Staff Report on:

EMISSION CONTROL TECHNOLOGIES AND LEVELS: TRENDS AND RESTRUCTURING IMPLICATIONS

Matthew Layton

Environmental Protection Office
Energy Facilities Siting and Environmental Protection Division
California Energy Commission

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Table of Contents

Page

INTRODUCTION AND ANALYSIS 1

CURRENT STATUS OF EMISSION LEVELS AND CONTROL TECHNOLOGIES FOR CALIFORNIA POWER PLANTS 1
- Best Available Control Technology (BACT) 1
  - Natural Gas Turbine Simple/Combined Cycle 1
  - Utility-Size Natural Gas-Fired Boiler 2
  - Cogeneration/Self-generation 2
- Best Available Retrofit Control Technology (BARCT) 2
  - Natural Gas Combined Cycle 3
  - Boilers 3

TRENDS IN EMISSION LEVELS AND CONTROL TECHNOLOGIES FOR POWER PLANTS 3
- Natural Gas Combined Cycle 4
- Distributed Generation Systems (DGS) 4
  - Fuel Cells 4
  - Small Generator Sets 4
- Boilers 5
- Large Out-of-State Power Plants 5
  - Coal 5
  - Natural Gas 6

EMISSION CONTROL TECHNOLOGIES: TRENDS AND IMPLICATIONS OF RESTRUCTURING 6

INTRODUCTION AND ANALYSIS

This paper responds to a portion of ***ER 96*** Issues Order, Implications of Electricity Industry Restructuring, Environmental Effects, Issues, I.C.1. and 2. Given restructuring, the issues ask:

1. **What trends in the location, size and type of new powerplants and transmission lines are likely?**

2. **What are the likely changes in major air emissions (including but not limited to the effects of those changes on global climate trends) resulting from the CPUC proposal (assuming, for the purpose of this issue, no mitigation measures that might be adopted in the EIR process)?**

We review the current status and likely future trends in required emission control technologies and emission control levels for new and existing power plants. The required emission control technologies and associated control levels are defined as the best available control technologies (BACT) and best available retrofit control technologies (BARCT) for new and existing power plants, respectively. Changes in these requirements may affect the total quantities of emissions produced by the electricity sector, and thus the ambient air quality, as well as the cost to developers to meet these regulations, in a restructured electricity market.

CURRENT STATUS OF EMISSION LEVELS AND CONTROL TECHNOLOGIES FOR CALIFORNIA POWER PLANTS

Best Available Control Technology (BACT)

Health and Safety Code section 40405 defines best available control technology (BACT) as the more stringent of: 1) the most stringent emission limitation contained in the state implementation plan for that class or category or source, or 2) the most stringent emission limitation that is achieved in practice by that class or category or source. Based on this definition, we expect some convergence on BACT between various air basins; however, this only appears to occur for larger (>50 MW) power plants, which are those subject to the Energy Commission's jurisdiction.

Natural Gas Turbine Simple/Combined Cycle

Currently, natural gas combustion turbines (CT) and combustion turbine combined cycles (CTCC) are licensed in California at a controlled emission level of 3 to 5 ppm NO_x. BACT for NO_x emissions is low-NO_x combustors and selective catalytic reduction (SCR). For CO, an oxidizing catalyst is considered BACT, reducing CO emissions to less than 2 ppm. The oxidizing catalyst also reduces precursor organic compound (POC) emissions. All these facilities use natural gas as BACT for SO_2 and PM_{10} emissions. Older combustion turbine and combined cycle facilities (>10 years old) have BACT emissions limits in the range of 8 to 42 ppm NO_x, depending on whether they have SCR installed, and generally do not have CO oxidizing catalysts installed.

Utility-Size Natural Gas-Fired Boiler

While this generation technology is widely installed and operated in California, it is not probable that any new boiler projects will be built in California since boilers are only about half as efficient as CTCCs, and their emissions are relatively higher. Most of the existing boilers, which are owned by the utilities, are greater than 30 years old. Their NO_x emissions are often quite high (100 to 200 ppm NO_x) because they have not yet installed emission controls and have high firing temperatures. However, their CO and POC emissions are relatively low compared to combustion turbines. Most boilers burn natural gas as BACT for SO_2 and PM_{10} emissions, however, some boilers still have permit conditions allowing them to burn oil during periods of gas curtailment or other emergencies. Emissions of all criteria pollutants are higher during oil firing.

Cogeneration/Self-generation

Natural gas combined cycle. See above discussion on current status of natural gas combined cycle power plants.

