Document Date: 04/28/2017
DAQ-2017-005321

THE UNIVERSITY OF UTAH

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April 28, 2017

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
APR 28 2017
DIVISION OF AIR QUALITY

Mr. Marty Gray
Utah Division of Air Quality
195 North 1950 West
Salt Lake City, Utah 84116

RE: The University of Utah
BACM/BACT Analysis – Direct $PM_{2.5}$ and $PM_{2.5}$ Precursors

Dear Mr. Gray:

The University of Utah (the University) is submitting this Best Available Control Measures/Technologies (BACM/BACT) analysis for direct particulate matter less than 2.5 microns ($PM_{2.5}$) and $PM_{2.5}$ precursors (including sulfur dioxide (SO_2), nitrogen oxide (NO_X), volatile organic compounds (VOCs), and ammonia (NH_3)) to the Utah Division of Air Quality (UDAQ), as requested in the letter dated January 23, 2017.

The University understands UDAQ is required to submit a Serious Area Attainment Control Plan as specified in 40 CFR 51, Subpart Z (Federal register (FR) Vol. 81, No. 164, August 24, 2016) due to the $PM_{2.5}$ serious nonattainment re-designation issued by the Environmental Protection Agency (EPA) on December 16, 2016. As the University is considered a major source of $PM_{2.5}$ and $PM_{2.5}$ precursors, its emission units will be included in the serious nonattainment control plan. This BACM/BACT analysis is in support of UDAQ's development of the Serious $PM_{2.5}$ Nonattainment control plan. As the University would like to continue to support UDAQ's SIP development effort, please feel free to reach out to me with any questions regarding the BACT/BACM analysis and I would appreciate the opportunity to review any draft conditions proposed for inclusion in the state implementation plan (SIP) that pertain to the University.

If you have any additional questions, please feel free to contact me at (801) 585-1617.

Sincerely,

Michael D. Brehm, P.E.
Manager, Environmental Protection

Enclosure

CC: David Quinlivan

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

APR 28 2017

DIVISION OF AIR QUALITY

$PM_{2.5}$ SERIOUS NONATTAINMENT SIP BACM ANALYSIS

The University of Utah > Salt Lake City, Utah

THE UNIVERSITY OF UTAH

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April 2017

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1. EXECUTIVE SUMMARY

The Utah Division of Air Quality (UDAQ) is required to submit a Serious Area Attainment Control Plan as specified with 40 CFR 51, Subpart Z (Federal register (FR) Vol 81, No 164, August 24, 2016) in accordance with the $PM_{2.5}$ serious nonattainment re-designation issued by Environmental Protection Agency (EPA) on December 16, 2016.[1] This rule requires UDAQ to identify, adopt, and implement Best Available Control Measures or Technologies (BACM/BACT) for major sources of direct $PM_{2.5}$ and $PM_{2.5}$ precursors (Sulfur Dioxide (SO_2), Nitrogen oxide (NO_X), volatile organic compounds (VOCs), and ammonia (NH_3)).

The University of Utah (University) has the potential to emit more than 70 tons or more per year for $PM_{2.5}$ and/or $PM_{2.5}$ precursors, the University is considered a major source. DAQ has requested that each major source prepare a BACM/BACT Analysis which includes the following information:

- Detailed analysis of all applicable control measures and techniques (BACM/BACT Analysis);
- Evaluation of Most Stringent Measures (MSM);
- Evaluation of emission limits; and
- Evaluations of emissions monitoring.

The UDAQ must complete the State Implementation Plan (SIP) process by the end of July 2017 so that it can be reviewed and approved for public comment by the Air Quality Board (AQB) in September 2017 and finalized in December 2017 for submittal to the Environmental Protection Agency (EPA) by December 31, 2017.[2] As such, the University is submitting this BACM/BACT analysis in order to meet DAQ's submission deadline of April 30, 2017 as requested in the letter received January, 23, 2017.

[1] Federal Register Vol. 81, No. 164, August 24, 2016, pp. 58151

[2] 40 CFR 51.1003 Attainment Plan Submittal Requirements

2. INTRODUCTION

2.1. DESCRIPTION OF FACILITY

The University is a public higher education institution with air emissions primarily due to the operation of boilers, comforting heating equipment, and emergency generators located in Salt Lake City. The University has taken great strides to make the campus more energy efficient and has a long term commitment to sustainability. This is demonstrated, through the University's initiative to implement newer boiler technology. In a continued effort to become increasingly energy efficient, the University also continues to work on the campus buildings to make them Leadership in Energy and Environmental Design (LEED) certified.

All correspondence regarding this submission should be addressed to:

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2.2. PERMITTING BACKGROUND

The University is operating as a stationary source under Title V Operating Permit Number #3500063003 from the UDAQ last Revised May 20, 2015 (expiring May 20, 2020) and an approval order (AO) dated September 30, 2013 (DAQE-AN103540025-13). The University was established in 1850, and therefore has several pieces of old equipment onsite that pre-dates some federal New Source Performance Standards (NSPS) requirements. Although the University has taken great strides to make the campus more energy efficient and has a long term commitment to sustainability. This is demonstrated, through the University's initiative to implement newer boiler and heating technology on campus. In 2008, the University replaced two dual fired (natural gas and coal) boilers (Boilers #1 and #2) in Building 303 with a natural gas fired turbine with SoLoNox technology. These are two examples of major upgrades the University has completed to demonstrate their commitment to ensuring a safe and healthy environment for students, staff, and the community. The most recent installment of boiler equipment occurred in 2016 with the replacement of an old boiler (Boiler #5) with two smaller boilers (Boilers #6 and #7) in Building 303 that emitted overall less pollutants to the atmosphere. Boilers #6 and #7 started up in 2017.

Furthermore, the University will be replacing the pre-NSPS Boilers #3 and #4 in Building 303 with a single, smaller, more efficient boiler that currently meets the BACM/BACT standards. Additionally, the University intends to replace two higher emitting boilers in Building 303 with a single smaller unit with lower overall emissions.

Other permitting actions have mainly focused on ensuring compliance with federal regulations regarding emergency generation units (NESHAP ZZZZ, NSPS IIII, and NSPS JJJJJJ).

The emissions associated with the University are divided among the sources reviewed for BACT as shown in Table 2-1.

Table 2-1. Current Short-term Source Specific Emission Limit Summary

Source	Location	NO_x		VOC
Boilers 3 and 4	LCHTWP	25 lb/hr (each)	187 ppmdv (each)	NA
Boilers 5 and 6	LCHTWP	0.25 lb/hr (each)	9 ppmdv (each)	NA
Gas Turbine (Only)	LCHTWP	2.65 lb/hr	9 ppmdv	NA
Gas Turbine and Duct Burner	LCHTWP	8.97 lb/hr	15 ppmdv	NA
Carpentry Shop and Print Plant	Building 350	--	--	5 ton (12 month rolling period)
Ethylene Oxide Sterilizer	University Hospital	--	--	1 tpy

3. BEST AVAILABLE CONTROL MEASURES (BACM)

The University previously submitted a Reasonably Available Control Technology (RACT) evaluation in October 2013. The 2013 RACT analysis and the University current SIP requirements as documented in UDAQ's Moderate Non-Attainment SIP have been achieved by the University. The 2013 RACT analysis serves as a baseline for the BACM/BACT analysis documented herein. A BACM/BACT analysis has been conducted for each source addressed in Approval Order No. DAQE-AN103540025-13 and Title V permit #3500063003 in the following sections. Where appropriate, the University has addressed startup and shutdown emissions for each source as part of the BACM/BACT analysis. The University has organized the BACM/BACT analysis by emission unit group and addressed $PM_{2.5}$ and each $PM_{2.5}$ precursor in this analysis in a format that is in accordance with U.S. EPA's top-down BACT procedures.

3.1. BACM/BACT METHODOLOGY

In a memorandum dated December 1, 1987, the United States Environmental Protection Agency (U.S. EPA) stated its preference for a "top-down" BACT analysis.[3] After determining if any New Source Performance Standard (NSPS) is applicable, the first step in this approach is to determine, for the emission unit in question, the most stringent control available for a similar or identical source or source category. If it can be shown that this level of control is technically, environmentally, or economically infeasible for the unit in question, then the next most stringent level of control is determined and similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated by any substantial or unique technical, environmental, or economic objections. Presented below are the five basic steps of a top-down BACT review as identified by the U.S. EPA.

3.1.1. Step 1 - Identify All Control Technologies

Available control technologies are identified for each emission unit in question. The following methods are used to identify potential technologies: 1) researching the Reasonably Available Control Technology (RACT)/BACT/LAER Clearinghouse (RBLC) database, 2) surveying regulatory agencies, 3) drawing from previous engineering experience, 4) surveying air pollution control equipment vendors, and/or 5) surveying available literature.

3.1.2. Step 2 - Eliminate Technically Infeasible Options

The second step in the BACT analysis is to eliminate any technically infeasible control technologies. Each control technology for each pollutant is considered, and those that are clearly technically infeasible are eliminated. U.S. EPA states the following with regard to technical feasibility:[4]

A demonstration of technical infeasibility should be clearly documented and should show, based on physical, chemical, and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review.

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

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

3.1.3. Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Once technically infeasible options are removed from consideration, the remaining options are ranked based on their control effectiveness. If there is only one remaining option or if all of the remaining technologies could achieve equivalent control efficiencies, ranking based on control efficiency is not required.

In a retroactive BACT analysis, this step differs from the equivalent step in the NSR BACT process in that the baseline from which control effectiveness is evaluated is the current emission rate, and not some hypothetical "uncontrolled" level.

3.1.4. Step 4 - Evaluate Most Effective Controls and Document Results

Beginning with the most effective control option in the ranking, detailed economic, energy, and environmental impact evaluations are performed. If a control option is determined to be economically feasible without adverse energy or environmental impacts, it is not necessary to evaluate the remaining options with lower control effectiveness.

The economic evaluation centers on the cost effectiveness of the control option. Costs of installing and operating control technologies are estimated and annualized following the methodologies outlined in the U.S. EPA's *OAQPS Control Cost Manual* (CCM) and other industry resources.[5] Note that the analysis is not whether controls are affordable, but whether the expenditure is effective.

3.1.5. Step 5 - Select BACT

In the final step, one pollutant-specific control option is proposed as BACT for each emission unit under review based on evaluations from the previous step.

The U.S. EPA has consistently interpreted the statutory and regulatory BACT definitions as containing two core requirements that the agency believes must be met by any BACT determination, regardless of whether the "top-down" approach is used. First, the BACT analysis must include consideration of the most stringent available control technologies, i.e., those which provide the "maximum degree of emissions reduction." Second, any decision to require a lesser degree of emissions reduction must be justified by an objective analysis of "energy, environmental, and economic impacts."[6]

The UDAQ NOI Guide also details the requirement to achieve BACT as required in the State of Utah permitting process. The proposed BACT must be based on the most effective engineering techniques and control equipment to minimize emission of air contaminants into the outside environment from its process.

3.2. UCHTWP BOILERS

The upper campus high temperature water plant (UCHWTP), located in Building 302, has three natural gas-fired boilers, 1, 3, and 4 that are each rated at 87.5 million British thermal units per hour (MMBtu/hr) with 15% flue gas recirculation (FGR). Diesel is used as a backup fuel during periods of natural gas curtailment. The University intends to idle 50% of the UCHTWP boilers' current capacity by 2019 with new boilers in the HSC Transformation project buildings (Upper Medical Campus). The BACT review herein, however, focuses on the existing units.

---

[5] Office of Air Quality Planning and Standards (OAQPS), *EPA Air Pollution Control Cost Manual*, Sixth Edition, EPA 452-02-001 (http://www.epa.gov/ttn/catc/products.html#cccinfo), Daniel C. Mussatti & William M. Vatavuk, January 2002.

[6] Ibid.

Startup and shutdown emissions are anticipated to be less than or equal to emissions during normal operations on the boilers at the UCHTWP.

3.2.1. $PM_{2.5}$

According to EPA's AP-42, Section 1.4, since natural gas is a gaseous fuel, filterable PM emissions are typically low. Particulate matter from natural gas combustion has been estimated to be less than one micrometer in size and has filterable and condensable fractions. Particulate matter in natural gas combustion is usually larger molecular weight hydrocarbons that are not fully combusted. Increased particulate matter emissions can result from poor air/fuel mixing or maintenance problems.

UCHTWP Boilers $PM_{2.5}$ Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[7]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NO_X Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- NSPS Subpart Dc - Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units[8]
- South Coast Air Quality Management District (SCAQMD) LAER/BACT Determinations;
- San Joaquin Valley Air Pollution Control District (SJVAPCD) BACT Clearinghouse;
- Bay Area Air Quality Management District (BAAQMD) BACT/TBACT Workbook; and
- Permits available online.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. The most closely related processes were as follows:

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[7] Database accessed February 27, 2017.

[8] Boilers applicable to NSPS Subpart Dc do not have PM emission standards for Natural Gas Fired Boilers (40 CFR 60.43c).

Table 2 - Medium Natural Gas Boilers (<100 MMBtu) $PM_{2.5}$ Emissions[9]

Company Listing	Location	Heat Input	Controls	Emission Rate
HARRAH'S[10] Operating Company, Inc.	Clark Co, NV	24 MMBtu/hr	Operating with Manufacturer's Specifications	0.0075 lb/MMBtu
MGM MIRAGE[11]	Clark Co, NV	41.46 MMBtu/hr	Limit to the use of Natural Gas	0.0077 lb/MMBtu
MGM MIRAGE[12]	Clark Co, NV	44 MMBtu/hr	Limit to the use of Natural Gas	0.0075 lb/MMBtu

The technologies identified as possible $PM_{2.5}$ reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

Pollutant	Control Technologies
$PM_{2.5}$	Fabric Filter
	Wet Scrubber
	Dry Electrostatic Precipitator
	Cyclone

UCHTWP Boilers $PM_{2.5}$ Step 2 - Eliminate Technically Infeasible Options

A summary of the controls evaluated is in the table below based on EPA controls fact sheets. EPA does not address particulate (or fine particulate) in the controls section of AP-42 for gas-fired boilers.

[9] The facilities were selected based on process type and purpose of equipment as well as location within similar Non-attainment areas and the application of SIP/PSD BACT.

[10] RBLC Reference NV-0049, Harrah's Operating Company permit was issued in 2009.

[11] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

[12] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

Table 3 – PM Controls Evaluation for Natural Gas Combustion[13]

Technology	Typical Loading	Typical $PM_{2.5}$ Removal Efficiency	NG PM Size	NG $PM_{2.5}$ Loading	SOURCE
ESP	Not specified	97%	< 1 μm	5.7 lb/MMscf 1.9 lb/MMscf	EPA Fact Sheet EPA-452/F-03-030
Packed Bed/Tower Wet Scrubber		50 - 95%	< 1 μm	5.7 lb/MMscf 1.9 lb/MMscf	EPRI ESPs AND FINE PARTICLE COLLECTION
Spray Chamber/Tower Wet Scrubber	250 - 10,000 ppmv	Not Used	< 1 μm	5.7 lb/MMscf 1.9 lb/MMscf	EPA Fact Sheet EPA-452/F-03-015
Venturi Wet Scrubber	0.1 - 50 gr/scf	70 - 99%	< 1 μm	.7 lb/MMscf 1.9 lb/MMscf	EPA Fact Sheet EPA-452/F-03-016

The BACT analysis for $PM_{2.5}$ controls is a follows, this analysis is specific to filterable $PM_{2.5}$.

Wet Scrubber

A wet gas scrubber is an air pollution control device that removes PM and acid gases from waste streams from stationary point sources. PM and acid gases are primarily removed through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. Wet scrubbers have some advantages over ESPs and baghouses in that they are particularly useful in removing PM with the following characteristics:

- Sticky and/or hygroscopic materials;
- Combustible, corrosive or explosive materials;
- Particles that are difficult to remove in dry form;
- PM in the presence of soluble gases; and
- PM in gas stream with high moisture content.

However, considering the low concentration of $PM_{2.5}$ and the small size of particulate, a wet scrubber is considered technically infeasible for a boiler firing primarily natural gas.

Electrostatic Precipitator

An ESP is a particle control device that uses electrical forces to move the particles out of the gas stream onto collector plates. This process is accomplished by the charging of particles in the gas stream using positively or negatively charged electrodes. The particles are then collected as they are attracted to oppositely opposed electrodes. Once the particles are collected on the plates, they are removed by knocking them loose from the plates, allowing the collected layer of particles to fall down into a hopper. ESP's are used to capture coarse particles at high concentrations. Small particles at low concentrations are not effectively collected by an ESP. As

[13] PM Controls evaluation documents EPA's fact sheets for PM Controls related to natural gas combustion.

the technology is primarily for the combustion of natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, ESP is considered technically infeasible for a boiler firing primarily natural gas.

Fabric Filter

A fabric filter unit (or baghouse) consists of one or more compartments containing rows of fabric bags. Particle-laden gases pass along the surface of the bags then through the fabric. Particles are retained on the upstream face of the bags and the cleaned gas stream is vented to the atmosphere. Fabric filters collect particles with sizes ranging from submicron to several hundred microns in diameter. Fabric filters are used for medium and low gas flow streams with high particulate concentrations. As the boilers combust primarily natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, a fabric filter is considered technically infeasible for a boiler firing primarily natural gas.

Good Combustion Practices and Use of Clean Burning Fuels

The use of good combustion practices usually include the following components: (1) proper fuel mixing in the combustion zone; (2) high temperatures and low oxygen levels in primary zone; (3) Overall excess oxygen levels high enough to complete combustion while maximizing boiler efficiency, and (4) sufficient residence time to complete combustion. Good combustion practices are accomplished through boiler design as it relates to time, temperature, and turbulence, and boiler operation as it relates to excess oxygen levels.

UCHTWP Boilers $PM_{2.5}$ Step 3-5 - Select BACT

Step 3 and 4 are not necessary since all control technologies that are not currently being used have been determined technically infeasible. No control technology is technically feasible, therefore this emission rate using good combustion practices and primarily natural gas is considered BACT.

UCHTWP Boilers $PM_{2.5}$ Most Stringent Measures

The most stringent measures would be identical to BACT as no control technology is technically feasible for these units.

3.2.2. NO_X

The NO_X that will be formed during combustion is from two major mechanisms: thermal NO_X and fuel NO_X. Since natural gas is relatively free of fuel-bound nitrogen, the contribution of this second mechanism to the formation of NO_X emissions in natural gas-fired equipment is minimal, leaving thermal NO_X as the main source of NO_X emissions. Thermal NO_X formation is a function of residence time, oxygen level, and flame temperature, and can be minimized by controlling these elements in the design of the combustion equipment.

UCHTWP Boilers NO_X Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[14]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NO_X Emissions from Utility Boilers;

[14] Database accessed February 27, 2017.

- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- NSPS Subpart Dc - Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units[15]
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook[16]; and
- Permits available online.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. The most closely related processes were as follows:

Table 4 – Medium Natural Gas Boilers (<100 MMBtu) NOx Emissions[17]

Company Listing	Location	Heat Input	Controls	Emission Rate	Concentration
HARRAH'S[18] Operating Company, Inc.	Clark Co, NV	24 MMBtu/hr	Low NOx Burner	0.0108 lb/MMBtu	9 PPM
MGM MIRAGE[19]	Clark Co, NV	41.46 MMBtu/hr	Low NOx Burner	0.011 lb/MMBtu	9 PPM
MGM MIRAGE[20]	Clark Co, NV	44 MMBtu/hr	Low NOx Burner	0.0109 lb/MMBtu	9 PPM

The technologies identified as possible NO_X reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

[15] Boilers applicable to NSPS Subpart Dc do not have NOx emission limitations for Natural Gas Fired Boilers.

[16] BACT(1) for NOx and CO (achieved using LNB+FGR+SCR and GCP) is 25 ppmvd NOx @3%O2

[17] The facilities were selected based on process type and purpose of equipment as well as location within similar Non-attainment areas and the application of SIP/PSD BACT. Up-to-date RBLC search run on April 23, 2017.

