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Duke Cliffside Unit 6 & 7 Project

Top-Down BACT Determination for Auxiliary Boiler

Duke Energy submitted a PSD permit application to construct two new generating units with supporting equipment at its Cliffside Steam Station in Rutherford and Cleveland Counties, North Carolina on December 16, 2005. During its technical review of the proposed application, NCDAQ requested additional supporting information regarding top-down BACT for the proposed 190 MMBtu/hr auxiliary boiler, and specifically to document the determination that add-on control technology is not cost effective for application to this particular emission source. This supporting information is provided in this addendum.

The proposed auxiliary boiler is a 190 MMBtu/hr "package" boiler, fired exclusively with low sulfur (0.05% S) No. 2 distillate oil. The auxiliary boiler will be used to provide steam for space heating, standby and startup needs when the proposed coal units are out of service; hence, Duke has proposed an enforceable operating restriction limiting operation of the auxiliary boiler to no more than 10% capacity factor, equivalent to full load operation for no more than 876 hours per year.

The Duke Cliffside Project (and its proposed auxiliary package boiler) is subject to PSD review and top-down BACT for NO_x, PM/PM_{10}, CO and VOC (but is not subject to PSD Review for SO_2 which is not addressed in this addendum).

Identification and Ranking of Candidate NO_x Control Technologies

EPA's BACT/RACT/LAER Clearinghouse did not identify application of emission controls to distillate oil-fired auxiliary package boilers other than combustion control for NO_x. Industrial package boilers are pre-assembled units that are delivered to the site as a prefabricated unit. Due to shipping size constraints, package boilers are very compact, and utilize a "down and back" horizontal gas path. The small furnace volumes of package boilers preclude application of a number of control alternatives that may be applied to field erected boilers, which typically are constructed with large furnace volumes and "up and down" vertical gas paths. While ENSR did not identify any distillate oil-fired package boilers using selective catalytic reduction (SCR) for NO_x control, we believe that SCR technology is transferable to this application and at a potential reduction of about 90% would represent the hypothetical "top" control case even though it could not be cost effective to a boiler that will only operate the equivalent of 37 days per year. As will be discussed in the following sections, selective non-catalytic reduction (SNCR), natural gas reburn, separated overfire air (SOFA), and Burners Out of Service (BOOS) were determined to be not technically feasible for application to package boilers. The next best level of control in the top-down BACT analysis, was therefore determined to be Low NO_x Burners (LNB) with Flue Gas Recirculation (FGR) to achieve an emission level of 0.01 lb NO_x/MMBtu.

SCR

Due to advances in technology, package boilers that burn low sulfur distillate are routinely supplied with burners of low NO_x design, and that utilize internal flue gas recirculation, with resulting NO_x emissions of around 0.1 lb NO_x/MMBtu. This proposed emission limit provides a maximum allowable NO_x emission rate from the proposed auxiliary boiler of 0.1 lb/MMBtu x 190 MMBtu/hr x 876 hrs/yr x 1 ton/2000lb = 8.3 tons NO_x/yr. Selective Catalytic Reduction (SCR) is believed to represent "transferable technology" for potential application to distillate oil-fired auxiliary boilers. While SCR is not well suited to operations of auxiliary units with frequent starts and stops (no NO_x control is experienced at all until the catalyst bed achieves full operating temperature, negating any NO_x control during the first few hours after startup), for this analysis we conservatively assume that a hypothetical SCR could remove 90% of the proposed potential annual NO_x emissions, or 7.5 tpy.

ENSR obtained a budgetary cost estimate to apply SCR to a similarly sized package boiler from Binder, Moss & Richter. As shown on the attached cost effectiveness estimating tables, the basic SCR equipment would have a capital cost of ~ $ 775,000. Using a factored cost estimating approach as outlined in USEPA's Control Cost Manual yields a total (installed) capital cost of $ 1,489,000. The annualized cost to operate SCR for 876 hours per year, including capital recovery based on 10% interest for a 10 year financing period, would exceed $388,000 / yr. The cost effectiveness of application of SCR to the proposed auxiliary package boiler, therefore, would be $52,000 / ton of NO_x controlled, which is clearly not cost effective for this particular application.

