier 1*	0.59	434398.10, 4390401.90	2361.18	1.0	No
	Tier 2**	0.47				No
Full Capacity	Tier 1*	0.80	434398.10, 4390401.90	2361.18	1.0	No
	Tier 2**	0.64				No
Island Mode	Tier 1*	0.64	434374.47, 4390393.73	2385.55	1.0	No
	Tier 2**	0.51				No

*Tier 1 values assume a 100% conversion rate of NO_x to NO_2
**Tier 2 values assume an 80% conversion rate of NO_x to NO_2

Table 8-7 presents the maximum 1-hour NO_2 concentrations for the three operating conditions averaged across the five years of meteorological data and presents a summary with a comparison to the PSD SIL. The distance to the maximum concentration from the center of the Wolf 1 CHP facility is also provided.

Table 8-7. Maximum 1-Hour NO_2 Concentrations

Operating Condition	Tier	Max Concentration ($\mu g/m^3$)	Location (UTM)	Distance (meters)	PSD SIL ($\mu g/m^3$)	Above SIL?
Normal	Tier 1*	10.63	434021.13, 4390502.64	2728.96	7.5	Yes
	Tier 2**	8.50				Yes
Full Capacity	Tier 1*	15.47	434021.13, 4390502.64	2728.96	7.5	Yes
	Tier 2**	12.37				Yes
Island Mode	Tier 1*	11.13	433971.13, 4390552.64	2776.65	7.5	Yes
	Tier 2**	8.90				Yes

*Tier 1 values assume a 100% conversion rate of NO_x to NO_2
**Tier 2 values assume an 80% conversion rate of NO_x to NO_2

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As a result of these findings, cumulative modeling was performed for NO_2 emissions during a 1-hour averaging time under normal and full load operating conditions.

8.3 CUMULATIVE MODELING RESULTS

Due to modeled indications that maximum air concentrations associated with the Wolf 1 CHP emissions would exceed the PSD SILs for the 24-hour PM_{10} and 1-hour NO_2 averaging times, cumulative modeling including other sources was performed to demonstrate compliance with the NAAQS. Discussions with DNREC identified a list of facilities that are major emitters of NO_X and PM_{10} within 10 kilometers of the proposed Wolf 1 CHP. Cumulative modeling focused on the fence line receptor and close receptor grid area, due to the PSD SILs being exceeded within that area. The results of the modeling are discussed in the following subsections.

8.3.1 CUMULATIVE MODELING FOR THE 24-HOUR PM_{10} NAAQS

Table 8-8 shows the results of the PM_{10} cumulative modeling for the full capacity case. The values shown in the table are the maximum concentration over five years that occurred at a fence line receptor or close receptor. The individual contributions from the Wolf 1 CHP emissions and off site facilities' emissions have been listed separately from the background for comparison. Since PM_{10} background concentration measurements are not available for Delaware, background concentrations were collected from the Philadelphia area at East Lycoming Street. This metropolitan location provides a conservative estimate of background PM_{10} concentrations near Wolf 1 CHP. The total concentration has been compared to the NAAQS to identify values in excess of that standard.

Table 8-8. Cumulative Modeling of 24-Hour PM_{10} Assessment at Full Capacity

Concentration from Wolf 1 and Off-Site Sources ($\mu g/m^3$)	Concentration from Background ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	Location (UTM)	NAAQS ($\mu g/m^3$)	Exceeds NAAQS?
11.26	67	78.26	433997.96, 4390538.33	150	No

The maximum concentration is below the NAAQS of 150 $\mu g/m^3$.