[18] RBLC Reference NV-0049, Harrah's Operating Company permit was issued in 2009.

[19] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

[20] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

Pollutant	Control Technologies
NO_X	Low NO_X Burners
	Ultra-Low NO_X Burners
	Flue Gas Recirculation
	Selective Catalytic Reduction
	Good Combustion Practices

UCHTWP Boilers NO_X Step 2 - Eliminate Technically Infeasible Options

To demonstrate a complete analysis, the University has evaluated the follow technologies including both replacement burners and add-on controls.

Low NOx Burners

LNB technology uses advanced burner design to reduce NO_X formation through the restriction of oxygen, flame temperature, and/or residence time. There are two general types of LNB: staged fuel and staged air burners. In a stage fuel LNB, the combustion zone is separated into two regions. The first region is a lean combustion region where a fraction of the fuel is supplied with the total quantity of combustion air. Combustion in this zone takes place at substantially lower temperatures than a standard burner. In the second combustion region, the remaining fuel is injected and combusted with left over oxygen from the first region. A staged air burner begins with full fuel but only partial combustion air, and then adds the remaining combustion air in the second combustion region. These techniques reduce the formation of thermal NO_X. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NO_X using a combination of SCR, LNB, and FGR. SCAQMD used LNB as the BACT determined control methodology for the University of California Irvine Medical Center boiler rated at 48.6 MMBtu/hr in 1999.

Ultra Low NOx Burners

ULNB technology uses internal FGR which involves recirculating the hot O_2 depleted flue gas from the heater into the combustion zone using burner design features and fuel staging to reduce NO_X. An ULNB is most commonly using an internal induced draft to reach the desired emission limitations. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NO_X using a combination of ULNB and FGR. SCAQMD used LNB plus FGR as the BACT determined control methodology for the Los Angeles County Internal Services Department boiler rated at 39 MMBtu/hr in 2004. An ULNB can achieve an emission rate of approximately 9 ppm or 0.011 pounds per million British thermal units (lb/MMBtu) when used in conjunction with FGR.

Flue Gas Recirculation

FGR is frequently used with both LNB and ULNB burners. FGR involves the recycling of post-combustion air into the air-fuel mixture to reduce the available oxygen and help cool the burner flame. External FGR requires the use of ductwork to route a portion of the flue gas in the stack back to the burner windbox; FGR can be either forced draft (where hot side fans are used) or induced draft. This technology is listed in the RBLC search as technically feasible and is paired with LNB for the BACT determined control technology. As previously discussed, both SCAQMD and BAAQMD have combined this technology with others to determine BACT. Currently, the UCHTWP boilers use this technology.

Selective Catalytic Reduction

SCR has been applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. It has been applied to large (>250 MMBtu/hr) utility and industrial boilers, process heaters, and combined cycle gas turbines. There has been limited application of SCR to other combustion devices and processes such as simple cycle gas turbines, stationary reciprocating internal combustion engines, nitric acid plants, and steel mill annealing furnaces. SCR can be applied as a stand-alone NO_X control or with other technologies such as combustion controls. The reagent reacts selectively with the flue gas NO_X within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_X into molecular nitrogen (N_2) and water vapor (H_2O).[21] The optimum operating temperature is dependent on the type of catalyst and the flue gas composition. Generally, the optimum temperature ranges from 480°F to 800°F.[22] In practice, SCR systems operate at efficiencies in the range of 70% to 90%.[23]

SCR is listed in the RBLC search as technically feasible. In some cases, this control technology is listed in combination with LNB and FGR. As previously mentioned, BAAQMD defines BACT as the combination of SCR, LNB, and FGR.

The ammonia "slip" associated with the SCR is a documented problem. The increased ammonia emissions (currently zero) from the implementation of this technology would offset the marginal air quality benefits the SCR option would provide from NO_X emissions reduction. Ammonia slip emissions have the potential to increase secondary $PM_{2.5}$ levels in the area more than the SCR controlled NO_X mass. Storage and handling of ammonia poses significant safety risks when applied at the University of Utah. Ammonia is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose, or throat. It is a commonly used material that is typically handled safely and without incident. However, there are potential health and safety hazards associated with the implementation of this technology. The UCHTWP is located in a densely-packed area with other public facilities including student dormitories and the Red Butte Amphitheater, and a significant number of University staff, students, and the general public potentially in harm's way. Locating ammonia tanks in these premises poses significant health risks for students, faculty, patients, family members and the general public if a leak were to occur. The exhaust stream entering the SCR will require additional heat to meet the SCR operating temperature requirements (minimum of 480°F). This increase in exhaust temperature would require an additional combustion device, also increasing NO_X, SO_2, and $PM_{2.5}$ emissions.

Furthermore, there is a physical space issue concerning this technology. Building 302, where the UCHTWP boilers are housed, is confined by other buildings in the immediate proximity and may not provide the space required to physically install an SCR. The location of the boilers within the building also presents a space challenge when installing an SCR. That being said, the costs of installing an SCR would likely be higher than that presented in Step 4 below due to the limited amount of space under the current configuration.

Though there are obvious physical limitations, public safety concerns, and additional pollutants being emitted to use this add-on control technology, the control device is being evaluated for cost feasibility.

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[21] Ibid.

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

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

Good Combustion Practices

Good combustion practices were previously addressed in the $PM_{2.5}$ control device evaluation for the UCHTWP boilers above.

UCHTWP Boilers NO_X Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Based on an RBLC search the following technologies are currently being used for boilers between 25 MMBtu/hr and 100 MMBtu/hr. These are ranked based on which technology can achieve the lowest emission rate. Note, an ULNB has not been proven with an SCR based on RBLC review.

1. SCR = 9 ppm or 0.011 lb/MMBtu[24]
2. ULNB = 9 ppm or 0.011 lb/MMBtu
3. LNB = 30 ppm or 0.036 lb/MMBtu
4. FGR = 42ppm or 0.05 lb/MMBtu

UCHTWP Boilers NO_X Step 4 - Evaluate Most Effective Controls and Document Results

The UCHTWP boilers are currently using 15% FGR and achieve an emission rate of 0.05 lb/MMBtu. To achieve an emission rate of 9 ppm, an SCR may be installed on each boiler. Assuming 70% control efficiency for the SCR, it would cost $149,046/ton of NO_X removed.[25] Calculations are shown in Appendix A and are based on generally provided capital costs from EPA's Air Pollution Control Cost Manual. The cost per ton of NO_X removed is beyond acceptable cost control effectiveness levels and therefore, the University has determined that this technology is economically infeasible for these units.

The University also reviewed replacing the current burner with an UNLB with an emission rate of 9 ppm NO_X or less. It would cost $109,755/ton of NO_x removed to achieve the 9 ppm emission rate. The cost per ton of NO_X removed is beyond acceptable cost control effectiveness levels and therefore, the University is considering this burner technology economically infeasible for these units. Detailed cost calculations for this control technology for the UCHTWP are provided in Appendix A. Installation of a lower efficiency burner, i.e. LNB technology, is not expected to decrease the capital investment substantially. Therefore, the University has assumed replacing the current burner with a LNB is also economically infeasible.

UCHTWP Boilers NO_X Step 5 - Select BACT

The University has selected the currently installed control technology as BACT for the UCHTWP boilers. The boilers have an emission rate of 0.05 lb/MMBtu using 15% FGR. As previously discussed, the University intends to idle 50% of the current capacity 2019 with new boilers in the Upper Medical Campus, in the University's continued effort to become more energy efficient.

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[24] Several sources listed within RBLC with an emission rate of 9 ppm. Each of these technology combinations have been shown to meet this level of control

[25] An efficiency of 70% was assumed, given that SCR can generally operate between 70% and 90% control efficiency. The University has not obtained a vendor guarantee for this level of control for a unit with such a low concentration exhaust stream and would require consultation with a vendor prior to installation of this equipment.

Table 3-5. BACT Summary for UCHTWP Boilers

Control Technologies	Controlled Emission Rate (lb/MMBtu)	Technically Feasible ?	Economic Feasibility ($/ton removal)	BACT
SCR	0.011	Yes	$149,046	
ULNB	0.011	Yes	$109,755	
LNB + FGR	0.011	Yes	--[a]	
LNB	0.036	Yes	$109,755[b]	
FGR (Current Technology)	0.05	Yes	--[c]	Yes
Good Combustion Practice	N/A	Yes		Yes

a. LNB + FGR was not considered for economic feasibility because the ULNB alone can achieve the desired emission rate.
b. Economic feasibility was not specifically determined for this control technology, but is expected to be reasonably close to the cost of an ULNB replacement.
c. This is the current technology used on the system, economic feasibility is not required.

UCHTWP Boilers NO_X Most Stringent Measures

MSM is installation of ULNB to achieve an emission rate of 0.011 lbs/MMBtu. This will be a substantial economic investment for the University.

3.2.3. SO_2

SO_2 emissions associated with the boilers are due to natural gas and diesel combustion. Emissions associated with all boilers are less than 1 tpy. Therefore, the University is proposing good combustion practices and use of natural gas (with diesel as a backup fuel) as BACT.[26]

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. The most closely related processes were as follows:

[26] BAAQMD BACT/TBACT Workbook - BACT(2) for SO2 and PM10 is the use of low sulfur fuel with < 0.05 wt% S

Table 6 – Medium Natural Gas Boilers (<100 MMBtu) SO_2 Emissions[27]

Company Listing	Location	Heat Input	Controls	Emission Rate
HARRAH'S[28] Operating Company, Inc.	Clark Co, NV	24 MMBtu/hr	Fuel is limited to Natural Gas	0.0006 lb/MMBtu
MGM MIRAGE[29]	Clark Co, NV	41.46 MMBtu/hr	Fuel is limited to Natural Gas	0.0007 lb/MMBtu
MGM MIRAGE[30]	Clark Co, NV	44 MMBtu/hr	Fuel is limited to Natural Gas	0.0007 lb/MMBtu

The technologies identified as possible SO_2 reduction technologies for Medium Size Natural Gas Boilers are natural gas and good combustion practices.

UCHTWP Boilers SO_2 Step 1 - Identify All Control Technologies

There are two primary mechanisms to reduce SO_2 emissions from combustion sources which are: (1) reduce the amount of sulfur in the fuel, and (2) remove the sulfur from the exhaust gases with post-combustion control device such as flue gas desulfurization utilizing wet scrubbers or dry scrubbers.

The University will be using pipeline-quality natural gas as the primary fuel which has a low sulfur content. The use of a fuel containing low sulfur content is considered a control technology.

Two main types of SO_2 post-combustion control technologies, wet and dry scrubbing, were identified to reduce SO_2 in the exhaust gas.

UCHTWP Boilers SO_2 Step 2 - Eliminate Technically Infeasible Options

The requirement for low-sulfur natural gas is a control technique that has been achieved in practice and is technically feasible and cost-effective and will be further considered for BACT. Post-combustion devices such as wet or dry scrubbers are typically installed on coal-fired power plants that burn fuels with much higher sulfur contents. The SO_2 concentrations in the natural gas combustion exhaust gases from the boilers are too low for scrubbing technologies to work effectively or to be technically feasible and cost effective. These control technologies require much higher sulfur concentrations in the exhaust gases to be feasible as a control technology. Thus, post-combustion SO_2 control devices, such as wet and dry scrubbing have not been achieved in practice on natural gas boilers. Since these controls are not technically feasible, they have been eliminated from further consideration for the boilers.

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[27] The facilities were selected based on process type and purpose of equipment as well as location within similar Non-attainment areas and the application of SIP/PSD BACT. Up-to-date RBLC search run on April 23, 2017.

[28] RBLC Reference NV-0049, Harrah's Operating Company permit was issued in 2009.

[29] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

[30] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

UCHTWP Boilers SO_2 Step 3 - 5 - Select BACT

The use of pipeline-quality natural gas as the primary fuel is the only feasible SO_2 control technology for the boilers to control SO_2. There is no adverse energy, environmental or cost impact associated with the use of this control technology. Thus, no further analysis is required under EPA's top-down BACT approach. SO_2 emissions associated with the boilers are due to fuel combustion. Emissions associated with this process are less than 1 tpy. Therefore, the University is proposing good combustion practices and use pipeline-quality natural gas as the primary fuel is considered BACT.

UCHTWP Boilers SO_2 Most Stringent Measures

MSM is equivalent to BACT in this instance since no add-on control technologies are available for these units.

3.2.4. VOC

UCHTWP Boilers VOC Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);31
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NOX Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook[32]; and
- Permits available online.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. The most closely related processes were as follows:

[31] Database accessed February 27, 2017.

[32] BAAQMD BACT/TBACT Workbook - BACT(2) for POC is GCP

Table 7 - Medium Natural Gas Boilers (<100 MMBtu) VOCs Emissions[33]

Company Listing	Location	Heat Input	Controls	Emission Rate
HARRAH'S[34] Operating Company, Inc.	Clark Co, NV	24 MMBtu/hr	Operating according to manufacturer's specifications	0.0054 lb/MMBtu
MGM MIRAGE[35]	Clark Co, NV	41.46 MMBtu/hr	Limiting to Natural Gas and Good Combustion Practices	0.0024 lb/MMBtu
MGM MIRAGE[36]	Clark Co, NV	44 MMBtu/hr	Limiting to Natural Gas and Good Combustion Practices	0.0055 lb/MMBtu

The technologies identified as possible VOC reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

Pollutant	Control Technologies
VOCs	Thermal Oxidizer/Afterburner
	Regenerative Thermal Oxidizer (RTO)
	Catalytic Oxidation
	Good Combustion Practices

UCHTWP Boilers VOC Step 2 - Eliminate Technically Infeasible Options

Simple Thermal Oxidizer or Afterburner (TO)

In a simple TO or afterburner, the flue gas exiting the boiler is reheated in the presence of sufficient oxygen to oxidize the VOC present in the flue gas. A typical TO is a flare and is not equipped with any heat recovery device. A TO will require additional fuel to heat the gas stream starting from 280°F to at least 1,600°F and which will generate additional emissions. Additionally, a TO is no different from the combustion chamber of the boiler. Therefore, there would be little expected reduction in VOC with an increase in other combustion pollutants for the required heating of the exhaust stream. Therefore, the TO is not considered further.

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[33] The facilities were selected based on process type and purpose of equipment as well as location within similar Non-attainment areas and the application of SIP/PSD BACT. Up-to-date RBLC search run on April 23, 2017.

[34] RBLC Reference NV-0049, Harrah's Operating Company permit was issued in 2009.

[35] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

[36] RBLC Reference NV-0050, MGM Mirage permit was issued in 2009.

Regenerative Thermal Oxidizer (RTO)

A RTO is equipped with ceramic heat recovery media (stoneware) that has large surface area for heat transfer and can be stable to 2,300°F. Operating temperatures of the RTO system typically range from 1,500°F to 1,800°F with a retention time of approximately one second. The combustion chamber of the RTO is surrounded by multiple integral heat recovery chambers, each of which sequentially switches back and forth from being a preheater to a heat recovery chamber. In this fashion, energy is absorbed from the gas exhausted from the unit and stored in the heat exchange media to preheat the next cycle of incoming gas. An RTO will require additional fuel to heat the gas stream from 280°F to at least 1,500°F and which will generate additional emissions; therefore, the RTO is not considered further.

Catalytic Oxidation

Catalytic oxidation allows complete oxidation to take place at a faster rate and a lower temperature than is possible with thermal oxidation. Oxidation efficiency depends on exhaust flow rate and composition. Residence time required for oxidation to take place at the active sites of the catalyst may not be achieved if exhaust flow rates exceed design specifications. Also, sulfur and other compounds may foul the catalyst, leading to decreased efficiency. In a typical catalytic oxidizer, the gas stream is passed through a flame area and then through a catalyst bed at a velocity in the range of 10 to 30 feet per second (fps). Catalytic oxidizers typically operate at a narrow temperature range of approximately 600°F to 1100°F. A catalytic oxidizer will require additional fuel to heat the gas stream from 280°F to at least 600°F and which will generate additional emissions; therefore, the catalytic oxidation is not considered further. This is listed in RBLC for a single source with higher emission rates than others using good operating practices.

Good Combustion Practices and Use of Clean Burning Fuels

Good combustion practices for VOCs include adequate fuel residence times, proper fuel-air mixing, and temperature control. As it is imperative for process controls, the University will maintain combustion optimal to their process. Most results in RBLC determined that this was sufficient controls for VOC. Additionally, BAAQMD and SCAQMD did not provide BACT determinations for VOC.

UCHTWP Boilers VOC Step 3-5 - Select BACT

Step 3 and 4 are not necessary since all control technologies not currently being used have been determined technically infeasible or current technologies have lower emission rates. BACT for the boilers is good combustion practices and the use of clean burning fuel.

UCHTWP Boilers VOC Most Stringent Measures

MSM is equivalent to BACT in this instance.

3.2.5. Ammonia

The University found ammonia emission factors for uncontrolled boilers on EPA's WebFIRE database.[37] The emission factors cited within this document are from the 1994 version of EPA's AP-42 Chapter 1.4. In 1998, this chapter was updated and ammonia emissions were removed from the list of emission factors associated with external combustion sources fueled by natural gas. As such, the University assumes there are minimal ammonia emissions associated with the boilers and have not considered them further for BACT.

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[37] Database accessed April 12, 2017.

3.3. LCHTWP BOILERS

The lower campus high temperature water plant (LCHTWP) provides the heating and cooling necessary for the lower (western) portion of campus and is located in Building 303. The LCHWTP has four natural gas-fired boilers and a cogeneration unit which consists of a turbine and a waste heat recovery unit.

The University has taken great strides to make the campus more energy efficient and has a long term commitment to sustainability. This is demonstrated, through the University's initiative to implement newer boiler technology, such as that planned for the UCHTWP boilers, and the new 6.5 megawatt (MW) combined heat and power (CHP) system installed in 2008. In a continued effort to become increasingly energy efficient, the University also continues to work on the campus buildings to make them LEED certified. The University currently exceeds State of Utah energy standards for construction, requiring 12% more energy cost savings over what is required by the State and code (32% vs 20%).

This section focuses on the boilers installed: two units rated at 105 MMBtu/hr each (Units 3 and 4) and two units rated at 50 MMBtu/hr each (Units 6 and 7). Table 3-8 below summarizes the operating characteristics and replacement schedule for each boiler.

Table 3-8 Operating Characteristics and Replacement Schedule

Boiler Number	Input Capacity (MMBtu/hr)	Installed/Operating Characteristics	Replacement Schedule
Unit 3	105	- Only used at peak demand or during a malfunction	- To be decommissioned by the end of 2018 - Replaced with a high efficiency unit (Unit #9) by December 31, 2018
Unit 4	105	- Only used at peak demand or during a malfunction	- To be decommissioned in 2018 - Will be removed
Unit 6	50	- Utilize LNB + FGR - 9 ppm	- Installed in 2016
Unit 7	50	- Utilize LNB + FGR - 9 ppm	- Installed in 2016

As part of the 2013 moderate non-attainment SIP development, the University committed to decommissioning Units 3 and 4 in 2019, respectively. In place of the units the University will install a single 75 MMBtu/hr high efficiency natural gas boiler. The University plans to meet the agreed upon deadlines for decommissioning and will have Units 3 and 4 will be decommissioned and replaced by December 31, 2018. In accordance with the $PM_{2.5}$ Moderate SIP, the BACT review presented below applies to the 75 MMBtu/hr replacement high efficiency boiler for Unit 3, as well as Units 6 and 7. The implementation of newer boiler technologies demonstrate the University's continued effort to become increasingly energy efficient, amongst other strides the University has taken and is taking as discussed in the UCHTWP boiler section, Section 3.2.

Startup and shutdown emissions are anticipated to be less than or equal to emissions during normal operations on the boilers at the LCHTWP.