Biomass/alternative fuel boilers. Most of these boilers depend on a solid waste stream for fuel, and their size and number are limited by local geography or the size and scope of adjacent agriculture, processing plants or industrial sources of fuel. The solid fuels, which consist of agriculture and timber wastes, food and lumber processing wastes, and municipal and construction wastes, are generally low quality fuels with variable energy, moisture and inert content, which makes it harder to burn them cleanly. Since these units tend to be small (< 50 MW), BACT requirements, if they apply at all, vary between air pollution control districts (districts). Most of these units have limited emission controls and have some of the highest emissions rates among fossil-fueled plants in the state.

Best Available Retrofit Control Technology (BARCT)

Best Available Retrofit Control Technology (BARCT) requirements apply to existing units that were licensed before current emission control rules and technologies were in place, and that emit air pollutants at much higher rates than more recently constructed projects. Retrofit control technologies are the same as existing control technologies, but are sometimes configured differently to fit on, and match the operations of, the existing facility. Retrofits of existing facilities can sometimes encounter space and operational constraints during implementation, which can make them expensive compared to a new project's emission control technologies. However, they are generally very cost-effective because of the significant reductions in emissions that can be realized from these older and much dirtier facilities with the installation of emissions controls.

Natural Gas Combined Cycle

Given the continuing developments in NO_x emission controls for combustion turbines (*e.g.,* low-NO_x combustors and SCR), retrofits are available for existing combustion turbines and combined cycles that can reduce NO_x emissions. Similarly, CO oxidation catalysts, while not usually required by districts as BARCT, are available for existing combustion turbines and combined cycles. Since the majority of combustion turbines in the state no longer burn oil, but burn natural gas as BACT for PM_{10} and SO_2, there are few fuel switching opportunities for additional PM_{10} and SO_2 emissions control on these units.

Boilers

Low-NO_x burners and back-pass SCR or SNCR systems are available for use on existing natural gas-fired boilers. Low-NO_x burners appear to be more easily matched to the design and operation of existing boilers. SCR and SNCR applications can be more problematic for existing boilers and their operating profiles (*e.g.,* load following), since these NO_x control systems are highly temperature dependant. These emission control retrofits are available, with similar limitations, for biomass/alternative fuel boilers and large out-of-state coal- and natural gas-fired boilers.

TRENDS IN EMISSION LEVELS AND CONTROL TECHNOLOGIES FOR POWER PLANTS

We assume that the most likely (*i.e.,* the most economically, technically and environmentally feasible) California power plants will be natural gas-fired combustion turbine combined cycle (CTCC) power plants. These have applications as large utility-sized new and repowering projects (100 to 500 MWe), small cogeneration and industrial units (25 to 100 MWe), and as part of a distributed generation system (< 25 MWe). The CTCC technology is commercially proven and readily available for most applications. Applicable emission control technologies, which make these CTCCs some of the cleanest fossil fuel-fired facilities currently available in California, continue to improve their effectiveness and to reduce their costs.

Other generation technologies which will possibly be used in California include boilers using solid waste fuels. However, the application of these boilers, which depends on the availability of the "niche" solid fuels (agriculture and timber wastes, food and lumber processing wastes, municipal and construction wastes), may continue to limit their size and the total number of units to a small fraction of the generating system. Emerging technologies, such as fuel cells, batteries, solar photovoltaic cells, internal combustion engine generator sets, and small combustion turbines, may be developed as part of a distributed generation system.

Natural Gas Combined Cycle

BACT for simple cycle gas turbines, combined cycles, and repowering projects should be uniform throughout the state. The Commission staff recommends using the following emission factors for new combustion turbines, combined cycles and repowering projects in the ER-96 analyses: NO_x: 40 lbs/GWh, or 1.4 ppm; SO_x: < 10 lbs/GWh; PM_{10}: 45 lbs/GWh; POC: 65 lbs/GWh; CO: 45 lbs/GWh; and CO_2: 925 klbs/GWh. BACT will most likely consist of dry low-NO_x combustors and selective catalytic reduction with ammonia injection for NO_x control, an oxidation catalyst to control CO and precursor organic compounds (POC), and natural gas-firing to limit SO_2 and PM_{10} emissions.

Distributed Generation Systems (DGS)

A typical DGS may consist of fuel cells, photovoltaic cells, storage devices (batteries, flywheels, etc.), small combustion turbines and combined cycles, and internal combustion generator sets. There are no wide-spread applications of distributed generation systems now operating commercially, so estimates of likely control technologies and emissions control levels for fuel cells and small generator sets are uncertain.

Fuel Cells

Air pollutant emissions from fuel cells are very low. More advanced fuel cells operate at higher temperatures, making them better matches in cogeneration applications, however, this can drive up NO_x emissions slightly. Commission staff recommends using the following emission factors for new fuel cells in the ER-96 analyses: NO_x: 0.4 lbs/GWh, or <0.1 ppm; SO_x: 0.3 lbs/GWh; PM_{10}: negligible; POC: negligible; CO: negligible; and CO_2: 810 klbs/GWh.