8.3.2 CUMULATIVE MODELING FOR THE 1-HOUR NO_2 NAAQS

Tables 8-9 and 8-10 show the results of the NO_2 cumulative modeling for

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the normal operating and full capacity cases. The modeled values shown in the tables are the highest, 8th highest daily maximum NO_2 concentrations averaged over the 5 year modeling period that occurred at a fence line receptor or close receptor. Tier 1 and Tier 2 value have been included, with Tier 2 values equal to 80% of the Tier 1 values. The individual contributions from the Wolf 1 CHP facility and off site facilities have been listed separately from the background for comparison. The total concentrations have been compared to the NAAQS to identify values in excess of that standard. The background concentration was obtained as explained in Section 7.5

Table 8-9. Summary of Cumulative Modeling of 1-Hour NO_2 at Normal Operations

Tier	Concentration from Wolf 1 and Off-Site Sources (µg/m^3)	Concentration from Background (µg/m^3)	Total Concentration (µg/m^3)	Location (UTM)	NAAQS (µg/m^3)	Exceeds NAAQS?
Tier 1	47.87	80.84	128.71	435471.13, 4391902.64	188	No
Tier 2	38.30		119.14			No

Table 8-10. Summary of Cumulative Modeling of 1-Hour NO_2 at Full Capacity Operations

Tier	Concentration from Wolf 1 and Off-Site Sources (µg/m^3)	Concentration from Background (µg/m^3)	Total Concentration (µg/m^3)	Location (UTM)	NAAQS (µg/m^3)	Exceeds NAAQS?
Tier 1	47.87	80.84	128.71	435471.13, 4391902.64	188	No
Tier 2	38.30		119.14			No

The maximum concentrations are below the NAAQS of 188 µg/m^3 for both Tier 1 and Tier 2 analyses.

8.4 CONCLUSIONS

Comprehensive and conservative air quality dispersion modeling using AERMOD demonstrates that maximum, potential ambient air quality impacts due to Wolf 1 CHP normal operations and maximum potential operations, under worst-case meteorological conditions, will:

- Have an insignificant ambient air quality impact. Maximum predicted air concentrations of PM_{10} and NO_2 are less than the PSD SILs for all pollutants and averaging times, except for the PM_{10} 24-hour averaging time concentration for the full capacity case and the NO_2 1-hour averaging time concentration during normal and full capacity operations. Further assessment through cumulative modeling of these pollutant cases indicates that the proposed Wolf 1 CHP facility will not cause or contribute to air concentrations of the PM_{10} 24-

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hour or NO_2 1-hour in excess of corresponding NAAQS.

- Be below the PSD preconstruction ambient monitoring *de minimis* levels for all pollutants.
- Not cause PSD increments to be exceeded.

Air quality dispersion modeling was conducted using AERMOD for the island mode operating condition. These modeling conditions were prepared for informational purposes regarding air quality impact from the island mode operating condition, and should be considered an intermittent condition. As such, island mode emission estimates were not subject to cumulative modeling.

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9.0 ADDITIONAL IMPACT ANALYSIS

Per Section 3.13.1 of DE Admin. Code 1125, "The owner or operator shall provide an analysis of the impairment to visibility, soils and vegetation that would occur as a result of the source or modification and general commercial, residential, industrial and other growth associated with the source or modification. The owner or operator need not provide an analysis of the impact on vegetation having no significant commercial or recreational value." Similarly, Section 3.12.2 of the same regulations requires the owner or operator shall provide an analysis of the air quality impact projected for the area as a result of general commercial, residential, industrial and other growth associated with the source or modification. The following sections provide that analysis.

9.1 GROWTH IMPACT ANALYSIS

The proposed Wolf 1 CHP and associated data storage facility is proposed to be constructed on the former Chrysler Newark Assembly Plant, which ceased operations during December 2008. The former Newark Assembly Plant was a major source of air emissions, primarily NO_x and VOCs in its final configuration, and employed thousands of people in up to three work shifts. As such, the proposed project represents "regrowth" rather than new growth. Many of the future employees of the facility are anticipated to come from the existing population of the City of Newark and nearby communities in New Castle County, Delaware, Cecil County, Maryland, and Chester County, Pennsylvania. The site location is urbanized, appropriately zoned for the proposed use, and will make use of existing public infrastructure that formerly supported the vehicle assembly plant operations. The proposed facility will produce fewer air emissions than the prior vehicle assembly plant. Given the existing degree of urbanization in the vicinity of the site, no appreciable additional population or services related growth is anticipated to result from construction of the proposed Wolf Technology Center 1, but the project is anticipated to replace some of the employment and area-wide property values that were lost when the former Chrysler Newark Assembly Plant closed.