3.3.1. $PM_{2.5}$

According to EPA's AP-42, Section 1.4, since natural gas is a gaseous fuel, filterable PM emissions are typically low. Particulate matter from natural gas combustion has been estimated to be less than one micrometer in size and has filterable and condensable fractions. Particulate matter in natural gas combustion is usually larger molecular weight hydrocarbons that are not fully combusted. Increased particulate matter emissions can result from poor air/fuel mixing or maintenance problems.

LCHTWP Boilers $PM_{2.5}$ Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[38]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NO_X Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

To demonstrate a complete analysis, the University has evaluated the following for $PM_{2.5}$.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. Similar to the LCHTWP had similar sources in the RBLC search as the LCHTWP, therefore it is not repeated from above. The same results for $PM_{2.5}$ can be found in Table 2 - Medium Natural Gas Boilers (<100 MMBtu) $PM_{2.5}$ Emissions Table 2.

The technologies identified as possible $PM_{2.5}$ reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

[38] Database accessed February 27, 2017.

Pollutant	Control Technologies
$PM_{2.5}$	Fabric Filter
	Wet Scrubber
	Electrostatic Precipitator
	Cyclone

LCHTWP Boilers $PM_{2.5}$ Step 2 - Eliminate Technically Infeasible Options

Wet Scrubber

A wet gas scrubber is an air pollution control device that removes PM and acid gases from waste streams from stationary point sources. PM and acid gases are primarily removed through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. Wet scrubbers have some advantages over ESPs and baghouses in that they are particularly useful in removing PM with the following characteristics:

- Sticky and/or hygroscopic materials;
- Combustible, corrosive or explosive materials;
- Particles that are difficult to remove in dry form;
- PM in the presence of soluble gases; and
- PM in gas stream with high moisture content.

However, considering the low concentration of $PM_{2.5}$ and the small size of particulate, a wet scrubber is considered technically infeasible for a boiler firing natural gas.

Electrostatic Precipitator

An ESP is a particle control device that uses electrical forces to move the particles out of the gas stream onto collector plates. This process is accomplished by the charging of particles in the gas stream using positively or negatively charged electrodes. The particles are then collected as they are attracted to oppositely opposed electrodes. Once the particles are collected on the plates, they are removed by knocking them loose from the plates, allowing the collected layer of particles to fall down into a hopper. ESP's are used to capture coarse particles at high concentrations. Small particles at low concentrations are not effectively collected by an ESP. As the technology is for the combustion of natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, ESP is considered technically infeasible for a boiler firing natural gas.

Fabric Filter

A fabric filter unit (or baghouse) consists of one or more compartments containing rows of fabric bags. Particle-laden gases pass along the surface of the bags then through the fabric. Particles are retained on the upstream face of the bags and the cleaned gas stream is vented to the atmosphere. Fabric filters collect particles with sizes ranging from submicron to several hundred microns in diameter. Fabric filters are used for medium and low gas flow streams with high particulate concentrations. As the boilers combust natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, a fabric filter is considered technically infeasible for a boiler firing natural gas.

Good Combustion Practices and Use of Clean Burning Fuels

The use of good combustion practices usually include the following components: (1) proper fuel mixing in the combustion zone; (2) high temperatures and low oxygen levels in primary zone; (3) Overall excess oxygen levels

high enough to complete combustion while maximizing boiler efficiency, and (4) sufficient residence time to complete combustion. Good combustion practices are accomplished through boiler design as it relates to time, temperature, and turbulence, and boiler operation as it related to excess oxygen levels.

LCHTWP Boilers $PM_{2.5}$ Step 3-5 - Select BACT

Step 3 and 4 are not necessary since all control technologies that are not currently being used have been determined technically infeasible. No control technology is technically feasible, therefore this emission rate using good combustion practices and natural gas is considered BACT.

LCHTWP Boilers $PM_{2.5}$ Most Stringent Measures

The most stringent measures would be identical to BACT as no control technology is technically feasible for these units.

3.3.2. NO_X

The NO_X that will be formed during combustion is from two major mechanisms: thermal NO_X and fuel NO_X. Since natural gas is relatively free of fuel-bound nitrogen, the contribution of this second mechanism to the formation of NO_X emissions in natural gas-fired equipment is minimal, leaving thermal NO_X as the main source of NO_X emissions. Thermal NO_X formation is a function of residence time, oxygen level, and flame temperature, and can be minimized by controlling these elements in the design of the combustion equipment.

LCHTWP Boilers NO_X Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[39]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NO_X Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process
- Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. Similar to the LCHTWP had similar sources in the RBLC search as the LCHTWP, therefore it is not repeated from above.

The technologies identified as possible NO_X reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

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[39] Database accessed February 27, 2017.

Pollutant	Control Technologies
NO_X	Low NO_X Burners
	Ultra-Low NO_X Burners
	Flue Gas Recirculation
	Selective Catalytic Reduction
	Good Combustion Practices

LCHTWP Boilers NO_X Step 2 - Eliminate Technically Infeasible Options

To demonstrate a complete analysis, the University has evaluated the follow technologies including both replacement burners and add-on controls.

Low NOx Burners

LNB technology uses advanced burner design to reduce NO_X formation through the restriction of oxygen, flame temperature, and/or residence time. There are two general types of LNB: staged fuel and staged air burners. In a stage fuel LNB, the combustion zone is separated into two regions. The first region is a lean combustion region where a fraction of the fuel is supplied with the total quantity of combustion air. Combustion in this zone takes place at substantially lower temperatures than a standard burner. In the second combustion region, the remaining fuel is injected and combusted with left over oxygen from the first region. A staged air burner begins with full fuel but only partial combustion air, and then adds the remaining combustion air in the second combustion region. These techniques reduce the formation of thermal NO_X. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NO_X using a combination of SCR, LNB, and FGR. SCAQMD used LNB as the BACT determined control methodology for the University of California Irvine Medical Center boiler rated at 48.6 MMBtu/hr in 1999.

Ultra Low NOx Burners

ULNB technology uses internal FGR which involves recirculating the hot O_2 depleted flue gas from the heater into the combustion zone using burner design features and fuel staging to reduce NO_X. An ULNB is most commonly using an internal induced draft to reach the desired emission limitations. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NO_X using a combination of ULNB and FGR. SCAQMD used LNB plus FGR as the BACT determined control methodology for the Los Angeles County Internal Services Department boiler rated at 39 MMBtu/hr in 2004. An ULNB can achieve an emission rate of approximately 9 ppm or 0.011 lb/MMBtu when used in conjunction with FGR. Unit 9, which will be installed in place of Units 3 and 4 in 2018 will utilize ULNB technology.

Flue Gas Recirculation

FGR is frequently used with both LNB and ULNB burners. FGR involves the recycling of post-combustion air into the air-fuel mixture to reduce the available oxygen and help cool the burner flame. External FGR requires the use of ductwork to route a portion of the flue gas in the stack back to the burner windbox; FGR can be either forced draft (where hot side fans are used) or induced draft. This technology is listed in the RBLC search as technically feasible and is paired with LNB for the BACT determined control technology. As previously discussed, both SCAQMD and BAAQMD have combined this technology with others to determine BACT. Currently, Units 6 and 7 utilize use this technology.

Selective Catalytic Reduction

SCR has been applied to stationary source, fossil fuel-fired, combustion units for emission control since the early 1970s. It has been applied to large (>250 MMBtu/hr) utility and industrial boilers, process heaters, and combined cycle gas turbines. There has been limited application of SCR to other combustion devices and processes such as simple cycle gas turbines, stationary reciprocating internal combustion engines, nitric acid plants, and steel mill annealing furnaces. SCR can be applied as a stand-alone NOX control or with other technologies such as combustion controls. The reagent reacts selectively with the flue gas NOX within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOX into molecular nitrogen (N2) and water vapor (H_2O).[40] The optimum operating temperature is dependent on the type of catalyst and the flue gas composition. Generally, the optimum temperature ranges from 480°F to 800°F.[41] In practice, SCR systems operate at efficiencies in the range of 70% to 90%.[42]

SCR is listed in the RBLC search as technically feasible. In some cases, this control technology is listed in combination with LNB and FGR. As previously mentioned, BAAQMD defines BACT as the combination of SCR, LNB, and FGR.

The ammonia "slip" associated with the SCR is a documented problem. The increased ammonia emissions (currently zero) from the implementation of this technology would offset the marginal air quality benefits the SCR option would provide from NO_X emissions reduction. Ammonia slip emissions have the potential to increase secondary $PM_{2.5}$ levels in the area more than the SCR controlled NO_X mass. Storage and handling of ammonia poses significant safety risks when applied at the University of Utah. Ammonia is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose, or throat, it is a commonly used material that is typically handled safely and without incident. However, there are potential health and safety hazards associated with the implementation of this technology. The LCHTWP is located in a densely-packed area with other public facilities and a significant number of University staff, students, and the general public potentially in harm's way. Locating ammonia tanks in these premises poses significant health risks for students, faculty, patients, family members and the general public if a leak were to occur. The exhaust stream entering the SCR will require additional heat to meet the SCR operating temperature requirements (minimum of 480°F). This increase in exhaust temperature would require an additional combustion device, also increasing NO_X, SO_2, and $PM_{2.5}$ emissions.

Furthermore, there is a physical space issue concerning this technology. Building 303, where the LCHTWP boilers are housed, is confined by other buildings in the immediate proximity and currently does not provide the space required to physically install an SCR. The location of the boilers within the building also presents a space challenge when installing an SCR. The physical space restriction within Building 303 is more confined than the physical space in Building 302 as discussed in Section 3.2.2. Therefore, the SCR is considered technically infeasible for the boilers located in Building 303 due to physical limitations, public safety concerns, and additional pollutants being emitted to use this add-on control technology.

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[40] Ibid.

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

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

Good Combustion Practices

Good combustion practices were previously addressed in the $PM_{2.5}$ control device evaluation for the LCHTWP boilers above.

LCHTWP Boilers NO_X Step 3-5 - Select BACT

Based on an RBLC search the following technologies are currently being used for boilers between 25 MMBtu/hr and 100 MMBtu/hr. These are ranked based on which technology can achieve the lowest emission rate. Note, an ULNB has not been proven with an SCR based on RBLC review.

1. ULNB or LNB + FGR = 9 ppm or 0.011 lb/MMBtu
2. LNB = 30 ppm or 0.036 lb/MMBtu
3. FGR = 187 ppm or 0.23 lb/MMBtu

Units 6 and 7 currently utilize LNB and FGR and have a permitted NO_x emission rate of 9 ppm (0.25 lb/hr), each.[43] Unit 9, which will replace existing Units 3 and 4 in 2018, will utilize ULNB technology and achieve an emission rate of 9 ppm. That being said, while other control technologies are available, all three (3) of these units will meet BACT with the control technologies that are currently employed or will be employed (in the case of Units 6 and 7, and Unit 9, respectively) and, thus, further evaluation is not needed. Consequently, the University has concluded BACT for Units 6 and 7 is LNB and FGR and BACT for Unit 9 is an ULNB.

LCHTWP Boilers NO_X Most Stringent Measures

MSM is identical to BACT in this instance.

3.3.3. SO_2

The top-down BACT analysis for SO_2 emissions for the LCHTWP boilers is presented below. The technologies identified as possible SO_2 reduction technologies for Medium Size Natural Gas Boilers are natural gas and good combustion practices as identified in Table 6 – Medium Natural Gas Boilers (<100 MMBtu) SO_2 Emissions.

SO_2 emissions associated with the boilers are due to natural gas combustion. Emissions associated with all boilers are less than 2 tpy. Therefore, the University is proposing good combustion practices and use of natural gas as BACT.

LCHTWP Boilers SO_2 Step 1 - Identify All Control Technologies

There are two primary mechanisms to reduce SO_2 emissions from combustion sources which are: (1) reduce the amount of sulfur in the fuel, and (2) remove the sulfur from the exhaust gases with post-combustion control device such as flue gas desulfurization utilizing wet scrubbers or dry scrubbers.

The University will be using pipeline-quality natural gas which has a low sulfur content. The use of a fuel containing low sulfur content is considered a control technology.

Two main types of SO_2 post-combustion control technologies, wet and dry scrubbing, were identified to reduce SO_2 in the exhaust gas.

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[43] AO AN103540025-13, Permit Condition II.B.2.c

LCHTWP Boilers SO_2 Step 2 - Eliminate Technically Infeasible Options

The requirement for low-sulfur natural gas is a control technique that has been achieved in practice and is technically feasible and cost-effective and will be further considered for BACT. Post-combustion devices such as wet or dry scrubbers are typically installed on coal-fired power plants that burn fuels with much higher sulfur contents. The SO_2 concentrations in the natural gas combustion exhaust gases from the boilers are too low for scrubbing technologies to work effectively or to be technically feasible and cost effective. These control technologies require much higher sulfur concentrations in the exhaust gases to be feasible as a control technology. Thus, post-combustion SO_2 control devices, such as wet and dry scrubbing have not been achieved in practice on natural gas boilers. Since these controls are not technically feasible, they have been eliminated from further consideration for the boilers.

LCHTWP Boilers SO_2 Step 3-5 - Select BACT

The use of pipeline-quality natural gas is the only feasible SO_2 control technology for the boilers to control SO_2. There is no adverse energy, environmental or cost impact associated with the use of these control technologies. Thus, no further analysis is required under EPA's top-down BACT approach. SO_2 emissions associated with the boilers are due to natural gas combustion. Emissions associated with this process are less than 2 tpy. Therefore, the University is proposing good combustion practices and use pipeline-quality natural gas as the primary fuel is considered BACT.

LCHTWP Boilers SO_2 Most Stringent Measures

MSM is equivalent to BACT in this instance since no add-on control technologies are available for these units.

3.3.4. VOC

LCHTWP Boilers VOC Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[44]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NOX Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

To demonstrate a complete analysis, the University has evaluated the follow technologies for VOCs.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. Similar to the LCHTWP had similar sources in the RBLC search as the LCHTWP,

[44] Database accessed February 27, 2017.

therefore it is not repeated from above. The same results for VOC can be found in Table 7 – Medium Natural Gas Boilers (<100 MMBtu) VOCs Emissions.

The technologies identified as possible VOC reduction technologies for Medium Size Natural Gas Boilers are shown in the table below.

Pollutant	Control Technologies
VOCs	Thermal Oxidizer/Afterburner
	Regenerative Thermal Oxidizer (RTO)
	Catalytic Oxidation
	Good Combustion Practices

LCHTWP Boilers VOC Step 2 - Eliminate Technically Infeasible Options

Simple Thermal Oxidizer or Afterburner

In a simple TO or afterburner, the flue gas exiting the boiler is reheated in the presence of sufficient oxygen to oxidize the VOC present in the flue gas. A typical TO is a flare and is not equipped with any heat recovery device. A TO will require additional fuel to heat the gas stream starting from 280°F to at least 1,600°F and which will generate additional emissions. Additionally, a TO is no different from the combustion chamber of the boiler. Therefore, there would be little expected reduction in VOC with an increase in other combustion pollutants for the required heating of the exhaust stream. Therefore, the TO is not considered further.

Regenerative Thermal Oxidizer

A RTO is equipped with ceramic heat recovery media (stoneware) that has large surface area for heat transfer and can be stable to 2,300°F. Operating temperatures of the RTO system typically range from 1,500°F to 1,800°F with a retention time of approximately one second. The combustion chamber of the RTO is surrounded by multiple integral heat recovery chambers, each of which sequentially switches back and forth from being a preheater to a heat recovery chamber. In this fashion, energy is absorbed from the gas exhausted from the unit and stored in the heat exchange media to preheat the next cycle of incoming gas. An RTO will require additional fuel to heat the gas stream from 280°F to at least 1,500°F and which will generate additional emissions; therefore, the RTO is not considered further.

Catalytic Oxidation

Catalytic oxidation allows complete oxidation to take place at a faster rate and a lower temperature than is possible with thermal oxidation. Oxidation efficiency depends on exhaust flow rate and composition. Residence time required for oxidation to take place at the active sites of the catalyst may not be achieved if exhaust flow rates exceed design specifications. Also, sulfur and other compounds may foul the catalyst, leading to decreased efficiency. In a typical catalytic oxidizer, the gas stream is passed through a flame area and then through a catalyst bed at a velocity in the range of 10 to 30 feet per second (fps). Catalytic oxidizers typically operate at a narrow temperature range of approximately 600°F to 1100°F. A catalytic oxidizer will require additional fuel to heat the gas stream from 280°F to at least 600°F and which will generate additional emissions; therefore, the catalytic oxidation is not considered further. This is listed in RBLC for a single source with higher emission rates than others using good operating practices.

Good Combustion Practices and Use of Clean Burning Fuels

Good combustion practices for VOCs include adequate fuel residence times, proper fuel-air mixing, and temperature control. As it is imperative for process controls, the University will maintain combustion optimal to their process. Most results in RBLC determined that this was sufficient controls for VOC. Additionally, BAAQMD and SCAQMD did not provide BACT determinations for VOC.

LCHTWP Boilers VOC Step 3-5 - Select BACT

Step 3 and 4 are not necessary since all control technologies not currently being used have been determined technically infeasible or current technologies have lower emission rates. BACT for the boilers is good combustion practices and the use of clean burning fuel.

LCHTWP Boilers VOC Most Stringent Measures

MSM is equivalent to BACT in this instance since no add-on control technologies are available for these units.

3.3.5. Ammonia

The University found ammonia emission factors for uncontrolled boilers on EPA's WebFIRE database.[45] The emission factors cited within this document are from the 1994 version of EPA's AP-42 Chapter 1.4. In 1998, this chapter was updated and ammonia emissions were removed from the list of emission factors associated with external combustion sources fueled by natural gas. As such, the University assumes there are minimal ammonia emissions associated with the boilers and have not considered them further for BACT.

3.4. LCHTWP TURBINE WITH WASTE HEAT RECOVERY UNIT

The University has a natural gas-fired turbine cogeneration plant which includes both a turbine and waste heat recovery unit (WHRU) with duct burner. This combination is also known as a combined cycle turbine. The turbine model is a Solar Taurus 70 T7800S equipped with Solar's SoLoNOx™ technology. The SoLoNOx™ technology uses lean-premixed combustion technology to ensure uniform air/fuel mixture, thus reducing formation of regulated pollutants. The unit is rated to 7.23 megawatts (MW) and de-rated to 6.5 MW based on altitude. The turbine has a heat input of 72.78 MMBtu/hr. The recycled waste heat from the gas turbine is sent to a Rentech waste heat recovery boiler. The supplemental duct burner is rated at 85 MMBtu/hr.

The WHRU is a part of the combined cycle turbine system. The WHRU cannot operate without the turbine. For general practice the WHRU and turbine operate together and therefore have been evaluated as one unit. This unit is subject to the requirements of NSPS Subpart KKKK.

The following sections detail potential controls and operating conditions necessary to achieve the required emissions for each pollutant. The review will detail controls as they apply to normal operations. Startup and shutdown operations manage emission rates by minimizing the duration of startup and shutdown. Therefore, the University of Utah during a startup will bring the turbine to the minimum load necessary to achieve compliance with the applicable NO_X and CO emission limits as quickly as possible, consistent with the equipment manufacturers' recommendations and safe operating practices. During a shutdown, once the turbine reaches a load that is below the minimum load necessary to maintain compliance with the applicable NO_X and CO emission

[45] Database accessed April 12, 2017.

limits, reduce the turbine load to zero as quickly as possible, consistent with the equipment manufacturers' recommendations and safe operating practices.

Startup and shutdown emissions are anticipated to be less than or equal to emissions during normal operations on the turbine and waste heat recover unit (WHRU) at the LCHTWP.

3.4.1. $PM_{2.5}$

According to EPA's AP-42, Section 1.4, since natural gas is a gaseous fuel, filterable PM emissions are typically low. Particulate matter from natural gas combustion has been estimated to be less than one micrometer in size and has filterable and condensable fractions. Particulate matter in natural gas combustion is usually larger molecular weight hydrocarbons that are not fully combusted. Increased particulate matter emissions can result from poor air/fuel mixing or maintenance problems. This section specifically addresses the filterable portion of $PM_{2.5}$, as the precursors are addressed as individual pollutants (NO_X, SO_2, VOCs, NH_3).