Small Generator Sets

These can be small combustion turbines or internal combustion engines. The small combustion turbine generator sets (<25 MWe) are commercially available and widely used on off-shore oil platforms and remote gas pipeline compressor sites. The emission levels from these technologies can be high compared to current utility-scale combined cycle projects. However, the current BACT requirements of air districts may not be triggered by these smaller units. The smaller size of the units has, in the past, made the application of emission control systems less cost effective than on the larger CTCCs. Because of advances in the performance of the units and the falling costs of control technologies, dry low-NO_x combustors, SCR, water or steam injection, and oxidizing catalysts may become standard emission control technologies for these small combustion turbines and combined cycles.

The internal combustion engine generator sets can be the least expensive option for additional capacity. However, emissions from these internal combustion engines can be high, although the small size of the units may keep them below district BACT trigger levels. The NO_x emissions for diesel engines can be > 10,000 lbs/GWh. With water injection, electronic ignition timing, and SCR, diesel emissions can be lowered to approximately 500 lbs/GWh. The use of natural gas instead of diesel should reduce NO_x emissions further, as will as limit SO_2, PM_{10}, and POC. If the units are used in a cogeneration mode, CO_2 emission should be similar to those of a combustion turbine combined cycle.

Boilers

If a natural gas-fired boiler were retrofit, such a boiler would be required to achieve an emission limit as low as 30 ppm, using a combination of low-NO_x burners and SCR or selective non-catalytic reduction (ammonia or urea injection). The natural gas-fired boiler's use of natural gas would be considered BARCT for SO_2 and PM_{10} emissions. CO and POC emissions would be limited due to the inherently low emissions characteristics of boilers for these pollutants. These emissions control technologies, which are commercially demonstrated and available, would also be appropriate retrofit technology for biomass or alternative fuel boilers.

Large Out-of-State Power Plants

Coal

Out-of-state coal-fired power plants may be subject to NO_x and SO_2 emission control retrofits to comply with federal acid rain and visibility legislation, respectively. Low-NO_x burner modifications and selective non-catalytic reduction (SNCR, consisting of ammonia or urea injection) would be the most likely NO_x control technologies used to comply with required emission limits. Both are relatively inexpensive, and prices are continuing to drop. A pair of California 70 MW coal-fired boilers were modified with a combination of low-NO_x burner and urea injection systems to reduce NO_x emissions by 70 percent for a total 1991 cost of $3.4 million. However, installing these additional systems increases capital, operating, and maintenance costs, and may negatively affect the reliability of the unit.

Most western coal plants use low-sulfur western coal. Still, several of the out-of-state coal plants may be required to install additional SO_2 control equipment if it is shown that the units' impact visibility at nearby National parks and wilderness areas. The most likely control technology to use in this case is flue gas desulfurization (FGD). FGD can be a large investment in terms of capital, operation, and maintenance costs, however, installed capital costs are tending down. The 2250 MW Navajo station in northern Arizona installed a FGD system in 1992 to remove 90 % of the SO_2 emissions at a cost of $430 million. This is approximately $200/kW installed, however, over the remaining 15 to 25 year life of the facility (for this retrofit), it should only add 0.1 to 0.2 ¢/kWh. Obviously the FGD system increases operating and maintenance costs, and may negatively affect the reliability of the unit. These additional costs and uncertainties are not reflected in the above calculations.

The 446 MW Hayden power plant in Colorado has agreed to install sulfur and nitrogen emission control equipment (85% and 50% reductions, respectively) at a cost of $140 million. This works out to be approximately 0.18 to 0.3 ¢/kWh, capital only, if the useful life is 15 to 25 years for this existing facility. This does not include interest, and operating and maintenance costs.

Natural Gas

See the BACT and BARCT discussions for in-state power plants (boiler technologies) using natural gas. Additional NO_x controls, if required, would be similar in design and cost to those described for out-of-state coal.

EMISSION CONTROL TECHNOLOGIES: TRENDS AND IMPLICATIONS OF RESTRUCTURING

Restructuring does not appear to depend unrealistically on emission control systems that may not yet be available. The current and next generation of natural gas-fired combustion turbine combined cycles, both in-state and out-of-state, will use commercially available emission control technologies that meet local and federal BACT permitting requirements. These same technologies are available for retrofit as BARCT on existing CTCCs. Existing boilers, coal- or natural gas-fired, can be retrofit to significantly reduce NO_x and SO_2 emissions. The cost effectiveness of these retrofits should be evaluated on a case-by-case basis. Emission control technologies and regulations for the distributed generation system are not yet precisely defined. However, control technologies exist that could reduce emissions from the fossil-fueled components of a DGS to levels similar to other traditional fossil-fueled generation equipment, and should be evaluated on a case-by-case basis.