Local air quality impacts associated with construction of the Wolf Technology Center 1 will be minor and temporary. While not readily quantifiable, the temporary increase in air emissions from construction equipment emissions, vehicle-miles traveled in the area by construction vehicles, material delivery vehicles and construction worker vehicles are anticipated to be insignificant in comparison to vehicle emissions associated with the adjoining railroad freight traffic, traffic on the adjoining State highways (Delaware Routes 2, 4 and 896) and nearby Interstate Highway 95.

The Wolf Technology Center 1 is forecast to employ approximately 370 fulltime equivalent employees and generate approximately 90 indirect jobs, when operational. Most full-time, part-time and contracted workers at the facility are anticipated to come from proximate locations (within a 10 mile radius of the site) and essentially partially replace the commuting work force formerly employed at the vehicle assembly plant. A 10 mile radius of the site includes: the densely

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populated portion of New Castle County, Delaware located to the north of the Chesapeake and Delaware Canal; the densely populated western portion of Cecil County, Maryland; and a portion of Chester County, Pennsylvania. The 2012 U.S. Census Bureau estimated populations for New Castle County, Delaware, Cecil County, Maryland and Chester County, Pennsylvania, respectively as 546,076, 101,696 and 506,575, respectively. The workforce needed to operate the proposed plant, represents a small fraction of the population already present in the immediate area. Therefore, while some small increase in area vehicle-miles traveled could occur, the air quality implications for the locality will be minimal.

9.2 IMPACTS ON SOILS, VEGETATION, AND WILDLIFE

Certain air pollutants in acute concentrations or chronic exposures can impact soils, vegetation, or wildlife resources. For instance, SO_2 and NO_x emissions can combine with atmospheric moisture and form acids. Those acids can contribute to soil and surface water acidification. The Wolf 1 CHP equipment will combust pipeline-quality natural gas and employ state-of-the-art equipment and emissions controls to reduce the formation of NOx and SO_2. Detrimental effects on soils, vegetation, and wildlife will be insignificant, based on the projected emissions rates and minimal potential air quality impacts. The emissions of those substances will be well within the limits established thorough Federal regulations that were intended to guard against environmental degradation. The emissions of these substances for the facility will be substantially less than those from the former power plant and manufacturing related emitting sources such as the paint shop and wastewater treatment plant that was located on STAR Campus and supported the former Chrysler Newark Assembly Plant.

Possibly the greatest potential impact to wildlife, as a whole, is degradation of the composition, structure, and habitat that can result from facility construction. The proposed facility will not result in a direct loss of trees or wildlife habitat. In fact, construction of the facility will result in significant increase of trees, plants, and other vegetation on the site. The site currently is almost 100% covered by pavements that are remnants of the former site usage.

Releases of pollutants can affect wildlife through inhalation, exposure through skin, or ingestion. However, based on low emissions levels from this facility, natural dispersion of emissions, and mobility of wildlife, no direct impacts to regional wildlife resources are expected.

Most impacts to wildlife due to emissions from fuel combustion are indirect. For instance, increased acidification to soils and water due to high levels of SO_2 affects amphibians through skin absorption, as well as impacting breeding success, particularly those that breed in vernal pools and acidified ponds. However, the facility's low emissions of pollutants known to stress vegetation will result in impacts below known thresholds of injury. To the extent that energy produced by facility displaces energy production at existing facilities that produce significantly

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larger amounts of such emissions, the CHP emissions should reduce impacts to sensitive vegetation in the region. Therefore, no adverse impacts to wildlife due to operation of the facility are predicted.