Turbine $PM_{2.5}$ Step 1 - Identify All Control Technologies

Potential control technologies were identified through the review of the following:

- SCAQMD LAER/BACT Determinations;
- BAAQMD BACT/TBACT Workbook;
- SJVAPCD BACT Clearinghouse;
- California Environmental Protection Agency (CEPA);
- EPA's RBLC Database for Combined Cycle Turbines (16.210);[46]
- NSPS KKKK – Standards of Performance for Stationary Combustion Turbines; and
- TCEQ BACT Requirements.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "16.210" (Small Combustion Turbine, Combined Cycle and Cogeneration < 25 Mega Watt (MW)), which covers operations associated with UCHTWP. Those with $PM_{2.5}$ limits and most closely related processes were as follows:

Table 9 – $PM_{2.5}$ Turbine Controls and Emission Rates from RBLC[47]

Facility Name	State	Permit Issu	Throughput	Control Method	Emission Limit	Averaging Time	Case-by-Case
MEDICAL AREA TOTAL ENERGY PLANT	MA	07/01/2016	203.4 MMBtu/hr		0.02 LB/MMB	1 hour block avg/Exlcuding SS,	BACT-PSD
WOODBRIDGE ENERGY CENTER	NJ	07/25/2012	40,297.60 MMcubic ft/yr	Use of natural gas, a clean burning fuel	12.1 LB/H	Avg of three tests	OTHER CASE-BY-CASE
WOODBRIDGE ENERGY CENTER	NJ	07/25/2012	40,297.60 MMcubic ft/yr	Good combustion practices and use of natural gas	19.1 LB/H	Avg of three tests	OTHER CASE-BY-CASE
HESS NEWARK ENERGY CENTER	NJ	11/01/2012	39,463 MMcubic ft/yr	Use of natural gas a clean burning fuel	11 LB/H	Avg of three tests	N/A
HESS NEWARK ENERGY CENTER	NJ	11/01/2012	39,463 MMcubic ft/yr	Use of natural gas a clean burning fuel	13.2 LB/H	Avg of three tests	N/A
CORNELL COMBINED HEAT & POWER PROJECT	NY	03/12/2008	155 MMBtu/hr	Sulfur in gas assumed max 1.2 g/100 scf Work Practice to minimize NH_3 Slip.	3.9 LB/H	Above 0°F, 1 hour avg.	BACT-PSD
CORNELL COMBINED HEAT & POWER PROJECT	NY	03/12/2008	155 MMBtu/hr	Ultra low sulfur in diesel at 15 ppm. Work Practice to minimize NH_3 Slip.	6.3 LB/H	Above 0°F, 1 hour avg.	BACT-PSD
CORNELL COMBINED HEAT & POWER PROJECT	NY	03/12/2008	155 MMBtu/hr	Sulfur in gas assumed max 1.2 g/100 scf Work Practice to minimize NH_3 Slip.	6.7 LB/H	Above/below, 1 hour avg.	BACT-PSD
CORNELL COMBINED HEAT & POWER PROJECT	NY	03/12/2008	155 MMBtu/hr	Ultra low sulfur in diesel at 15 ppm. Work Practice to minimize NH_3 Slip.	8.3 LB/H	Above 0°F, 1 hour avg.	BACT-PSD
WA PARISH ELECTRIC GENERATING STATION -E	TX	12/19/2012	80 MW	Good combustion and use of natural gas	16.58 LB/H	1 Hour	BACT-PSD

[46] Database accessed March 13, 2017.

[47] Up-to-date RBLC search run on April 23, 2017.

The technologies identified as possible $PM_{2.5}$ reduction technologies for small combustion, combined cycle and cogeneration turbines are shown in the table below.

Pollutant	Control Technologies
$PM_{2.5}$	Fabric Filter (Baghouse)
	Natural Gas Usage and Good Combustion Practices

Turbine $PM_{2.5}$ Step 2 - Eliminate Technically Infeasible Options

Fabric Filter

A fabric filter unit (or baghouse) consists of one or more compartments containing rows of fabric bags. Particle-laden gases pass along the surface of the bags then through the fabric. Particles are retained on the upstream face of the bags and the cleaned gas stream is vented to the atmosphere. Fabric filters collect particles with sizes ranging from submicron to several hundred microns in diameter. Fabric filters are used for medium and low gas flow streams with high particulate concentrations. The turbine and duct burner associated with the WHRU combust natural gas, resulting in low concentration of $PM_{2.5}$. With such low concentrations a fabric filter would not be effective and therefore is considered technically infeasible for a turbine and WHRU duct burner firing natural gas.

Natural Gas Usage and Good Combustion Practices

Natural gas usage and good combustion practices are listed in the SJVAPCD BACT Clearinghouse, BAAQMD BACT/TBACT Workbook, and RBLC as the appropriate control technology for $PM_{2.5}$. Emissions associated with $PM_{2.5}$ for the turbine and WHRU duct burner are low in concentration due to the use of natural gas fuel in comparison to other available fuel types. Increased particulate matter emissions can result from poor air/fuel mixing or maintenance problems. The turbine is equipped with the SoLowNOx™ technology allowing proper air/fuel mixing. The turbine and WHRU duct burner are natural gas fired and regularly maintained in accordance with manufacturer recommendations to ensure good combustion practices are maintained.

Turbine $PM_{2.5}$ Step 3-5 - Select BACT

Step 3 and 4 are not necessary since the University is using the best available control technology recommended in state-by-state nonattainment area SIPs and the RBLC. The turbine and WHRU duct burner will continue to use natural gas fuel and good combustion practices as BACT.

Turbine $PM_{2.5}$ Most Stringent Measures

The most stringent measures would be identical to BACT as no control technology is technically feasible for these units.

3.4.2. NO_X

The NO_X that will be formed during combustion by two major mechanisms: thermal NO_X and fuel NO_X. Since natural gas is relatively free of fuel-bound nitrogen, the contribution of this second mechanism to the formation of NO_X emissions in natural gas-fired equipment is minimal and thermal NO_X is the chief source of NO_X emissions. Thermal NO_X formation is a function of residence time, oxygen level, and flame temperature, and can be minimized by controlling these elements in the design of the combustion equipment.

The turbine is permitted for an emission rate of 9 ppm NO_X at 15% O_2 and 2.65 pounds per hour (lbs/hr).[48] The combined turbine and WHRU duct burner is permitted for an emission rate of 15 ppm NO_X at 15% O_2 and 18.97 lb/hr.[49]

Turbine NO_X Step 1 - Identify All Control Technologies

Potential control technologies were identified through the review of the following:

- SCAQMD LAER/BACT Determinations;
- BAAQMD BACT/TBACT Workbook;
- SJVAPCD BACT Clearinghouse;
- CEPA;
- EPA's RBLC Database for Combined Cycle Turbines (16.210);[50]
- EPA Alternative Control Techniques Document – NO_X Emissions from Stationary Gas Turbines;
- NSPS KKKK – Standards of Performance for Stationary Combustion Turbines; and
- TCEQ BACT Requirements.

To demonstrate a complete analysis the University of Utah has evaluated the following technologies for NO_X.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "16.210" (Small Combustion Turbine, Combined Cycle and Cogeneration < 25 Mega Watt (MW)), which covers operations associated with UCHTWP. The most closely related processes were as follows:

Table 10 – NO_X Turbine Controls and Emission Rates from RBLC[51]

Facility Name	State	Permit Issua	Throughput	Control Method	Emission Limit	Averaging Time	Case-by-Case
MEDICAL AREA TOTAL ENERGY PLANT	MA	7/1/2016	203.4 MMBtu/hr	Dry Low NOx Combustor and SCR	2 PPMVD@15% O_2	1 HR BLOCK AVG/EXCLUDING SS, NG FIRING	OTHER CASE-BY
GEISINGER MED CTR/DANVILLE	PA	6/18/2010	55.62 MMBtu/hr	SoLoNOx combustor	15 PPMVD@15% O_2	IN SOLONOX MODE	OTHER CASE-BY
DEER CREEK STATION	SD	6/29/2010	300 Megawatts	SCR	25.8 lb/hr	3-HOUR, EXCLUDES SSM	BACT-PSD
ENDICOTT PRODUCTION FACILITY, LIBERTY DEVELOPMENT PROJECT	AK	6/15/2009	7.5 KW	Dry Low NOx Combustors	25 PPMVD@15% O_2	WHEN AMBIENT TEMPERATURE => 10 DEG-F	BACT-PSD
AUBURNDALE CITRUS FACILITY	FL	6/12/2008	62.7 MMBtu/hr	Dry Low NOx Burner	25 PPMVD	HR AVG/CORRECTED TO 25% O2	BACT-PSD
AUBURNDALE CITRUS FACILITY	FL	6/12/2008	62.7 MMBtu/hr	Dry Low NOx Burner	25 PPMVD	HR AVG/CORRECTED TO 25% O2	BACT-PSD
LEESBURG CITRUS FACILITY	FL	6/2/2008	62.7 MMBtu/hr	Dry Low NOx Burner	25 PPMVD	HR AV/CORRECTED TO 25% O2	BACT-PSD
WESTLAKE FACILITY	LA	7/12/2016	159.46 MMBtu/hr	Dry low NOx combustor (SoLoNOx)	14.25 lb/hr	HOURLY MAXIMUM	BACT-PSD
WOODBRIDGE ENERGY CENTER	NJ	5/2012	40298 mmcubic ft/yr	DLN combustion system with SCR on e	2 PPMVD	3-HR ROLLING AVE BASED ON 1-HR BLOCK	LAER
WOODBRIDGE ENERGY CENTER	NJ	5/2012	40298 mmcubic ft/yr	Low NOx burners and Selective Cataly	19.8 lb/hr	AVERAGE OF THREE 1- HOUR TESTS	LAER
HESS NEWARK ENERGY CENTER	NJ	11/1/2012	39463 MMCubic ft/yr	SCR System and use of natural gas	0.75 lb/hr	AVERAGE OF THREE TESTS	LAER
WA PARISH ELECTRIC GENERATING STATION -DEMONSTRATION PROJECT	TX	12/19/2012	80 MW	Dry Low NOx combusters on the turbine and SCR	2 PPMVD	3-HR ROLLING AVG, AT 15% OXYGEN	LAER
UTILITY PLANT	TX	12/2/2014	49 MW	SCR	2 PPMVD	@15% O2, 24-HR ROLLING AVERAGE	BACT-PSD
W. A. PARISH ELECTRIC GENERATING STATION	TX	12/21/2012	80 MW	SCR	2 PPMVD@15% O_2	3-HR AVERAGE	LAER

The technologies identified as possible NO_X reduction technologies for small combustion, combined cycle and cogeneration turbines are shown in the table below.

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[48] Title V Operating Permit #3500063003 Condition II.B.8.a.

[49] ibid.

[50] Database accessed March 13, 2017.

[51] Up-to-date RBLC search run on April 23, 2017.

Pollutant	Control Technologies
NO_X	Dry Low NO_X Combustors/Low NO_X Burner
	Selective Catalytic Reduction (SCR)
	EMx (formerly SCONOx) System
	Water/Steam Injection
	Natural Gas Usage and Good Combustion Practices

Control technologies included in this table are those that have been shown in practice for use in one of the previously listed databases.

Turbine NO_X Step 2 - Eliminate Technically Infeasible Options

Dry Low NO_X Combustors/Low NO_X Burner (Turbine Only)

Although dry low NO_X (DLN) combustors designed by different manufacturers may vary, they all employ the strategies of fuel and air pre-mixing and staged combustion to minimize NO_X formation in combustion turbines. The combustors burn a lean, pre-mixed fuel and air mixture to avoid localized high temperature regions. A lean air-to-fuel ratio approaching the lean flammability limit is maintained, and the excess air acts as a heat sink to lower combustion temperatures, which lowers thermal NOx formation. A pilot flame is used to maintain combustion stability in this fuel-lean environment. Other techniques, such as variable geometry, fuel staging, or combustion staging, are also incorporated in DLN combustor design. The turbine currently includes this control technology, also known as the SoLowNOx™ technology.

Ultra-Low NO_X Burner (WHRU Only)

ULNB technology combines internal flue gas recirculation (FGR), a low NO_X burner and advanced engineering principle to further optimize oxygen concentrations, flame temperature, and/or residence time which involves recirculating the hot O_2 depleted flue gas from the heater into the combustion zone using burner design features and fuel staging to reduce NO_X. Since ULNB technology utilizes FGR technology the implementation of an ULNB is not technically feasible since the implementation of FGR technology is not technically feasible. Additionally, based on an inquiry with the duct burner manufacturer, the duct burner has NO_X emission guarantee for 0.08 lbs/MMBtu High Heat Value (HHV) (equivalent to 66 ppm). The duct burner manufacturer does not have a burner that can offer lower emissions.

Selective Catalytic Reduction

SCR refers to the process in which NO_X is reduced by ammonia over a heterogeneous catalyst in the presence of oxygen. The process is termed selective because the ammonia preferentially reacts with NO_X rather than oxygen, although the oxygen enhances the reaction and is a necessary component of the process. The overall reactions can be written:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O \qquad \text{(Equation 1)}$$
$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O \qquad \text{(Equation 2)}$$

SCR can be applied as a stand-alone NO_X control or with other technologies such as combustion controls. The SCR process requires a reactor, a catalyst, and an ammonia storage and injection system. The effectiveness of an SCR system is dependent on a variety of factors, including the inlet NO_X concentration, the exhaust temperature, the ammonia injection rate, and the type of catalyst. According to EPA, the optimum temperature range over which SCR is effective is dependent on the type of catalyst and the flue gas composition. In general, the optimum temperature range is between 480 and 800°F.[52] SCR units typically achieve 70 - 90% NO_X reduction.[53] However, if the upstream NO_X concentration is already low, as is the case with these units, it is difficult to achieve these control efficiencies.

The ammonia "slip" associated with the SCR is a documented problem. The increased ammonia emissions (currently zero) from the implementation of this technology would offset the marginal air quality benefits the SCR option would provide from NO_X emissions reduction. Ammonia slip emissions have the potential to increase secondary $PM_{2.5}$ levels in the area more than the SCR controlled NO_X mass. Storage and handling of ammonia poses significant safety risks when applied at the University. Ammonia is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose, or throat, it is a commonly used material that is typically handled safely and without incident. However, there are potential health and safety hazards associated with the implementation of this technology. The LCHTWP (Bldg 303) is located in a densely-packed area, adjacent to the TRAX line, the Huntsman Event Center, The Utah Museum of Fine Arts, and other public facilities, with a significant number of University staff, students, and the general public potentially in harm's way. Locating ammonia tanks in these premises poses significant health risks for students, faculty, patients, family members, and the general public if a leak were to occur.

The exhaust stream entering the SCR will require additional heat to meet the SCR operating temperature requirements (minimum of 480°F). This increase in exhaust temperature would require an additional combustion device, also increasing NO_X, SO_2, and $PM_{2.5}$ emissions.

Furthermore, there is a physical space issue concerning this technology and the current location. Building 303, where the LCHTWP boilers and the turbine are housed, is confined by other buildings in the immediate proximity and currently does not provide the space required to physically install an SCR. The location of the turbine within the building also presents a space challenge when installing an SCR. The physical space restriction within Building 303 is more confined than the physical space in Building 302 as discussed in Section 3.2.2. Therefore, the SCR is considered technically infeasible for the turbine and WHRU located in building 303 due to physical limitations, public safety concerns, and additional pollutants being emitted to use this add-on control technology.

SCONOx (EMx)

SCONOx is a catalytic oxidation and absorption technology that uses a single catalyst for the removal of NO_X, CO, and VOC. This technology has been used since the late 1990s and is proven for use on combined cycle turbines, lean burn reciprocating engines, diesel vehicles, and refineries. This technology has several advantages over an SCR including:

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[52] L.M. Campdell, D.K. Stone, and G.S. Shareef, *Sourcebook: NO_x Control Technology Data*, EPA/600/S2-91/029, 1991.
[53] OAQPS, *EPA Air Pollution Control Cost Manual*, Sixth Edition, EPA/424/B-02-001 (http://www.epa.gov/ttn/catc/dir1/c_allchs.pdf); January 2002

- Provides control for several pollutants - lowering overall reported emissions of NO_X, CO, VOC, and PM;
- No use of ammonia;
- Requires lower exhaust temperatures; and
- Available on a range of emission unit sizes – installed on units as small as 1 MW.

Estimates of control system efficiency vary. However, EMx Design information indicates testing showing emission reduction as much as 99.5%.[54] Commercially quoted NOx emission rates for the SCONOx system range from 2.0 ppm on a 3-hour average basis, representing a 78% reduction, to 1.0 ppm with no averaging period specified (96% reduction).

The control technology has specific requirements for use, and may be added as a retrofit technology or may require a new turbine to install the technology. Based on physical space constraints as discussed in the SCR section, the University has deemed this control technically infeasible as well.

Water/Steam Injection

Combustion control using water or steam lowers combustion temperatures, which reduces thermal NO_X formation. Water or steam, treated to quality levels comparable to boiler feedwater, is injected into the combustor and acts as a heat sink to lower flame temperatures. This control technique is available for all new turbine models and can be retrofitted to most existing installations. Although uncontrolled emission levels vary widely, the range of achievable controlled emission levels using water or steam injection is relatively small. Controlled NO_X emission levels range from 25 to 42 ppmv for natural gas fuel.[55]

Good Combustion Practices

Good combustion practices involve controlling the operating parameters of the combustors for temperature and turbulence, excess oxygen levels, and air/fuel mixing to ensure continual operation as close to optimum (i.e., minimum emission) conditions as possible.

Turbine NO_X Step 3 - Rank Remaining Control Technologies by Control Effectiveness

SoLowNOx technology (DLN combustor), water/steam injection, and good combustion practices are all considered technically feasible. The turbine currently has the SoLowNOx technology installed and achieves an emission rate of 9 ppm. The water/steam inject states it is only able to achieve emission levels as low as 25 ppm. As such, the water/steam injection is removed from further consideration. The remaining technologies are ranked based on their lowest achievable emission rate:

1. SoLowNOx technology™ – 9 ppm for Turbine alone[56]
2. Good Combustion Practices

For the WHRU, based on inquiry with the duct burner manufacturer, the current burner is the best available NO_X guarantee for the application that is available.

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[54] Reduction shown in PowerPoint presentation sent to Beth Ryder, trinity Consultants from Josh Gillespie, EmeraChem LLC.

[55] Alternative Control Techniques Document— NOx Emissions from Stationary Gas Turbines

[56] Title V Operating Permit #3500063003 Condition II.B.8.a.

Turbine NO_X Step 4 - Evaluate Most Effective Controls and Document Results

The turbine is currently equipped with SoLowNOx technology for combustion control on the turbine and the WHRU duct burner is using good combustion practices. These are the most effective controls available for the unit.

Turbine NO_X Step 5 - Select BACT

Based on the analysis performed, the use of SoLowNOx™ currently installed control technology as BACT. The turbine uses the SoLowNOx technology and the duct burner good combustion practices. Emission limits will remain at 9 ppmdv NO_X (2.65 lb/hr) for the turbine and 15 ppm NO_X (8.97 lb/hr) for the turbine and WHRU combined.

Turbine NO_X Most Stringent Measures

The most stringent measures would be identical to BACT.

3.4.3. SO_2

SO_2 emissions associated with the turbine and WHRU duct burner are due to natural gas combustion. Emissions are less than 1 tpy. Therefore, the University is proposing good combustion practices and use of natural gas as BACT.