Capital Cost of SCR

	SCR System 90% Reduction	Basis
DIRECT COSTS:		
PURCHASED EQUIPMENT		
(a) Basic Equipment (BE)	$774,729	Vendor Quote Binder, Moss & Richter
(b) Auxiliaries	included	
(c) Instrumentation & Controls	77,500	10% of BE
(d) Tax & Freight	68,200	8% of (1a) -> (1c)
TOTAL PURCHASED EQUIPMENT (PE):	**$920,429**	
DIRECT INSTALLATION		
(a) Foundations and Support	73,634	8% of PE
(b) Handling and Erection	128,860	14% of PE
(c) Electrical	36,817	4% of PE
(d) Piping	18,409	2% of PE
(e) Insulation for Ductwork	9,204	1% of PE
(f) Painting	9,204	1% of PE
TOTAL DIRECT INSTALLATION (DI):	**$276,129**	
TOTAL DIRECT COST (TDC):	**$1,196,558**	
INDIRECT COSTS:		
INDIRECT INSTALLATION		
(a) Engineering & Supervision	92,000	10% of PE
(b) Construction & Field Expenses	46,000	5% of PE
(c) Contractor Fees	92,000	10% of PE
(d) Contingencies	27,600	3% of PE
OTHER INDIRECT COSTS		
(a) Startup & Performance Tests	27,600	3% of PE
(b) Working Capital	7,000	30 days O&M cost
TOTAL INDIRECT COST:	**$292,200**	
TOTAL CAPITAL COST:	**$1,489,000**	

Annualized Costs of SCR

	SCR System 90% Reduction	Basis
DIRECT OPERATING COSTS:		
DIRECT LABOR (DL)		
(a) Operators	1,900	0.5 hour/shift @ $35/hr
(b) Supervisors	300	15% of operating labor
MAINTENANCE		
(a) Labor	2,500	0.5 hour/shift @ $45/hr
(b) Material	2,500	100% of maintenance labor
MEDIA REPLACEMENT	75,000	3 year life, 10% interest
UTILITIES		
(a) Natural Gas		
(b) Electricity	329	$ 0.05 kwhr
(c) Steam		
(d) Ammonia	2,625	$350.00 ton ENSR Estimate
INDIRECT OPERATING COSTS:		
OVERHEAD	1,300	44% of OL + 12% ML
PROPERTY TAX	14,900	1% of Total Capital Cost
INSURANCE	14,900	1% of Total Capital Cost
ADMINISTRATION	29,800	2% of Total Capital Cost
CAPITAL RECOVERY	242,300	10 yr life, 10% interest rate
TOTAL ANNUALIZED COST:	**$388,354**	
BASE EMISSION RATE (TON/YR)	8.30	
CONTROL EFFICIENCY (%)	90	
OVERALL TONS/YR CONTROLLED	7.47	
OVERALL COST EFFECTIVENESS ($/TON):	**$52,000**	
Notes: Basic equipment cost scaled from 99.7 MMBtu/hr to 190 MMBtu/hr and adjusted for CPI (2001-2006)		

SNCR

Selective Non-Catalytic Reduction (SNCR), a less effective but less costly control technique, was also reviewed for potential application to the proposed auxiliary package boiler. SNCR requires excellent gas:gas mixing which requires large furnace volumes and residence time, and also requires a precise and stable temperature window in the furnace at which to inject the ammonia or urea. As stated previously, the proposed auxiliary boiler will only operate the equivalent of 876 hours per year, and then will serve a range of startup and space heating duties. This sporadic operation with load following over a turndown range of as much as 10:1, will create wide firing and temperature distribution variations within a furnace volume that is inherently too small for ammonia and NO_x to effectively contact, which precludes the ability to utilize SNCR for NO_x control. The USEPA document, "Alternative Control Techniques Document -- NO_x Emissions from Industrial/Commercial/Institutional (ICI) Boilers" (ACT), states "… SNCR is not considered applicable to small packaged watertube and firetube boilers and units with large fluctuations in steam load." (p 5-68).

SNCR is determined to be not technically feasible for application to the proposed distillate-fired auxiliary package boiler.

Burners Out of Service, Separated Over-fire Air, and Gas Reburn

Various staged combustion techniques have been applied to vertically oriented, field erected boilers, including Burners Out of Service (BOOS), Separated Over-fire Air (SOFA) and Natural Gas Reburn. All of these technologies seek to limit the formation of NO_x by vertical combustion staging in the furnace of a field-erected boiler, where sufficient volume and residence time exists to starve the high temperature combustion zone of oxygen, and then adding the oxygen back to complete combustion in the upper section of the furnace. Industrial package boilers are simply not configured with the volume, residence time or temperature windows to employ such combustion macro-staging. No listings of distillate oil-fired auxiliary package boilers were found in the RBLC which employ burners out of service, separated over-fire air, or gas reburn technologies for control of NO_x, nor were any of these technologies discussed in the EPA's ATC Document as applicable to this type of boiler. None of these methods of NO_x control are determined to be technically feasible for application to the proposed auxiliary package boiler.