Given the apparent lack of particularly sensitive soils or vegetation in the site area, air pollutant impacts well below the NAAQS should cause no adverse effects on soils or vegetation. At the national level, the primary AAQS have been established to protect the public health, while the secondary AAQS have been established to protect the public welfare, property, vegetation, and other ecological systems from any known or anticipated detrimental effects. Ambient concentrations of the criteria pollutants at levels below the NAAQS would not be expected to harm most types of soils, vegetation or wildlife. Predicted maximum substance concentrations in air that would result from operation of the proposed facility are well below the NAAQS (Table 3-1). Therefore, no adverse effects are expected.

In summary, based on the types of soils, vegetation, and wildlife onsite and in the vicinity, as well as the minimal emissions levels associated with plant operation, no impacts to soils, vegetation, or wildlife in the Wolf 1 CHP facility site vicinity are anticipated.

9.3 VISIBILITY IMPAIRMENT POTENTIAL

No visibility impairment at the local level is expected due to the types and quantities of emissions projected from the facility sources. The opacity of exhausts from the facility will be low and typically at or approaching zero, principally due to the low concentrations of particulates and the virtual absence of sulfur oxides associated with natural gas combustion. The contribution of emissions of VOC to potential haze formation in the area will be minimal given the low VOC emissions rate from the Wolf 1 CHP.

Wet mechanical draft cooling towers transfer heat from facility processes to the atmosphere through the evaporation and dispersion of cooling water. Depending on the meteorological conditions, warm, moist air leaving a tower may become cooled to the point of saturation, causing the water to condense forming a visible plume. Based on the size of the cooling towers and the frequency of occurrence the magnitude of a visible plume is expected to be small, and not significantly noticeable beyond the Wolf 1 site.

Aesthetically, the site was previously dominated by a large industrial facility. The site is separated from the closest residential community by the Northeast Corridor Railroad and a rail car switch/storage yard. The site design for Wolf 1 includes visual screening devices (topography, berms and vegetation) to minimize the aesthetic impact of the facility on residents located to the north of the railroad. The facility is set-back a distance of approximately 500 feet from the closest highway's (Delaware Routes 2 and 4 (Christina Parkway)] and is partially screened from view by existing woodlands and the Bloom Energy manufacturing facility that is also being constructed on STAR Campus. The proposed facility should not adversely affect aesthetic or visual qualities in the area.

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10.0 PSD CLASS I AREA IMPACT ANALYSIS RESULTS

Under the CAA, the Federal Land Managers (FLMs) and the federal official with direct responsibility for management of Federal Class I parks and wilderness areas (i.e., park superintendent, refuge manager, forest supervisor) have affirmative responsibility to protect the air quality-related values (AQRVs) (including visibility) of such lands and consider whether a proposed major emitting facility will have an adverse impact on such values. The FLMs' decision regarding whether there is an adverse impact is then conveyed to the permitting authority (usually a state agency) for consideration in its determinations regarding the permit. The permitting authority's determinations generally consider a wide range of factors, including the potential impact of the new source or major modification on the AQRVs of Class I areas, if applicable.

This section provides the results of the air quality assessment at two PSD Class I areas: the Shenandoah National Park (NP) and Brigantine National Wildlife Area (NWA). Section 8.0 previously addressed facility air quality impacts in the vicinity of the site.

Shenandoah NP and Brigantine NWA are located within 300 km of the facility site. The PSD Class I area nearest to the site is the Brigantine NWA located approximately 113 km north- west of the site. The Shenandoah NP is located approximately 225 km west of the site at its closet point. The Class I impact analyses addresses these two PSD Class I areas.

10.1 INITIAL SCREENING ANALYSIS

For new sources that will be located at a distance of 50 km or greater from a Class I area, the Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase 1 Report (revised 2010) guidance on initial screening criteria recommends using the ratio of potential project emissions rates divided by the project's distance from a Class I area (i.e., Q/D or 10D Rule) to determine whether an assessment of Class I area AQRVs is necessary. Potential project emissions (i.e., Q) include SO_2, NO_2, PM_{10}, and H_2SO_4 mist annual emissions in tpy, based on 24-hour maximum allowable emissions. The distance (i.e., D) is the distance in kilometers from the Class I area. For cases in which the source is located more than 50 km and has a calculated Q/D ratio of 10 or less, the FLMs will consider the source to have negligible impacts with respect to Class I AQRVs and would not request further Class I AQRV impact analyses for such sources.