To demonstrate a complete analysis, the University of Utah has evaluated the following technologies for SO_2.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "16.210" (Small Combustion Turbine, Combined Cycle and Cogeneration < 25 Mega Watt (MW)), which covers operations associated with UCHTWP. The sources with SO_2 limits and most closely related processes were as follows:

Table 11 - SO_2 Turbine Controls and Emission Rates from RBLC[57]

Facility Name	State	Permit Issu.	Throughput	Control Method	Emission Limit	Averaging Time	Case-by-Case
MEDICAL AREA TOTAL ENERGY PLANT	MA	07/01/2016	203.4 MMBtu/hr	clean fuels - using natural gas as primary fuel and ultra low sulfur diesel as backup.	0.6 PPMVD@	1 hour block avg/Exlcuding SS,	OTHER CASE-BY-CASE
WOODBRIDGE ENERGY CENTER	NJ	07/25/2012	40,297.60 MMcubic ft/yr	Use of only natural gas a clean burning fuel	4.1 lb/hr	Avg of three tests	OTHER CASE-BY-CASE
WOODBRIDGE ENERGY CENTER	NJ	07/25/2012	40,297.60 MMcubic ft/yr	Good Combustion Practices and Use of Natural gas,a clean burning fuel.	4.9 lb/hr	Avg of three tests	OTHER CASE-BY-CASE
HESS NEWARK ENERGY CENTER	NJ	11/01/2012	39,463 MMcubic ft/yr	Use of natural gas, a clean low sulfur fuel	2.5 lb/hr	Avg of three tests	N/A
HESS NEWARK ENERGY CENTER	NJ	11/01/2012	39,463 MMcubic ft/yr	Use of natural gas a clean low sulfur fuel	2.8 lb/hr	Avg of three tests	N/A

Turbine SO_2 Step 1 - Identify All Control Technologies

There are two primary mechanisms to reduce SO_2 emissions from combustion sources which are: (1) reduce the amount of sulfur in the fuel, and (2) remove the sulfur from the exhaust gases with post-combustion control device such as flue gas desulfurization utilizing wet scrubbers or dry scrubbers.

The University will be using pipeline-quality natural gas as the primary fuel which has a low sulfur content. The use of a fuel containing low sulfur content is considered a control technology.

[57] Up-to-date RBLC search run on April 23, 2017.

Two main types of SO_2 post-combustion control technologies, wet and dry scrubbing, were identified to reduce SO_2 in the exhaust gas.

Turbine SO_2 Step 2 - Eliminate Technically Infeasible Options

The requirement for low-sulfur natural gas is a control technique that has been achieved in practice. This technology is technically feasible and cost-effective and will be further considered for BACT. Post-combustion devices such as wet or dry scrubbers are typically installed on coal-fired power plants that burn fuels with much higher sulfur contents. The SO_2 concentrations in the natural gas combustion exhaust gases from the turbine and WHRU duct burner are too low for scrubbing technologies to work effectively or to be technically feasible and cost effective. These control technologies require much higher sulfur concentrations in the exhaust gases to be feasible as a control technology. Thus, post-combustion SO_2 control devices, such as wet and dry scrubbing have not been achieved in practice on natural gas combustion. Since these controls are not technically feasible, they have been eliminated from further consideration for the turbine and WHRU duct burner.

Turbine SO_2 Step 3-5 - Select BACT

The use of pipeline-quality natural gas is the only feasible and cost effective SO2 control technology for the turbine and WHRU duct burner. There is no adverse energy, environmental or cost impact associated with the use of this control technologies. The University will continue to use natural gas which contains 20 grains of sulfur or less per 100 standard cubic feet and has potential sulfur emissions of less than less than 26 ng SO_2/J (0.060 lb SO_2/MMBtu) heat input Thus, no further analysis is required under EPA's top-down BACT approach.

Turbine SO_2 Most Stringent Measures

MSM is equivalent to BACT because no add-on SO_2 control technologies are available for these units.

3.4.4. VOC

Turbine VOC Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[58]
- EPA's Air Pollution Technology Fact Sheets;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

To demonstrate a complete analysis, the University of Utah has evaluated the following technologies for VOCs.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "16.210" (Small Combustion Turbine, Combined Cycle and Cogeneration < 25 Mega Watt (MW)), which covers operations associated with UCHTWP. The sources with VOC limits and most closely related processes were as follows:

[58] Database accessed February 27, 2017.

Table 12 - VOC Turbine Controls and Emission Rates from RBLC[59]

Facility Name	State	Permit Issuan	Throughput	Control Method	Emission Limit	Averaging Time	Case-by-Case
MEDICAL AREA TOTAL ENERGY PLAN	MA	7/1/2016	203.4 MMBtu/hr	Oxidation Catalyst	1.7 PPMVD @ 15% O_2	1 hour block average/excluding SS	OTHER CASE-BY-CASE
GEISINGER MED CTR/DANVILLE	PA	6/18/2010	55.62 MMBtu/hr	Natural gas	0.6 lb/hr	In SoLoNO$_X$ Mode	OTHER CASE-BY-CASE
WESTLAKE FACILITY	LA	7/12/2016	159.46 MM Btu/hr	Good combustion practices, including good equipment design, use of gaseous fuels	1.64 lb/hr	Hourly Maximum	BACT-PSD
WOODBRIDGE ENERGY CENTER	NJ	7/25/2012	40,297.60 mmcubic ft/yr	Oxidation Catalyst and Good Combustion Practices and use of clean fuel (Natural gas)	2 PPMVD	3- hour rolling avg, based on 1-hr b	LAER
WOODBRIDGE ENERGY CENTER	NJ	7/25/2012	40,297.60 mmcubic ft/yr	Oxidation catalyst and Good Combustion Practices, use of natural gas a clean burning fuel	2.9 lb/hr	Avg fo 3 test runs	LAER
HESS NEWARK ENERGY CENTER	NJ	11/1/2012	39,463 mmcubic ft/yr	Oxidation catalyst	1 PPMVD	3- hour rolling avg, based on 1-hr b	LAER
HESS NEWARK ENERGY CENTER	NJ	11/1/2012	39,463 MMCubic ft/yr	Oxidation Catalyst and Good Combustion Practices and use of natural gas a clean burning fuel	2.9 lb/hr	Avg fo 3 test runs	LAER
WA PARISH ELECTRIC GENERATING S	TX	12/19/2012	80 MW	Oxidation catalyst	2 PPMVD	Initial stack test	LAER
UTILITY PLANT	TX	12/2/2014	49 MW	Oxidation catalyst	4 PPMVD	@15% O2, 24-hour rolling avg	BACT-PSD
W. A. PARISH ELECTRIC GENERATING	TX	12/21/2012	80 MW	Oxidation catalyst	2 PPMVD @ 15% O_2		LAER

The technologies identified as possible VOC reduction technologies for small combustion, combined cycle and cogeneration turbines are shown in the table below.

Pollutant	Control Technologies
VOCs	Catalytic Oxidation
	Thermal Oxidation
	Good Combustion Practices

Turbine VOC Step 2 - Eliminate Technically Infeasible Options

Catalytic Oxidation

Catalytic oxidation allows complete oxidation to take place at a faster rate and a lower temperature than is possible with thermal oxidation. Oxidation efficiency depends on exhaust flow rate and composition. Residence time required for oxidation to take place at the active sites of the catalyst may not be achieved if exhaust flow rates exceed design specifications. Also, sulfur and other compounds may foul the catalyst, leading to decreased efficiency. In a typical catalytic oxidizer, the gas stream is passed through a flame area and then through a catalyst bed at a velocity in the range of 10 to 30 feet per second (fps). Catalytic oxidizers typically operate at a narrow temperature range of approximately 600°F to 1100°F. A catalytic oxidizer will require additional fuel to heat the gas stream at least 600°F and which will generate additional emissions; therefore, the catalytic oxidation is not being considered further.

Simple Thermal Oxidizer or Afterburner

In a simple TO or afterburner, the flue gas exiting the turbine and WHRU duct burner is reheated in the presence of sufficient oxygen to oxidize the VOC present in the flue gas. A typical TO is a flare and is not equipped with any

[59] Up-to-date RBLC search run on April 23, 2017.

heat recovery device. A TO will require additional fuel to heat the gas stream starting from 280°F to at least 1,600°F and which will generate additional emissions. Therefore, there would be little expected reduction in VOC with an increase in other combustion pollutants for the required heating of the exhaust stream. Therefore, the TO is not being considered further.

Good Combustion Practices

Good combustion practices refer to the operation of engines at high combustion efficiency which reduces the products of incomplete combustion. The turbine installed has been designed to achieve maximum combustion efficiency. The University follows all instructions given in the operation and maintenance manuals that detail the required methods to achieve the highest levels of combustion efficiency.

Turbine VOC Step 3 through 5 - Select BACT

Since other add on control technologies require additional combustion units and therefore pollutant emissions, good combustion practices is the control for VOC emissions on a natural gas turbine and WHRU duct burner.

Turbine VOC Most Stringent Measures

MSM is equivalent to BACT.

3.4.5. Ammonia

The University found ammonia emission factors for uncontrolled boilers on EPA's WebFIRE database.[60] The emission factors cited within this document are from the 1994 version of EPA's AP-42 Chapter 1.4. In 1998, this chapter was updated and ammonia emissions were removed from the list of emission factors associated with external combustion sources fueled by natural gas. As such, the University assumes there are minimal ammonia emissions associated with the boilers and have not considered them further for BACT.

3.5. ADDITIONAL SMALL BOILERS

The University operates several other boilers around campus to support individual building needs. All boilers combust natural gas. Diesel is used as a backup fuel in some of the boilers during times of natural gas curtailment. A complete list of these boilers is contained in in the Table 3-13. The University plans to replace 587 boilers by December 31, 2018. This analysis evaluates the additional small boilers taking this replacement into consideration.

[60] Database accessed April 12, 2017.

Table 3-13. Additional Small Boilers at the University

Location				Fuel Type	
Building Number	Building Name	Operating Scenario	Capacity (MMBtu/hr)	Primary	Backup
32	Rice-Eccles Stadium	Primary	3	Natural Gas	-
32	Rice-Eccles Stadium	Primary	3	Natural Gas	-
32	Rice-Eccles Stadium	Primary	1	Natural Gas	-
33	Clark Football Center	Primary	5.25	Natural Gas	-
151	Sorenson Biotechnology Bldg. - USTAR	Backup	20.67	Natural Gas	-
521/525/526	University Hospital	Backup	10.5	Natural Gas	Fuel Oil
521/525/526	University Hospital	Backup	10.5	Natural Gas	Fuel Oil
521/525/526	University Hospital	Out-of-Service	13.5	Natural Gas	Fuel Oil
523	Moran Eye Center	Backup	8.165	Natural Gas	-
523	Moran Eye Center	Backup	25.2	Natural Gas	Diesel
523	Moran Eye Center	Backup	25.2	Natural Gas	Diesel
555	Hunstman Cancer Institute	Primary	16.8	Natural Gas	Diesel
555	Hunstman Cancer Institute	Primary	16.8	Natural Gas	Diesel
555	Hunstman Cancer Institute	Backup	5	Natural Gas	Diesel
555	Hunstman Cancer Institute	Backup	5	Natural Gas	Diesel
556	Huntsman Cancer Hospital	Backup	6	Natural Gas	Fuel Oil
556	Huntsman Cancer Hospital	Backup	6	Natural Gas	Fuel Oil
565	Emma-Eccles-Jone Medical Research Center	Backup	19	Natural Gas	-
853	Health Profession Education	Primary	2	Natural Gas	-
853	Health Profession Education	Primary	2	Natural Gas	-
581	School of Pharmacy Building	Backup	17	Natural Gas	-
587	CMC	Primary	13.5	Natural Gas	-
587	CMC	Primary	13.5	Natural Gas	-
865	Williams Building	Regular Use	10	Natural Gas	-

Startup and shutdown emissions are anticipated to be less than or equal to emissions during normal operations on the additional small boilers.

3.5.1. $PM_{2.5}$

According to EPA's AP-42, Section 1.4, since natural gas is a gaseous fuel, filterable PM emissions are typically low. Particulate matter from natural gas combustion has been estimated to be less than one micrometer in size and has filterable and condensable fractions. Particulate matter in natural gas combustion is usually larger molecular weight hydrocarbons that are not fully combusted. Increased particulate matter emissions can result from poor air/fuel mixing or maintenance problems.

Additional Boilers $PM_{2.5}$ Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[61]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NOX Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

To demonstrate a complete analysis, the University has evaluated the follow for $PM_{2.5}$.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers, <100 MMBtu/hr), which covers operations associated with UCHTWP. Additionally small boiler sources are listed in the RBLC search; therefore it is not repeated from above. The same results for $PM_{2.5}$ can be found in Table 2.

The technologies identified as possible $PM_{2.5}$ reduction technologies for additional Natural Gas Boilers are shown in the table below.

[61] Database accessed February 27, 2017.

Pollutant	Control Technologies
$PM_{2.5}$	Fabric Filter (Dust Collector)
	Wet Scrubber
	Dry Electrostatic Precipitator (ESP)
	Cyclone

Additional Boilers $PM_{2.5}$ Step 2 - Eliminate Technically Infeasible Options

Wet Scrubber

A wet gas scrubber is an air pollution control device that removes PM and acid gases from waste streams from stationary point sources. PM and acid gases are primarily removed through the impaction, diffusion, interception and/or absorption of the pollutant onto droplets of liquid. Wet scrubbers have some advantages over ESPs and baghouses in that they are particularly useful in removing PM with the following characteristics:

- Sticky and/or hygroscopic materials;
- Combustible, corrosive or explosive materials;
- Particles that are difficult to remove in dry form;
- PM in the presence of soluble gases; and
- PM in gas stream with high moisture content.

However, considering the low concentration of $PM_{2.5}$ and the small size of particulate, a wet scrubber is considered technically infeasible for a boiler firing primarily natural gas.

ESP

An ESP is a particle control device that uses electrical forces to move the particles out of the gas stream onto collector plates. This process is accomplished by the charging of particles in the gas stream using positively or negatively charged electrodes. The particles are then collected as they are attracted to oppositely opposed electrodes. Once the particles are collected on the plates, they are removed by knocking them loose from the plates, allowing the collected layer of particles to fall down into a hopper. ESP's are used to capture coarse particles at high concentrations. Small particles at low concentrations are not effectively collected by an ESP. As the technology is primarily for the combustion of natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, ESP is considered technically infeasible for a boiler firing primarily natural gas.

Fabric Filter

A fabric filter unit (or baghouse) consists of one or more compartments containing rows of fabric bags. Particle-laden gases pass along the surface of the bags then through the fabric. Particles are retained on the upstream face of the bags and the cleaned gas stream is vented to the atmosphere. Fabric filters collect particles with sizes ranging from submicron to several hundred microns in diameter. Fabric filters are used for medium and low gas flow streams with high particulate concentrations. As the boilers combust primarily natural gas, concentration of $PM_{2.5}$ is low and small in size. As such, a fabric filter is considered technically infeasible for a boiler firing primarily natural gas.

Good Combustion Practices and Use of Clean Burning Fuels

The use of good combustion practices usually include the following components: (1) proper fuel mixing in the combustion zone; (2) high temperatures and low oxygen levels in primary zone; (3) Overall excess oxygen levels high enough to complete combustion while maximizing boiler efficiency, and (4) sufficient residence time to complete combustion. Good combustion practices are accomplished through boiler design as it relates to time, temperature, and turbulence, and boiler operation as it related to excess oxygen levels.

Additional Boilers $PM_{2.5}$ Step 3 - 5 - Select BACT

Step 3 and 4 are not necessary since all control technologies not currently being used have been determined technically infeasible.

No control technology is technically feasible, therefore this emission rate using good combustion practices and primarily natural gas is considered BACT.

Additional Boilers $PM_{2.5}$ Most Stringent Measures

The most stringent measures would be identical to BACT as no control technology is technically feasible for these units.

3.5.2. NO_X

The NO_X that will be formed during combustion is from two major mechanisms: thermal NO_X and fuel NO_X. Since natural gas is relatively free of fuel-bound nitrogen, the contribution of this second mechanism to the formation of NO_X emissions in natural gas-fired equipment is minimal, leaving thermal NO_X as the main source of NO_X emissions. Thermal NO_X formation is a function of residence time, oxygen level, and flame temperature, and can be minimized by controlling these elements in the design of the combustion equipment.

Additional Boilers NO_X Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[62]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NO_X Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process
- Heaters;
- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;[63]
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

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[62] Database accessed February 27, 2017.

[63] SJVAPCD BACT Clearinghouse Boiler: < or = 20.0 MMBtu/hr, Natural Gas or Propane Fired *RESCINDED* http://www.valleyair.org/busind/pto/bact/chapter1.pdf

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers ,<100 MMBtu/hr), which covers operations associated with UCHTWP. Additional small boilers are considered in the RBLC search; therefore it is not repeated from above. The same results for NO_X can be found in Table 4 – Medium Natural Gas Boilers (<100 MMBtu) NOx Emissions.

To demonstrate a complete analysis, the University has evaluated the follow technologies including both replacement burners and add-on controls.[64]

Pollutant	Control Technologies
NO_X	Low NO_X Burners
	Ultra-Low NO_X Burners
	Flue Gas Recirculation
	Good Combustion Practices

Additional Boilers NO_X Step 2 - Eliminate Technically Infeasible Options

Low NO_X Burners

LNB technology uses advanced burner design to reduce NO_X formation through the restriction of oxygen, flame temperature, and/or residence time. There are two general types of LNB: staged fuel and staged air burners. In a stage fuel LNB, the combustion zone is separated into two regions. The first region is a lean combustion region where a fraction of the fuel is supplied with the total quantity of combustion air. Combustion in this zone takes place at substantially lower temperatures than a standard burner. In the second combustion region, the remaining fuel is injected and combusted with left over oxygen from the first region. A staged air burner begins with full fuel but only partial combustion air, and then adds the remaining combustion air in the second combustion region. These techniques reduce the formation of thermal NO_X. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NO_X using a combination of SCR, LNB, and FGR. SCAQMD used LNB as the BACT determined control methodology for the University of California Irvine Medical Center boiler rated at 48.6 MMBtu/hr in 1999.

Ultra Low NO_X Burners

ULNB technology uses internal FGR which involves recirculating the hot O2 depleted flue gas from the heater into the combustion zone using burner design features and fuel staging to reduce NO_X. An ULNB is most commonly using an internal induced draft to reach the desired emission limitations. Due to this induced draft, a ULNB cannot handle a quick change in load to achieve the desired operational flexibility necessary for the varied products in the paper machine. This technology is listed in the RBLC search as a technically feasible control technology. BAAQMD lists typical technology for BACT for NOX using a combination of ULNB and FGR. SCAQMD used LNB plus FGR as the BACT determined control methodology for the Los Angeles County Internal Services Department boiler rated at 39 MMBtu/hr in 2004. An ULNB can achieve an emission rate of approximately 9

[64] Note, during review of available control technology through RBLC and other databases, an SCR was not listed for any source less than 26 MMBtu/hr. Therefore, this control technology was not evaluated for use on the boilers in this section.

ppm or 0.011 lb/MMBtu when used in conjunction with FGR. Though this burner type risks loss in product due to the increased time to change between load rates, it is being considered for economic feasibility.

Flue Gas Recirculation

FGR is frequently used with both LNB and ULNB burners. FGR involves the recycling of post-combustion air into the air-fuel mixture to reduce the available oxygen and help cool the burner flame. External FGR requires the use of ductwork to route a portion of the flue gas in the stack back to the burner windbox; FGR can be either forced draft (where hot side fans are used) or induced draft. This technology is listed in the RBLC search as technically feasible and is paired with LNB for the BACT determined control technology. As previously discussed, both SCAQMD and BAAQMD have combined this technology with others to determine BACT.

Good Combustion Practices

The use of good combustion practices usually include the following components: (1) proper fuel mixing in the combustion zone; (2) high temperatures and low oxygen levels in primary zone; (3) Overall excess oxygen levels high enough to complete combustion while maximizing boiler efficiency, and (4) sufficient residence time to complete combustion. Good combustion practices are accomplished through boiler design as it relates to time, temperature, and turbulence, and boiler operation as it related to excess oxygen levels.