Low NO_x Burners with Flue Gas Recirculation

All identified top-down BACT decisions for similar auxiliary package boilers conclude that Low NO_x Burners (LNB) with internal flue gas recirculation (FGR) represent the best practical and cost effective alternative for this particular source type. Most LNB's sold by the major manufacturers utilize internal "micro combustion staging", whereby flue gas is internally recirculated into the highest temperature portion of the flame, and additional air is added downstream to complete burn out of products of incomplete combustion. The lowest emission rate that can be achieved when burning distillate oil with this technology is 0.1 lb NO_x / MMBtu.

Selection of BACT for NO_x for the Proposed Auxiliary Package Boiler

Although application of an SCR to a boiler for removal of NO_x can typically reach a 90% removal rate, it has been determined to not be cost-effective for an auxiliary boiler limited to 10% capacity. The 876 hour per year operating limit pushes the cost per ton of NO_x removed to $52,000. This eliminates it from consideration as BACT. An SNCR system would only remove approximately 30% of NO_x emissions from the auxiliary boiler if it were technically feasible for such an application. SNCR, Burners out of service, Over-fire air, and Gas reburn are all eliminated from consideration for BACT due to technical infeasibility. Therefore BACT for the auxiliary boiler is determined to be Low-NO_x burners and Flue-gas recirculation. This combination of control technologies will limit NO_x emissions to 0.1 lb/MMBtu.

Identification and Ranking of PM/PM_{10} Control Technologies

No add-on particulate controls have been identified that would be technically feasible or applicable to distillate oil-fired boilers. All listings in the BACT/RACT/LAER Clearinghouse cite the use of clean fuels. The Cliffside Generating Station does not have natural gas service. Back up units such as the proposed auxiliary boilers require on-site fuel storage (pipeline natural gas is an interruptible fuel supply); the cleanest fuel available for this service, therefore is distillate oil, which contains essentially no ash. The use of distillate oil for the proposed backup auxiliary boiler is therefore determined to represent the top level of control for particulate matter (PM) and particulate matter less than 10 microns (PM_{10}) from the proposed auxiliary package boiler.

Selection of BACT for PM_{10} for the Proposed Auxiliary Package Boiler

The top level of control for this particular source type was determined to be the use of clean fuels to avoid emitting particulate. The use of distillate oil for the proposed backup auxiliary boiler is therefore determined to represent BACT for particulate matter and particulate matter less than 10 microns for this particular emission source.

Identification and Ranking of Control Technologies for Products of Incomplete Combustion (CO and VOC)

Emissions of carbon monoxide (CO) and volatile organic compounds (VOC) are both products of incomplete combustion (PICs) of the fuel. All CO and VOC control techniques seek to more fully burn out these PICs with excess oxygen typically present. Oxidation catalysts have been routinely applied to combustion turbines (which exhibit much higher levels of PICs than steam boilers), however oxidation catalyst technology is not applicable to auxiliary package boilers. The oxidation catalyst must be placed within a section of the furnace where the flue gas temperature is consistently 800 - 1,000 degrees F. Further, the catalyst bed requires a large surface area (as in the full-height HRSG of a combined cycle turbine) to limit space velocity of the flue gases across the catalyst bed and to limit adverse pressure drop. Finally, the placement of a catalyst barrier within the furnace of a package boiler would increase risk of explosion in the event of flame out. The application of oxidation catalyst technology within the compact, load-following design of a package boiler is concluded to be not technically feasible. The next best level of control is achieved with good combustion control via time, temperature and turbulence. Today's generation of LNB seek to provide low NO_x profiles through staged combustion, while simultaneously adding back oxygen to effectively burn out CO and VOC. This represents the top level of control for products of incomplete combustion from this source type.

Selection of BACT for CO and VOC for the Proposed Auxiliary Package Boiler

The top level of control for this particular source type was determined to be the use of combustion controls to avoid incomplete combustion of CO and VOC. What little CO and VOC is emitted is a necessary side effect of simultaneously controlling NO_x to very low levels. The use of LNB designed for good combustion control for the proposed backup auxiliary boiler is therefore determined to represent BACT for CO and VOC for the proposed distillate oil-fired auxiliary package boiler.