A Q/D ratio was calculated for the Wolf 1 CHP using the potential emissions of the facility (based on 8,760 hours of operation at the maximum load, which is representative of the 24-hour maximum allowable emissions as required by the FLM screening guidance) and the nearest distance to each of the two Class I areas located within 300 km of the Wolf 1 CHP project site. Table 10-1 summarizes the facility's NO_2, SO_2, H_2SO_4 mist, and PM potential annual emissions in tpy, the distance to each Class I area (km), and the calculated Q/D ratio for each Class I area.

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Table 10-1. PSD Class I Area Initial Screen Analysis

Subject	NOx	SO_2	H_2SO_4	PM	Total Annual Emissions (Q)
TDC potential emissions	74.04 tpy	9.21 tpy	8.02 tpy	59.45 tpy	150.72 tpy
Class I Entity	Brigantine National Wildlife Refuge			Shenandoah National Park	
Distance from TDC (D)	97		km	212	km
Q/D screening ratio	1.6 Ton/yr-km			0.71 Ton/yr-km	

The calculated Q/D ratios are below the FLM threshold of 10; therefore, further Class I AQRV analyses are not required in accordance with the FLAG guidance. The United States Fish and Wildlife Service indicated in their response to the modeling protocol that "based on the emissions and distance from the Brigantine Wildness [area], the USFWS anticipates that modeling would not show any significant additional impacts to the AQRV at the Class I area."

10.2 GENERAL APPROACH

Generally, Class I area impact assessments are conducted using the CALPUFF dispersion model because steady state dispersion models like AERMOD are not suitable for predicting air quality at distances greater than 50 km. CALPUFF is used to predict air quality at receptors located at Class I areas which may be up to 300 km from a proposed emissions source. Due to the low total expected emissions from TDC however, AERMOD was used to predict air quality at a distance of 50 km from TDC. These results were compared to the Class I SILs.

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10.3 MODEL SELECTION AND USE

AERMOD was used to model predicted air quality impact at receptors located at a 50 km radius from the proposed TDC site. The same weather data used for the Class II impact analysis was used for this Class I impact analysis. The sources and stack parameters used in the Class II impact analysis were also used for this Class I impact analysis. The emission rates correspond with all the combustion units at TDC operating at a 100% load.

10.4 MODEL RESULTS

The results of the modeling are provided in Table 10-2. Neither the PM_{10} annual averaging time nor 24 hour averaging time predicted concentrations exceed the applicable Class I SILs. The NO_x annual averaging time predicted concentration does not exceed the applicable Class I SIL either. Based upon these results at 50 km, no Class I SILs are anticipated to be exceeded at Shenandoah NP and Brigantine NWA.

Table 10-2. Results of Modeling

Parameter	PM10 Annual	PM10 24 Hour	NOx Annual
Maximum Predicted Concentration ($\mu g/m^3$)	0.0025	0.082	0.0032
Location (UTM Coordinates)	467014.71, 4352878.74	461443.71, 4432547.75	467014.71, 4352878.74
PSD Class I SIL ($\mu g/m^3$)	0.2	0.3	0.1
SIL Exceeded?	No	No	No

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FIGURES

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APPENDIX A

AQM FORMS

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APPENDIX B

EMISSION CALCULATIONS AND
SUPPORTING DOCUMENTS
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Table B-1 FacilityWide Emissions
Table B-2 Combustion Turbine Emissions
Table B-3 Reciprocating Gas Engine Emissions
Table B-4 Hazardous Air Pollutant (HAPs) Emissions

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APPENDIX C

MODELING PROTOCOL

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APPENDIX D

MODELING PROTOCOL COMMENTS

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APPENDIX E

RBLC BACT/LAER TABLES

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APPENDIX F

MODELING INPUT/OUTPUT FILES (CD-ROM)

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APPENDIX G

MSDS FOR NATURAL GAS AND AMMONIA

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