Additional Boilers NO_X Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Based on an RBLC search the following technologies are currently being used for boilers between 1 MMBtu/hr and 26 MMBtu/hr. These are ranked based on which technology can achieve the lowest emission rate.

1. ULNB = 9 ppm or 0.011 lb/MMBtu
2. LNB = 30 ppm or 0.036 lb/MMBtu
3. Good Combustion Practices

Additional Boilers NO_X Step 4 - Evaluate Most Effective Controls and Document Results

The Moran Eye Center boilers (25.2 MMBtu/hr, each) are rated for 15 ppm NO_X. All other boilers are assumed to have an emission rate equivalent to AP-42 emission factors at 100 pounds per million standard cubic feet (lb/MMscf), While ULNB and LNB are available for units of this size, the University has determined that it would be economically infeasible to replace each burner on units of this size. Considering that the University showed that the cost to replace the burner on the much larger UCHTWP boilers in Section 3.2.2 was economically infeasible, the burners of much smaller capacity also come to that conclusion.

Additional Boilers NO_X Step 5 - Select BACT

BACT for these boilers is good combustion and operating practices. The boilers located in building 587 will be replaced with boilers that meet 9 ppm NO_X emission limit during the summer of 2017.

Additional Boilers NO_X Most Stringent Measures

MSM is equivalent to BACT.

3.5.3. SO_2

The top-down BACT analysis for SO_2 emissions for the additional small boilers is presented below. The technologies identified as possible SO_2 reduction technologies for Medium Size Natural Gas Boilers are natural gas and good combustion practices as identified in Table 6 – Medium Natural Gas Boilers (<100 MMBtu) SO_2 Emissions.

SO_2 emissions associated with the boilers are due to natural gas combustion.

Additional Boilers SO_2 Step 1 - Identify All Control Technologies

There are two primary mechanisms to reduce SO_2 emissions from combustion sources which are: (1) reduce the amount of sulfur in the fuel, and (2) remove the sulfur from the exhaust gases with post-combustion control device such as flue gas desulfurization utilizing wet scrubbers or dry scrubbers.

The University will be using pipeline-quality natural gas as the primary fuel which has a low sulfur content. The use of a fuel containing low sulfur content is considered a control technology.

Two main types of SO_2 post-combustion control technologies, wet and dry scrubbing, were identified to reduce SO_2 in the exhaust gas.

Additional Boilers SO_2 Step 2 - Eliminate Technically Infeasible Options

The requirement for low-sulfur natural gas is a control technique that has been achieved in practice and is technically feasible and cost-effective and will be further considered for BACT. Post-combustion devices such as wet or dry scrubbers are typically installed on coal-fired power plants that burn fuels with much higher sulfur contents. The SO_2 concentrations in the natural gas combustion exhaust gases from the boilers are too low for scrubbing technologies to work effectively or to be technically feasible and cost effective. These control technologies require much higher sulfur concentrations in the exhaust gases to be feasible as a control technology. Thus, post-combustion SO_2 control devices, such as wet and dry scrubbing have not been achieved in practice on natural gas boilers. Since these controls are not technically feasible, they have been eliminated from further consideration for the boilers.

Additional Boilers SO_2 Step 3-5 - Select BACT

The use of pipeline-quality natural gas as the primary fuel is the only feasible SO_2 control technology for the boilers to control SO_2. There is no adverse energy, environmental or cost impact associated with the use of these control technologies. Thus, no further analysis is required under EPA's top-down BACT approach. SO_2 emissions associated with the boilers are due to fuel combustion. Therefore, the University is proposing good combustion practices and use pipeline-quality natural gas as the primary fuel is considered BACT.

Additional Boilers SO_2 Most Stringent Measures

MSM is equivalent to BACT in this instance since no add-on control technologies are available for these units.

3.5.4. VOC

Additional Boilers VOC Step 1 - Identify All Control Technologies

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Natural Gas External Combustion Units (process type 13.31);[65]
- EPA's Air Pollution Technology Fact Sheets;
- EPA's CATC Alternative Control Techniques Document – NOX Emissions from Utility Boilers;
- NESHAP DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters;

[65] Database accessed February 27, 2017.

- NESHAP JJJJJJ – Industrial, Commercial, and Institutional Boilers at Area Sources;
- SCAQMD LAER/BACT Determinations;
- SJVAPCD BACT Clearinghouse;
- BAAQMD BACT/TBACT Workbook; and
- Permits available online.

To demonstrate a complete analysis, the University has evaluated the follow technologies for VOCs.

A search was conducted by querying all sources within the RBLC database in which the "Process Type Code" contained the number "13.310" (Medium Natural Gas Boilers ,<100 MMBTu/hr), which covers operations associated with UCHTWP. Additional small boilers are considered in the RBLC search; therefore it is not repeated from above. The same results for VOC can be found in Table 7 – Medium Natural Gas Boilers (<100 MMBtu) VOCs Emissions

To demonstrate a complete analysis, the University has evaluated the follow technologies including add-on controls and good combustion practices.

Pollutant	Control Technologies
VOCs	Thermal Oxidizer/Afterburner
	Regenerative Thermal Oxidizer
	Catalytic Oxidation
	Good Combustion Practices

Additional Boilers VOC Step 2 - Eliminate Technically Infeasible Options

Simple Thermal Oxidizer or Afterburner

In a simple TO or afterburner, the flue gas exiting the boiler is reheated in the presence of sufficient oxygen to oxidize the VOC present in the flue gas. A typical TO is a flare and is not equipped with any heat recovery device. A TO will require additional fuel to heat the gas stream starting from 280°F to at least 1,600°F and which will generate additional emissions. Additionally, a TO is no different from the combustion chamber of the boiler. Therefore, there would be little expected reduction in VOC with an increase in other combustion pollutants for the required heating of the exhaust stream. Therefore, the TO is considered technically infeasible.

Regenerative Thermal Oxidizer

A RTO is equipped with ceramic heat recovery media (stoneware) that has large surface area for heat transfer and can be stable to 2,300°F. Operating temperatures of the RTO system typically range from 1,500°F to 1,800°F with a retention time of approximately one second. The combustion chamber of the RTO is surrounded by multiple integral heat recovery chambers, each of which sequentially switches back and forth from being a preheater to a heat recovery chamber. In this fashion, energy is absorbed from the gas exhausted from the unit and stored in the heat exchange media to preheat the next cycle of incoming gas. An RTO will require additional fuel to heat the gas stream from 280°F to at least 1,500°F and which will generate additional emissions; therefore, the RTO is considered technically infeasible.

Catalytic Oxidation

Catalytic oxidation allows complete oxidation to take place at a faster rate and a lower temperature than is possible with thermal oxidation. Oxidation efficiency depends on exhaust flow rate and composition. Residence time required for oxidation to take place at the active sites of the catalyst may not be achieved if exhaust flow rates exceed design specifications. Also, sulfur and other compounds may foul the catalyst, leading to decreased efficiency. In a typical catalytic oxidizer, the gas stream is passed through a flame area and then through a catalyst bed at a velocity in the range of 10 to 30 feet per second (fps). Catalytic oxidizers typically operate at a narrow temperature range of approximately 600°F to 1100°F. A catalytic oxidizer will require additional fuel to heat the gas stream from 280°F to at least 600°F and which will generate additional emissions; therefore, the catalytic oxidation is considered technically infeasible. This is listed in RBLC for a single source with higher emission rates than others using good operating practices.

Good Combustion Practices and Use of Clean Burning Fuels

Good combustion practices for VOCs include adequate fuel residence times, proper fuel-air mixing, and temperature control. As it is imperative for process controls, the University will maintain combustion optimal to their process. Most results in RBLC determined that this was sufficient controls for VOC. Additionally, BAAQMD and SCAQMD did not provide BACT determinations for VOC.

Additional Boilers VOC Step 3-5 - Select BACT

Step 3 and 4 are not necessary since all control technologies not currently being used have been determined technically infeasible. BACT for the boilers is good combustion practices and the use of clean burning fuel.

Additional Boilers VOC Most Stringent Measures

MSM is equivalent to BACT in this instance since no add-on control technologies are available for these units.

3.5.5. Ammonia

The University found ammonia emission factors for uncontrolled boilers on EPA's WebFIRE database.[66] The emission factors cited within this document are from the 1994 version of EPA's AP-42 Chapter 1.4. In 1998, this chapter was updated and ammonia emissions were removed from the list of emission factors associated with external combustion sources fueled by natural gas. As such, the University assumes there are minimal ammonia emissions associated with the boilers and have not considered them further for BACT.

3.6. DIESEL EMERGENCY GENERATORS

Diesel-fired engines are classified as compression ignition (CI) internal combustion engines (ICE). The primary pollutants in the exhaust gases include NO_X, VOC, SO_2, and $PM_{2.5}$. The diesel-fired engines installed at the University of Utah (the University) are for emergency use only (except for readiness testing) and will use diesel fuel meeting the requirements of 40 CFR §80.510(b) for non-road diesel fuel (i.e., a maximum sulfur content of 15 ppm and either a minimum cetane index of 40 or a maximum aromatic content of 35 percent by volume).

The University has multiple diesel-fired emergency generators permitted in Approval Orders (AO AN103540024-13 and AO AN103540025-13), as well as Title V Permit No. 3500063003.

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[66] Database accessed April 12, 2017.

The University has small diesel-fired emergency generator engines that are each rated less than 600 hp and having a combined total capacity of up to 9,835 hp.

The University also has large diesel-fired emergency generator engines that are each rated greater than 600 Hp and having a combined total capacity of up to 47,250 hp.

EPA's RBLC was queried to identify controls for other similar-sized emergency generator engines. The RBLC shows that most diesel-fired emergency generator engines have BACT emission limits or permitted emission limits under other regulatory programs at or above the recently promulgated NSPS Subpart IIII emissions standards.

Presented below are the five steps of the top-down BACT review for diesel-fired emergency generator engines.

3.6.1. $PM_{2.5}$, NO_x, SO_2 and VOC

Diesel Emergency Generators Step 1 - Identify All Control Technologies

The following sources were reviewed to identify available control technologies:

- EPA's RBLC Database for Diesel Generators (process type 17.110 Large Internal Combustion Engines [>500 Hp] – Fuel Oil);[67]
- EPA's Air Pollution Technology Fact Sheets; and
- South Coast Air Quality Management District Example Permits.

Available control technologies for diesel-fired emergency generator engines include the following:

- Limited Hours of Operation
- Good Combustion Practices
- Use of a Tier Certified Engine
- Engine Design
- Diesel Particulate Filter
- Ultra Low Sulfur Fuel
- Diesel Oxidation Catalyst
- Selective Catalyst Reduction (SCR)

The following step evaluates the technical feasibility of each of these options.

Diesel Emergency Generators Step 2 - Eliminate Technically Infeasible Options

Limited Hours of Operation

One of the apparent opportunities to control the emissions of all pollutants released from emergency generator engines is to limit the hours of operation for the equipment. Due to the designation of these equipment as emergency equipment, only 100 hours of operation for maintenance and testing are permitted per NSPS Subpart

[67] Database accessed March 3, 2017.

IIII.[68] The University complies with NSPS Subpart IIII requirements and minimizes operation time for emergency generator engines to maintenance and testing[69].

Good Combustion Practices

Good combustion practices refer to the operation of engines at high combustion efficiency, which reduces the products of incomplete combustion. The emergency generator engines are designed to achieve maximum combustion efficiency. The manufacturer has provided operation and maintenance manuals that detail the required methods to achieve the highest levels of combustion efficiency. The University operates and maintains all diesel-fired engines in accordance with the manufacture provided instructions and best industry practices[70].

Use of an Appropriate Tier Certified Engines

EPA noted that non-road engines were a significant source of emissions and began adopting emission standards for these emission units in 1994. Today engines are required to meet certain emission limits, or tier ratings, based on the size and model year. Emission standards for these engines have progressively gotten more stringent over time and are an indicator of good combustion design. The University has installed non-road engines with a Tier rating available at the time of purchase. Since most of the engines were purchased on or after 2007[71], the existing non-road engines are either Tier 2 or 3 certified. However, the University maintains and operates four (4) diesel-fired emergency generator engines that have a capacity greater than 600 hp (as well as various smaller units) that were installed prior to the implementation of EPA's Tier system. An analysis pertaining to necessary control measures for these four (4) larger engines is contained in the discussion regarding most stringent measures (MSM) for diesel-fired emergency generator engines.

Diesel Particulate Filters

This simple technology is placed in the exhaust pathway to prevent the release of particulate and may be coated with a catalyst to further capture hydrocarbon emissions.

According to EPA's Response to Public Comments on Notice of Reconsideration of NESHAP for RICE and NSPS for Stationary ICE, "Diesel particulate filters are also proven, commercially available technology for retrofit applications to stationary engines...and are capable of reducing diesel PM by 90 percent or more."[72] Additionally the CA ARB was able to determine that this technology was technically feasible for emergency and prime engines through obtaining several vendor quotes.[73]

However EPA remained concerned with the installation of a catalyzed particulate filter, citing technical issues including the fact that many older engines are not electronically controlled, PM emissions are often too high for

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[68] 40 CFR 60.4211(f)(2)

[69] Per Condition II.B.25.d of the Title V permit (3500063003)

[70] Per Condition II.B.25.b of the Title V permit (3500063003)

[71] Per Condition II.B.25.a of the Title V permit (3500063003)

[72] Response to Public Comments on Notice of Reconsideration of National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and New Source Performance Standards for Stationary Internal Combustion Engines, EPA Docket EPA-HQ-OAR-2008-0708, June 16, 2014

[73] Response to Public Comments on Notice of Reconsideration of National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and New Source Performance Standards for Stationary Internal Combustion Engines, EPA Docket EPA-HQ-OAR-2008-0708, June 16, 2014

efficient operation and, in some cases, engine exhaust temperatures are not high enough for filter substrate regeneration.[74]

While a catalytic diesel particulate filter is not considered to be technically feasible, consideration of a simple particulate filter will be evaluated.

Ultra Low Sulfur Diesel

Ultra low sulfur diesel contains less than 0.0015 % sulfur by weight. The reduced sulfur content reduces the potential for SO_2 emissions. Additionally the low sulfur content results in a lower potential for aggregation of sulfur containing compounds and thus reduces $PM_{2.5}$ emissions. The University uses ultra-low sulfur diesel fuel for the diesel-fired emergency engines on-site[75].

Diesel Oxidation Catalyst

A diesel oxidation catalyst (DOC) utilizes a catalyst such as platinum or palladium to further oxidize the engine's exhaust, which includes hydrocarbons (HC), (e.g., VOC), to carbon dioxide (CO_2) and water. Use of a diesel oxidation catalyst can result in approximately 90 percent reduction in HC/VOC emissions.[76] In addition to controlling HC/VOC, a DOC also has the potential to reduce PM emissions by 30 percent (based on the concentration of soluble organics) and CO emissions by 50 percent if low sulfur diesel fuel is used.[77]

The use of a diesel oxidation catalyst reduces the effective power output of RICE and results in a solid waste stream. However, for the purposes of identifying technical feasibility, no formal consideration of these adverse energy and environmental impacts is presented. A diesel oxidation catalyst is considered technically feasible and is further considered for BACT.

Selective Catalytic Reduction

Selective catalytic reduction (SCR) systems introduce a liquid reducing agent such as ammonia or urea into the flue gas stream prior to a catalyst. The catalyst reduces the temperature needed to initiate the reaction between the reducing agent and NO_x to form nitrogen and water.

For SCR systems to function effectively, exhaust temperatures must be high enough (200°C to 500°C) to enable catalyst activation. For this reason, SCR control efficiencies are expected to be relatively low during the first 20 to 30 minutes after engine start up, especially during maintenance and testing. There are also complications controlling the excess ammonia (ammonia slip) from SCR use. Since SCR is anticipated to have a relatively low combustion efficiency during maintenance and testing, SCR is not considered technically feasible for emergency units.

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[74] Response to Public Comments on Notice of Reconsideration of National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and New Source Performance Standards for Stationary Internal Combustion Engines, EPA Docket EPA-HQ-OAR-2008-0708, June 16, 2014

[75] Per Condition II.B.25.c of the Title V permit (3500063003)

[76] U.S. EPA, *Alternative Control Techniques Document: Stationary Diesel Engines*, March 5, 2010, p. 41. (https://www.epa.gov/sites/production/files/2014-02/documents/3_2010_diesel_eng_alternativecontrol.pdf)

[77] Response to Public Comments on Notice of Reconsideration of National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and New Source Performance Standards for Stationary Internal Combustion Engines, EPA Docket EPA-HQ-OAR-2008-0708, June 16, 2014

Diesel Emergency Generators Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Effective control technologies for diesel engines include limited hours of operation, good combustion practices, use of tier certified engines, use of high efficiency engines, diesel particulate filters, ultra-low sulfur diesel, and diesel oxidation catalysts. All control technologies considered effective are currently implemented with the exception of diesel particulate filters and diesel oxidation catalysts. Both technologies result in significant emission reductions and are further evaluated to determine the economic feasibility of implementation.

Diesel Emergency Generators Step 4 - Evaluate Most Effective Controls and Document Results

When reviewing the implementation and costs associated with installing diesel oxidation catalyst controls for an emergency-use or intermittent-use engines, the University found that "[b]ecause these engines are typically used only a few number of hours per year...[s]uch engines rarely if ever use the [diesel oxidation catalyst] type of emission controls."[78] Additionally, in its 2010 MACT/GACT evaluation for engines, EPA concluded for emergency engines: "Because these engines are typically used only a few number of hours per year [(27 hours per year per NFPA codes)], the costs of emission control are not warranted when compared to the emission reductions that would be achieved."[79] Based on EPA's assessment and the fact that the RBLC contains no records of diesel oxidation catalyst installation on emergency-use or non-road engines, installation of a diesel oxidation catalyst is eliminated from consideration as BACT.

EPA gathered cost estimates for installing a diesel particulate filter when reviewing NESHAP ZZZZ and NSPS IIII and JJJJ, and determined the costs to be excessive.[80] EPA determined that the cost per ton of PM reduced from engines between 300 and 600 HP was close to $260,000 and more than $700,000 for engines above 750 HP when installed at the time of manufacturing.[81] EPA concluded that the installation of a diesel particulate filter was only required for the operation of non-emergency engines as documented in NESHAP Subpart ZZZZ, therefore this technology is not further considered.[82]

Diesel Emergency Generators Step 5 - Select BACT

The diesel-fired emergency generator engines are well designed, efficient, reliable, and operated using good combustion practices[83]. The diesel-fired engines installed after the implementation of the EPA's Tier system meet the required Tier rating in 40 CFR 89 based on available inventory at the time of purchase. Additionally, the emergency generator engines will be operated and maintained in accordance with good combustion

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[78] U.S. EPA, Memorandum: *Response to Public Comments on Proposed National Emission Standards for Hazardous Air Pollutants for Existing Stationary Reciprocating Internal Combustion Engines Located at Area Sources of Hazardous Air Pollutant Emissions or Have a Site Rating Less Than or Equal to 500 Brake HP Located at Major Sources of Hazardous Air Pollutant Emissions*, August 10, 2010, p. 172-173. (EPA-HQ-OAR-2008-0708)

[79] Ibid.

[80] Response to Public Comments on Notice of Reconsideration of National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines and New Source Performance Standards for Stationary Internal Combustion Engines, EPA Docket EPA-HQ-OAR-2008-0708, June 16, 2014

[81] Memorandum from Tanya Parise, Alpha-Gamma Technologies to Jaime Pagán, EPA. Cost per Ton for NSPS for Stationary CI ICE. EPA-HQ-OAR-2005-0029-0276. May 12, 2006.

[82] 40 CFR 63.6625(g)

[83] Per Condition II.B.25.b of the Title V permit (3500063003)

practices and combust only ultra-low sulfur diesel.[84] The hours of operation are restricted to 100 hours for maintenance and testing per year in accordance with 40 CFR 60, Subpart IIII[85]. As a result, the diesel-fired emergency generator engines meet BACT.

Diesel Emergency Generators Most Stringent Measures

The MSM for the diesel-fired emergency generators would be equivalent to BACT as specified above.[86]

3.7. NATURAL GAS EMERGENCY GENERATORS

The University utilizes four (4) natural gas-fired emergency generators on campus to maintain critical systems during an emergency. Specific information pertaining to the natural gas-fired emergency generators and their respective building locations are summarized in the table below.

Building Number	Engine Capacity (hp)
Building 64	134
Building 67	402
Building 350	402
Building 685	402

3.7.1. $PM_{2.5}$, NO_x, SO_2 and VOC

Natural Gas Non-Road Engines Step 1 - Identify All Control Technologies

The following sources were reviewed to identify available control technologies:

- South Coast Air Quality Management District;
- Bay Area Quality Management District;
- San Joaquin Valley Air Pollution Control District;
- Texas Commission on Environmental Quality BACT Requirements;
- EPA's RBLC Database for Natural Gas Generators (process type 17.230 Small Internal Combustion Engines [<500 Hp] – Natural Gas);[87] and
- EPA's Air Pollution Technology Fact Sheets.

Available control technologies for natural gas-fired emergency generator engines includes the following:

- Limited Hours of Operation

[84] Per Condition II.B.25.c of the Title V permit (3500063003)

[85] Per Condition II.B.25.d of the Title V permit (3500063003)

[86] Approval to replace emergency generators or any combustion equipment requires funding approval by the Utah State Legislature.

[87] Database accessed April 13, 2017.

- Routine Maintenance
- Good Combustion Practices
- Use of Natural Gas
- Lean Burn Technology
- Selective Catalyst Reduction (SCR)

The following step evaluates the technical feasibility of each of these options.

Natural Gas Non-Road Engines Step 2 - Eliminate Technically Infeasible Options

Limited Hours of Operation

One of the apparent opportunities to control the emissions of all pollutants released from natural gas-fired emergency generator engines is to limit the hours of operation for the equipment. Under NSPS Subpart JJJJ and RICE NESHAP[88], only 100 hours of operation for maintenance and testing are allowed for generators designated as emergency. The University will comply with the federal requirements and minimize operation time for emergency generators to maintenance and testing.

Routine Maintenance

Routine maintenance ensures the engines are working properly and as efficiently as possible, which, in turn, helps reduce emissions. For spark ignition internal combustion engines, such as those utilized by the University, RICE NESHAP[89] requires sources to:

- Change oil and filters every 500 hours of operation or annually, whichever comes first;
- Inspect spark plugs every 1,000 hours of operation or annually, whichever comes first, and replace as necessary; and
- Inspect all hoses and belts every 500 hours of operation or annually, whichever comes first, and replace as necessary.

The University will comply with the routine maintenance specified in RICE NESHAP and summarized herein.

Good Combustion Practices

Good combustion practices refer to the operation of engines at high combustion efficiency, which reduces the products of incomplete combustion. The natural gas-fired emergency generator engines installed at the University are designed to achieve maximum combustion efficiency. The manufacturer has provided operation and maintenance manuals that detail the required methods to achieve the highest levels of combustion efficiency for each unit. The University operates and maintains these generator engines in accordance with the manufacture provided instructions and best industry practices.

Use of Natural Gas

Natural gas is the cleanest fossil fuel and is a highly efficient form of energy. It is composed mainly of methane and its combustion results in less particulate matter, NO_x, and SO_2 in comparison to other fossil fuels. The University uses natural gas for these four (4) emergency engines on-site.

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[88] 40 CFR 60.4243(d)(2) and 40 CFR 63.6640(f), respectively

[89] 40 CFR 63.6603(a)

Lean Burn Technology

With lean burn combustion technology excess air is introduced into the engine along with the fuel. In lean burn engines the air:fuel ratio may be as lean as 65:1 by mass. Excess air, in turn, reduces the temperature of the combustion process and combusts more of the fuel which ultimately results in fewer hydrocarbons being emitted. The four (4) natural gas-fired emergency generator engines at the University utilize lean burn technology.

Selective Catalytic Reduction

SCR systems introduce a liquid reducing agent such as ammonia or urea into the flue gas stream prior to a catalyst. The catalyst then reduces the temperature needed to initiate the reaction between the reducing agent and NO_x to form nitrogen and water.

For SCR systems to function effectively, exhaust temperatures must be high enough (200°C to 500°C) to enable catalyst activation. For this reason, SCR control efficiencies are expected to be relatively low during the first 20 to 30 minutes after engine start up, especially during maintenance and testing. There are also complications controlling the excess ammonia (ammonia slip) from SCR use. Since SCR is anticipated to have a relatively low combustion efficiency during maintenance and testing due to short periods of operation and frequent starts/stops, implementing a SCR technology for emergency units is challenging, if not infeasible.

Natural Gas Non-Road Engines Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Effective control technologies for natural gas-fired engines include the limited hours of operation, routine maintenance, good combustion practices, use of natural gas, and lean burn technology. All control technologies considered effective are currently implemented or will be implemented at the University, with the exception of SCR technology, which is evaluated further in Step 4 below to determine the economic feasibility of implementation.

Natural Gas Non-Road Engines Step 4 - Evaluate Most Effective Controls and Document Results

In the 2010 MACT/GACT evaluation for engines, EPA concluded for emergency engines: "Because these engines are typically used only a few number of hours per year [(27 hours per year per NFPA codes)], the costs of emission control are not warranted when compared to the emission reductions that would be achieved."[90] Based on EPA's assessment and the fact that the RBLC contains no records of SCR installation on emergency-use or non-road engines, installation of a SCR system is eliminated from consideration as BACT.

Natural Gas Non-Road Engines Step 5 - Select BACT

The University natural gas-fired emergency generator engines will be operated and maintained in accordance with good combustion practices, which will include routine maintenance being performed on the units in accordance with the RICE NESHAP requirements, combust only natural gas, and utilize lean burn technology. The hours of operation will be limited to 100 hours for maintenance and testing per year in accordance with NSPS Subpart JJJJ and RICE NESHAP. As a result, the University engines will meet BACT.

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[90] Ibid.

Natural Gas Non-Road Engines Most Stringent Measures

MSM would be the same as the BACT requirements specified above for natural gas-fired emergency generator engines.

3.8. VOC FUGITIVES

Fugitive VOC emissions result from the printing plant, spray paint booth and parts washers at the University. The paint booth and printing plant cumulatively these sources are limited to 5 tpy of VOC emissions.[91]

3.8.1. VOC

VOC Fugitives Step 1 - Identify All Control Technologies

The University reviewed EPA's Alternative Control Technology Paper "Control Techniques for Volatile Organic Compound Emissions from Stationary Sources" published in December of 1992 to determine appropriate control technologies. The University has also included additional control technologies specific to painting and degreasing operations cited in the TCEQ BACT Guidelines and the BAAQMD BACT/TBACT Workbook. VOC emissions can be reduced via three approaches: alternative chemical properties, good housekeeping practices and add on control technologies.

VOC Fugitives Step 2 - Eliminate Technically Infeasible Options

Alternative Chemical Properties

Alternative chemical properties prevent VOC emissions through a reduced potential for the material to evaporate. One common method is to use alternative materials with chemical properties that are less likely to result in VOC emissions. Chemical properties that are likely to result in low VOC emissions include materials with a low VOC content and low vapor pressure.

Good Housekeeping Practices

Good housekeeping measures ensure that VOC containing materials are not permitted to evaporate unnecessarily or used in excess of process requirements. Examples of good housekeeping practices include covering containers containing VOC material, enclosing waste material with VOC containing material, diminishing exposure to heat and open atmosphere as much as the process allows.

Add on Controls

Add on controls would be accomplished through the use of control techniques that oxidize, combust or otherwise change VOC emissions produced from a process into less harmful pollutants or a less harmful form of the pollutant. Any control system that destroys VOC emissions from a process has two fundamental components. The first is the containment or capture system, which is a single device or group of devices whose function is to collect the pollutant vapors and direct them into a duct leading to a control device. The second component is the control device, which reduces the quantity of the pollutant emitted to the atmosphere.[92]

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[91] Condition II.B.4 of AO AN103540025-13.

[92] EPA's Alternative Control Technology Paper "Control Techniques for Volatile Organic Compound Emissions from Stationary Sources" published in December of 1992.

The fugitive sources described in this section are small sources with minor emissions per source located throughout the University. Creating a capture system that spans this much area is technically infeasible therefore no destruction control techniques have been further evaluated.

VOC Fugitives Step 3 - 5 - Select BACT

Alternative chemical properties (1st) and good housekeeping practices (2nd) are both technically feasible. These control technologies are used in conjunction with one another to ensure practically low VOC emissions. The highest ranked control measures are currently being implemented; therefore, no economic, energy, or environmental analysis was conducted. The University proposes these two activities as BACT as described below.

Print Plant and Paint Booth

When possible, the University utilizes low VOC inks, fountain solutions, cleaners, solvents and water based paints. Further, combined emissions of VOC from the Building 350 Paint Booth and Print Plant are limited to 5.0 tons per rolling 12-month period per Condition II.B.9.a of the Title V Operating Permit (Permit Number 3500063003). The print plant is not subject to Utah Administrative Code (UAC) Rule R-307-351, Graphic Arts, however, the University implements the work practice standards detailed in R307-351-7, as applicable, to help minimize fugitive VOC emissions from these sources. These work practice standards include: 1) utilizing fitting covers for open tanks; and 2) keeping cleaning materials, used shop towels, and solvent wiping cloths in closed containers.

Parts Washer

When possible, the University utilizes low VOC solvents and degreasers. Additionally, the parts washers throughout the University are subject to UAC Rule R307-335, Degreasing and Solvent Cleaning Operations. This regulation requires the University to meet several good housekeeping related requirements as detailed in Condition II.B.2.a of the Title V Operating Permit (Permit Number 3500063003).

VOC Fugitives Most Stringent Measures

MSM is the same as BACT for these sources.

3.9. PM FUGITVES

The following sources of fugitive PM are grouped into two groups for BACT analysis. These sources have similar control techniques, but have been evaluated separately for completeness purposes. The sources with $PM_{2.5}$ fugitives are as follows:

Carpentry Shop

Fugitive PM emissions result from the carpentry shop at the University. This source produces less than 0.5 ton per year of PM emissions.[93]

Paint Booth

A review of previous BACT analyses, the California Air Resources Board, EPA's RACT/BACT/LAER (RBLC) Clearinghouse, and other state databases was performed to identify possible $PM_{2.5}$ control technologies that are

[93] 2014 Emission Inventory

available on the market and have been proven in practice in the coating industries with similar requirements for surface coating and stripping/depainting operations.

3.9.1. $PM_{2.5}$

The University has reviewed the following sources to ensure all available control technologies have been identified:

- EPA's RBLC Database for Other Fugitive Dust Sources (process type 99.190);[94] and
- EPA's Air Pollution Technology Fact Sheets.

PM Fugitives Step 1 - Identify All Control Technologies

Control technologies include:

- Baghouse/Fabric Filter
- Wet Electrostatic Precipitator (ESP)
- Wet Scrubber
- High-Efficiency Cyclone
- Good Operating Practices

PM Fugitives Step 2 - Eliminate Technically Infeasible Options

Carpentry Shop

Baghouse

Baghouses remove particulates by collecting particulates on the filter bag as the exhaust stream passes through the baghouse. Baghouses typically cannot withstand high exhaust temperatures (greater than 500 °F). Fabric filters have been considered effective for medium and low gas flow streams with high particulate concentrations. Baghouses have been shown to obtain a particulate collection efficiency up to 99.5% for PM_{10}, and up to 99% capture for $PM_{2.5}$. A baghouse is currently used to control particulate emissions from the Carpentry Shop.

Wet ESP

As part of this analysis, the possibility of using a Wet Electrostatic Precipitator (ESP) was also reviewed. Wet ESP technology removes particulates by electrically charging the particles and collecting the charged particles on plates. The collected particulate is washed off the plates and collected in hoppers at the bottom of the ESP. High efficiency ESPs have been shown to achieve control of particulates up to 99.5% for PM_{10}, and up to 95% capture for $PM_{2.5}$. Due to the molecular structure of the wood particles generated from the carpentry activities it is difficult to induce the electrical charge required to capture particulate matter composed of this material. Without the ability to create an electrical charge this control technology is not technically feasible.

Wet Scrubber

Wet gas scrubber (WGS) technology was also evaluated for use as a particulate control technology for the proposed gas stream. A WGS reduces particulate emissions by mixing flue gas with scrubber liquid to remove

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[94] Accessed March 3, 2017.

particulate. The purge stream containing the collected particulate exits the bottom of the WGS to be further treated as wastewater. High efficiency wet scrubbers have been shown to achieve 99% capture for PM_{10}, but only up to 90% capture for $PM_{2.5}$. This type of control may be feasible for use with the proposed gas stream. However, the baghouse currently in use with the carpentry operations provides better control efficiency than a wet scrubber for control of $PM_{2.5}$.

Cyclone

Cyclones use centrifugal force and inertia to remove particles from a gas stream. The inertia of the particles resists the change in direction of the gas and they move outward under the influence of centrifugal force until they strike the walls of the cyclone. At this point, the particles are caught in a thin laminar layer of air next to the cyclone wall and are carried downward by gravity where they are collected in hoppers. Cyclones are capable of removing in excess of 90 percent of the larger diameter (> 30 μm) PM. However, their efficiency decreases with smaller particles. The baghouse currently in use with the carpentry operations provides better control efficiency than a cyclone for control of $PM_{2.5}$.

Paint Booth

As there is a minimal amount of particulate emissions from the paint booth, the University has considered the following:

Wet ESP

ESP's were not identified in the literature or databases as a means of controlling PM from spray booth operations. Thus, this control technology was eliminated from further consideration.

Wet Scrubber

For a wet scrubber the solubility of the material being collected needs to be considered. Since the particulate to be controlled is not readily soluble in water, this technology was eliminated from further consideration.

Good Operating Practices

Good operating Practices include any overspray (particulate) is controlled in a paint booth, through application, and/or exhausted through filter media. Filter media is currently in place on the ventilation and capture system of the paint booth.

High Transfer Efficiency Application Techniques

The coatings are applied using high-volume, low-pressure (HVLP) spray nozzle gun used within the booth. Therefore, minimal particulate emissions escaping from the process.

PM Fugitives Step 3 - Rank Remaining Control Technologies by Control Effectiveness

The control technologies under consideration are ranked as follows in order of most effective to least effective for control of $PM_{2.5}$:

Carpentry Shop

Pollutant	Control Technologies	Approximate Control Efficiency
$PM_{2.5}$	Baghouse (Dust collector)	99% - 99.5%
	Wet scrubber	90%-99%
	Cyclone	20%-70%

Paint Booth

Pollutant	Control Technologies	Approximate Control Efficiency
$PM_{2.5}$	Good Operating Practices	Intrinsic
	High transfer efficiency application techniques	Intrinsic

PM Fugitives Step 4 - Evaluate Most Effective Controls and Document Results

Carpentry Shop

While wet scrubber and cyclone controls are technically feasible control options, the control efficiency for these technologies are ranked less than the baghouse currently installed for the process. As a result, no detailed economic, energy, and environmental impact evaluations were conducted for the Carpentry Shop.

Paint Booth

Since available control technology is currently being implemented, no detailed economic, energy, and environmental impact evaluations were conducted.

PM Fugitives Step 5 - Select BACT

Carpentry Shop

BACT for $PM_{2.5}$ emissions is the existing baghouse that has an estimated control efficiency of 99% and a grain outlet loading of 0.16 gr/dscf. Additionally, the dust collector is limited in hours and may only be used for 1043 hours per rolling 12-month period.[95]

Paint Booth

As the University is currently implementing BACT through the use of a filter particulate capture system, the following good operating practices are being implemented as specified in Title V condition II.B.11.a.1. Specifically, the spray booth particulate capture system is inspected before each use to verify that it is functioning properly which include but are not limited to the following:

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[95] Title V Operating Permit #3500063003 Condition II.B.12.b

a. Inspection for holes in the particulate filters.
b. Inspection of the particulate filters to determine proper installation within the support rack.
c. Inspection of the exhaust fan to ensure that it is operating

Most Stringent Measures

MSM is the same technology as BACT in this case.

3.10. INSIGNIFICANT ACTIVITIES

The following unit types have small emission rates that the University is considering negligible for emission control. These sources emit VOCs and PM and are fugitive in nature. An analysis for these units would be similar or identical to the analysis provided in the VOC Fugitives and PM Fugitive Sections. Since emissions from these sources are minor and fugitive, the University has not considered control technologies beyond best operating practices for these units.

3.10.1. Ethylene Oxide Sterilizer

The ethylene oxide sterilizer is used at the University Medical Center for the sterilization of medical equipment. Per Title V Operating Permit #3500063003 Condition II.A.32, the sterilization unit uses less than 1 tpy of ethylene oxide. Ethylene oxide is a VOC emissions, therefore due to permit conditions, the University can emit a maximum of1 tpy of VOC from this process.

Additionally, the sterilizer is subject to NESHAP WWWWW, Hospital Ethylene Oxide Sterilizers.[96] Therefore the sterilizer will "...run full loads of items having a common aeration time, except under medically necessary circumstances."[97] Furthermore, the University is not subject to NESHAP O, Ethylene Oxide Emissions Standards for Sterilization Facilities, because they do not use more than 1 tpy of ethylene oxide within 12 consecutive months and they are a hospital. The University has low enough emissions that NESHAP O does not apply and complies with the management practice requirements of NESHAP WWWWW to ensure the sterilizer is used as efficiently as possible while meeting medical requirements.

3.10.2. Underground Storage Tanks

The university maintains four underground storage tanks - two diesel tanks with a capacity of 20,000 gallons, one diesel tank with a capacity of 30,000 gallons, and one jet fuel tank with a capacity of 12,000 gallons. Emissions from fixed roof storage tanks result from displacement of headspace vapor during filling operations (working losses) and from diurnal temperature and heating variations (breathing losses).[98] Losses due to changes in temperature or barometric pressure are minimal for underground tanks because the surrounding earth limits the diurnal temperature change and changes in the barometric pressure would result in only small losses.[99]. The University has considered emissions from these underground storage tanks negligible.

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[96] Title V Operating Permit #3500063003 Condition II.B.27.a

[97] 40 CFR 63.10390

[98] EPA, Emission Factor Documentation for AP-42 Section 7.1 Organic Liquid Storage Tanks, September 2006.

[99] Ibid.

3.10.3. Small Fuel Storage Tanks

Various small fuel storage tanks are located throughout the University and have no federal applicable requirements. All tanks have a capacity of 10,000 gallons or less. Due to the small size and infrequent use, the University has considered emissions from these storage tanks negligible.

3.10.4. Ironmaking

The flash ironmaking conducted at the University is solely for research purposes and is performed on an infrequent basis. The bench reactor consists of a refractory-lined vertical vessel in which iron oxide concentrates will react with hot reducing gases (hydrogen and carbon monoxide) generated internally by the partial combustion of natural gas or hydrogen. The solid product particles (iron (Fe) with varying amounts of iron oxides (FeO and Fe_3O_4)) will fall to the bottom of the vessel into a quench chamber. Nitrogen will be injected into the quench chamber to lower the temperature of the solid product and offgas to approximately 400 °C. The resulting offgas will contain nitrogen, hydrogen, water vapor, carbon monoxide, carbon dioxide, and a small amount of reduced iron dust. Flammable gases will be completely burned in an afterburner chamber before being released to the atmosphere through a flare stack. Flammable gases will be completely burned in an afterburner chamber before being released to the atmosphere through a flare stack. The flare has a heat input of 3.78 MMBtu/hr which is less than the source category exemptions listed in UAC Rule R307-401-10. Dust particles will be oxidized to hematite (Fe_2O_3).

It's expected the dust particles after going through the flare stack will be greater than 20 microns. Additionally, the experiments will generally occur twice a week and last approximately 3 hours per test. Consequently, $PM_{2.5}$, NO_X, SO_2, and VOC emissions from this activity are assumed to be negligible.

4.1. EMISSION SUMMARY

The following table provides emission limits during normal operation and startup, shutdown and maintenance settings. Refer to Table 4-1

Table 4-1 Facility-Wide Impact of Emission Units

Operating Scenario	Pollutant				
	$PM_{2.5}$[100]	NO_x	SO_2	VOC	NH_3[101]
Normal Operation	19.29	100.05	3.85	14.07	'--

[100] The $PM_{2.5}$ limits in the University of Utah's current Approval Order (DAQE-AN103540025-13) only represent the filterable portion of $PM_{2.5}$ and does not account for the condensable fraction. An increase in $PM_{2.5}$ emissions limit is required to ensure both have been accounted for in the total.

[101] The University currently does not have an NH_3 limit in its Approval Order (DAQE-AN103540025-13).

Table 5-1 below is a summary of monitoring conditions for the site, both existing and proposed.

Table 5-1 Summary of Monitoring Conditions

Monitoring Condition	Frequency	Source(s) Covered	Permit Condition
Good air pollution control practices during startup, shutdown, and malfunction	As necessary	Source-wide	#3500063003 Condition II.B.1.c.1
Fuel use and fuel type records	When in operation	Source-wide	#3500063003 Condition II.B.1.e.1
Emergency generator use: dates of use, reason, duration	When in operation	Source-wide	#3500063003 Condition II.B.1.f.1
Natural gas consumption in boilers > or = 5.0 MMBtu/hr	Monthly Calculation by the 25th day of the month	Source-wide	#3500063003 Condition II.B.1.g.1
Fuel use in boiler: dates of use, reason, duration	As necessary when a boiler combusts fuel other than natural gas	Source-wide	#3500063003 Condition II.B.1.h.1
Visual observation of conditions of parts washers – covers in place, adequate solvent drainage, condition of storage tanks and containers, posted procedures, etc.	Monthly	Miscellaneous Parts Washers	#3500063003 Condition II.B.2.a.1
Fuel usage/type	Unspecified	Bldg 32 West Boiler	#3500063003 Condition II.B.3.a.1
Monitoring per 40 CFR 60 Subpart A	Daily	Bldg 32 West Boiler	#3500063003 Condition II.B.3.b.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 32 West Boiler	#3500063003 Condition II.B.3.c.1
Fuel usage/type	Unspecified	Bldg 33 Boiler	#3500063003 Condition II.B.4.a.1
Generator use: dates used, duration, reason	As necessary when operated	Bldg 151 3 Diesel-fired 1,175 hp emergency generators	#3500063003 Condition II.B.5.a.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 151 Boiler	#3500063003 Condition II.B.5.b.1

Monitoring Condition	Frequency	Source(s) Covered	Permit Condition
Fuel usage	Daily	Bldg 151 Boiler	#3500063003 Condition II.B.5.d.1
Fuel usage Visual emission survey	Daily when burning natural gas Semiannually if burning fuel oil, Method 9 within 24 hours if VE are observed	Bldg 302 Boiler	#3500063003 Condition II.B.6.a.1
Fuel usage – type, amount	Monthly	Bldg 302 Boiler	#3500063003 Condition II.B.6.b.1
Stack Testing	Every 3 years	Bldg 303 Boilers 3 & 4, 6 & 7	#3500063003 Condition II.B.7.a.1
Fuel usage	Not specified	Bldg 303 Boilers 3 & 4, 6 & 7	#3500063003 Condition II.B.7.b.1
Fuel usage – type, amount	Monthly	Bldg 303 Boilers 6 & 7	#3500063003 Condition II.B.7.c.1
Monitoring per 40 CFR 60 Subpart A – Fuel Usage	Daily	Bldg 303 Boilers 6 & 7	#3500063003 Condition II.B.7.d.1
Stack Test	Annually between December 1 and February 29	Water Plant Cogen Unit and WHRU Duct Burner	#3500063003 Condition II.B.8.a.1
Fuel Usage – type, amount	Not specified	Water Plant Cogen Unit and WHRU Duct Burner	#3500063003 Condition II.B.8.b.1
Sulfur Content of gas burned	Not specified	Water Plant Cogen Unit and WHRU Duct Burner	#3500063003 Condition II.B.8.c.1
Monitoring per 40 CFR 60 Subpart A	Daily	Water Plant Cogen Unit and WHRU Duct Burner	#3500063003 Condition II.B.8.d.1
VOC/HAP Emissions on 12-month rolling total	By the 20th of each month	Bldg 350 Paint Booth and Print Shop	#3500063003 Condition II.B.9.a.1
Inspection of waste containers	Daily	Print Plant	#3500063003 Condition II.B.10.a.1
Inspection of VOC solvent containers	Daily	Print Plant	#3500063003 Condition II.B.10.b.1

Monitoring Condition	Frequency	Source(s) Covered	Permit Condition
Visible emissions Method 9	Annually	Bldg 350 Carpentry Shop Dust Collector	#3500063003 Condition II.B.12.a.1
Hours of operation	Rolling 12-month total determined monthly by the 20th	Bldg 350 Carpentry Shop Dust Collector	#3500063003 Condition II.B.12.b.1
Fuel type verification when natural gas is being combusted Opacity survey when fuel oil is combusted	As necessary Semiannually if burning fuel oil, Method 9 within 24 hours if VE are observed	Bldg 521/525/526 Hosptial Boilers	#3500063003 Condition II.B.13.a.1
Fuel use type	As necessary	Bldg 532 Hospital Boilers	#3500063003 Condition II.B.14.a.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 532 Hospital Boilers	#3500063003 Condition II.B.14.b.1
Monitoring per 40 CFR 60 Subpart A – fuel type, amount, supplier certifications for fuel oil	As necessary	Bldg 532 Hospital Boilers	#3500063003 Condition II.B.14.c.1
Fuel use type	As necessary	Bldg 523 Eye Center Boiler	#3500063003 Condition II.B.15.a.1
Fuel type verification when natural gas is being combusted Opacity Method 9 when fuel oil is combusted more than 12 hours	As necessary Daily	Bldg 555 Huntsman Cancer Inst. Boiler	#3500063003 Condition II.B.16.a.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 555 Huntsman Cancer Inst. 16.8 MMBtu/hr NSPS Boilers	#3500063003 Condition II.B.16.c.1
Fuel type verification when natural gas is being combusted Opacity Method 9 when fuel oil is combusted more than 12 hours	As necessary Daily	Bldg 556 Huntsman Cancer Inst. Boilers	#3500063003 Condition II.B.17.a.1
Fuel use type	As necessary	Bldg 565 E-E-J Medical Research Center Boiler	#3500063003 Condition II.B.18.a.1

Monitoring Condition	Frequency	Source(s) Covered	Permit Condition
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 565 E-E-J Medical Research Center Boiler	#3500063003 Condition II.B.18.c.1
Fuel type usage	As necessary	Bldg 853 Health Profession Education	#3500063003 Condition II.B.19.a.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 581 School of Pharmacy	#3500063003 Condition II.B.20.a.1
Monitoring per 40 CFR 60 Subpart A [102]	Daily	Bldg 581 School of Pharmacy	#3500063003 Condition II.B.20.b.1
Fuel use type	As necessary	Bldg 865 Boiler	#3500063003 Condition II.B.21.a.1
Fuel use type	As necessary	Bldg 587 Boiler	#3500063003 Condition II.B.22.a.1
Monitoring per 40 CFR 60 Subpart A [103]	Daily	Bldg 587 Boiler	#3500063003 Condition II.B.22.b.1
Monitoring per 40 CFR 60.48c(g) – Fuel usage for each fuel	Monthly report fuel on a daily basis	Bldg 587 Boiler	#3500063003 Condition II.B.22.c.1
Method 9	Annually	Small Diesel Fired Engines	#3500063003 Condition II.B.23.a.1
Method 9	Annually	Large Diesel Fired Engines	#3500063003 Condition II.B.24.a.1
Monitor generator usage (type – testing, maintenance & emergency use), hours of operation, reason for operation,	Each time a generator is operated	Bldg 85, 168 Hp Bldg 526, 1475 Hp Bldg 526 1475 Hp	#3500063003 Condition II.B.25.a.1
Engine certifications Operation & maintenance consistent with manufacturer recommendations	Must have always Every time units operate	See List Below	#3500063003 Condition II.B.25.a.1 Condition II.B.25.b.1
Sulfur content of diesel fuel	Each time generator fuel tank is filled	Bldg 85, 168 Hp Bldg 526 1475 Hp Bldg 526 1475 Hp See List Below	#3500063003 Condition II.B.25.c.1
Monitor generator usage (type – testing, maintenance & emergency use), hours of operation, reason for operation,	Every time a unit operates (records kept monthly)	Bldg 85, 168 Hp Bldg 526 1475 Hp Bldg 526 1475 Hp See List Below	#3500063003 Condition II.B.25.d.1

Monitoring Condition	Frequency	Source(s) Covered	Permit Condition
Fuel use	Every time a unit operates	Natural Gas Fired Emergency Generators	#3500063003 Condition II.B.26.a.1

Per 40 CFR 60.48c(g)(1) "the owner or operator of each affected facility shall record and maintain records of the amount of fuel each day."

[102] Per 40 CFR 60.Subpart Dc – the only monitoring requirement for natural gas is found in 40 CFR 60.48c(g), and consist of daily fuel use monitoring.

[103] Per 40 CFR 60.Subpart Dc – the only monitoring requirement for natural gas is found in 40 CFR 60.48c(g), and consist of daily fuel use monitoring.

6. PROPOSED SIP CONDITIONS

Include a brief list of conditions that the source anticipates will be necessary for the SIP.

i. Emissions to the atmosphere from the listed emission points in Building 303 shall not exceed the following concentrations:

EMISSION POINT	POLLUTANT	ppmdv (3% O_2 dry)	
A. Boilers #3	NO_x	187	(Replace with new boiler at 9 PPM by December 31, 2018).
B. Boilers #4	NO_x	187	Decommission in 2018.
C. Boilers #6	NO_x	9	
C. Boilers #7	NO_x	9	
D. Turbine	NO_x	9	
E. Turbine and WHRU Duct burner	NO_x	15	

ii. Stack testing to show compliance with the emissions limitations of Condition i above shall be performed as specified below:

EMISSION POINT	POLLUTANT	INITIAL TEST	TEST FREQUENCY
A. Boilers #9	NO_x	2019	every 3
B. Boilers #3 & #4	NO_x	*	every 3
C. Boilers #6	NO_x	*	every 3
D Boilers #7	NO_x	*	every 3
E. Turbine	NO_x	*	every year
F. Turbine and WHRU Duct Burner	NO_x	*	every year

* Initial test already performed

APPENDIX A: COST ANALYSIS

BACT CONTROL COST EVALUATION

Technology: Selective Catalytic Reduction (SCR)
Application: UCHTWP Natural Gas Fired Boiler
Pollutants: Oxides of Nitrogen (NOx)

Selective Catalytic Reduction (SCR)

Key Assumptions	Each UCHTWP Boiler	Notes
Process Information		
Uncontrolled Emissions (tpy)	4.85	
Heat Input (MMBtu/hr)	87.50	
Control Efficiency (%)	70%	- 70% efficiency assumed due to low concentration in exhaust
Catalyst Volume (ft^3)	487	
SCR Height (ft)	17	
Ammonia Reagent (lb/hr)	10 20	
Electrical Consumption (kWh/year)	429,240	
Gas Consumption (MMBtu/year)	7,665	
Water Consumption (Mgal/year)	0	
Utility Costs		
Electricity ($/kWh)	$ 0.089	Average Utah prices
Natural Gas ($/MMBtu)	$ 2.83	Average U S. Prices (Jan 2017)
Water ($/Mgal)	$ 33.45	Sandy Utah (2" Meter, July 2016)
Ammonia Reagent ($/lb)	$ 0.48	
Labor Costs		
Operator ($/hour)	$ 15.00	
Supervisor ($/hour)	$ 20 00	
Maintenance ($/hour)	$ 20.00	
Economic Factors		
Dollar Inflation (2002 to 2017)	1.3416	U S Consumer Price Index
Equipment Life Expectancy (Years)	10	
Interest Rate (%)	7%	Current Avg SBA Loan Rate
Capital Recovery Factor (CRF)	0.1424	

DIRECT COSTS

Capital Cost	Each UCHTWP Boiler	Notes
Purchased Equipment Costs		
Total Equipment Cost[1]	880,422	A
Instrumentation	88,042	0 10 × A
Sales Tax	52,825	0 06 × A
Freight	44,021	0.05 × A
Total Purchased Equipment Costs	*1,065,311*	*B = 1.18 × A*
Direct Installation Costs [2]		
Foundations and Supports	85,225	0.08 × B
Handling and Erection	149,143	0 14 × B
Electrical	42,612	0.04 × B
Piping	21,306	0.02 × B
Insulation	10,653	0.01 × B
Painting	10,653	0.01 × B
Site Preparation & Buildings	-	No estimate / Site specific
Additional duct work	-	No estimate / Site specific
Total Direct Installation Costs	*319,593*	*C = 0.30 × B*
Indirect Installation Costs [2]		
Engineering	106,531	0 10 × B
Construction and Field Expense	53,266	0.05 × B
Contractor Fees	106,531	0.10 × B
Start-up	21,306	0.02 × B
Performance Test	10,653	0.01 × B
Process Contingencies	31,959	0.03 × B
Total Indirect Installation Costs	*330,246*	*D = 0 31 × B*
Total Capital Investment ($)	**1,715,150**	**TCI = B + C + D**

ANNUAL COSTS

Operating Cost	Each UCHTWP Boiler	Notes
Direct Annual Costs[3]		
Operating Labor (0.5 hr, per 8-hr shift)	8,213	E
Supervisory Labor (15% operating labor)	1,232	F = 0.15 × E
Maintenance Labor (0.5 hr, per 8-hr shift)	10,950	G
Maintenance Materials	8,576	H = 0.005 x TCI
Electricity	38,202	I
Natural Gas	21,692	J
Water	0	K
Reagent	42,443	L
Catalyst Replacement (Cost x CRF for 3 yrs)	44,577	M
Total Direct Annual Costs	*175,885*	*DAC = E +F+ G+ H+ I+ J +K+L+M*
Indirect Annual Costs[3]		
Overhead	17,382	N = 0.60 × (E + F + G + H)
Administrative Charges	34,303	O = 0.02 × TCI
Property Tax	17,151	P = 0.01 × TCI
Insurance	17,151	Q = 0.01 × TCI
Capital Recovery[4]	244,199	R
Total Indirect Annual Costs	*330,187*	*IDAC = N+O+P+Q+R*
Total Annual Cost ($)	**506,072**	*TAC = DAC + IDAC*
Pollutant Removed (tpy)	3.40	
Cost per ton of Pollutant Removed ($)	**149,064**	*$/ton = TAC / Pollutant Removed*
New Emission Rate (tpy)	1.46	
New Emission Factor (lb/MMBtu)	0.004	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (7th Edition)*, May 2016, Section 4.2, Chapter 2 (Selective Catalytic Reduction), Tab
2. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, January 2002, Section 3.2, Chapter 2, Table 2 8 (assume same as cata
3. U.S EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, January 2002, Section 3.2, Chapter 2, Table 2.10 (assume same as cat
4. Capital Recovery factor calculated based on Equation 2.8a (Section 1, Chapter 2, page 2-21) and Table 1.13 (Section 2, Chapter 1, page 1-52) of U.S. EPA OAQPS, EPA Air Pollution Control Cost Manual (6th Edition), January 2002.

Trinity Consultants

BACT CONTROL COST EVALUATION

Technology: Ultra Low NO_X Burner
Application: Natural Gas Fired Boiler
Pollutants: Oxides of Nitrogen (NOx)

Ultra Low NOX Burner

Key Assumptions	Each UCHTWP Boiler	Notes
Process Information		
Uncontrolled Emissions (tpy)	4.85	
Heat Input (MMBtu/hr)	87.50	
Controlled Emissions (tpy)	3.20	
Utility Costs		
Labor Costs		
Operator ($/hour)	$ 15.00	
Supervisor ($/hour)	$ 20.00	
Maintenance ($/hour)	$ 20.00	
Economic Factors		
Dollar Inflation (2002 to 2017)	1.3416	U.S. Consumer Price Index
Equipment Life Expectancy (Years)	10	
Interest Rate (%)	7.00%	Current Avg SBA Loan Rate
Capital Recovery Factor (CRF)	0.1424	

DIRECT COSTS

Capital Cost	Each UCHTWP Boiler	Notes
Purchased Equipment Costs		
Total Equipment Cost[1]	400,000	A
Instrumentation	40,000	0.10 × A
Sales Tax	24,000	0.06 × A
Freight	20,000	0.05 × A
Total Purchased Equipment Costs	*484,000*	*B = 1.18 × A*
Direct Installation Costs [2]		
Foundations and Supports	38,720	0.08 × B
Handling and Erection	67,760	0.14 × B
Electrical	19,360	0.04 × B
Piping	9,680	0.02 × B
Insulation	4,840	0.01 × B
Painting	4,840	0.01 × B
Site Preparation & Buildings	-	No estimate / Site specific
Additional duct work	-	No estimate / Site specific
Total Direct Installation Costs	*145,200*	*C = 0.30 × B*
Indirect Installation Costs [2]		
Engineering	48,400	0.10 × B
Construction and Field Expense	24,200	0.05 × B
Contractor Fees	48,400	0.10 × B
Start-up	9,680	0.02 × B
Performance Test	4,840	0.01 × B
Process Contingencies	14,520	0.03 × B
Total Indirect Installation Costs	*150,040*	*D = 0.31 × B*
Total Capital Investment ($)	**779,240**	**TCI = B + C + D**

ANNUAL COSTS

Operating Cost	Each UCHTWP Boiler	Notes
Direct Annual Costs [3]		
Operating Labor (0.5 hr, per 8-hr shift)	8,213	E
Supervisory Labor (15% operating labor)	1,232	F = 0.15 × E
Maintenance Labor (0.5 hr, per 8-hr shift)	10,950	G
Maintenance Materials	3,896	H = 0.005 x TCI
Total Direct Annual Costs	*24,291*	*DAC = E +F+ G+ H+ J*
Indirect Annual Costs [3]		
Overhead	14,574	N = 0.60 × (E + F + G + H)
Administrative Charges	15,585	O = 0 02 × TCI
Property Tax	7,792	P = 0 01 × TCI
Insurance	7,792	Q = 0 01 × TCI
Capital Recovery[4]	110,946	R
Total Indirect Annual Costs	*156,690*	*IDAC = N+O+P+Q+R*
Total Annual Cost ($)	**180,981**	*TAC = DAC + IDAC*
Pollutant Removed (tpy)	1.65	
Cost per ton of Pollutant Removed ($)	**109,755**	*$/ton = TAC / Pollutant Removed*

1. Allan Woodbury with North Associate, Inc. provided estimate.
2. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, January 2002, Section 3.2, Chapter 2, Table 2.8 (assume same as catalytic incineration)
3. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, January 2002, Section 3.2, Chapter 2, Table 2 10 (assume same as catalytic incineration)
4. Capital Recovery factor calculated based on Equation 2.8a (Section 1, Chapter 2, page 2-21) and Table 1.13 (Section 2, Chapter 1, page 1-52) of U.S. EPA OAQPS, EPA Air Pollution Control Cost Manual (6th Edition), January 2002.
5. It is assumed that the cost and consumption of natural gas will not be influenced by the purchase of a new unit.