WHAT'S NEXT? NORTHERN CALIFORNIA'S NEW EMISSIONS RULE AND THE POTENTIAL IMPACT TO REGIONAL REFINERS

August 26, 2021

California has a long history of leading the U.S. in environmental regulations and of taking federal environmental rules to the next level. Back in the 1960s, for example, the state became the first to regulate emissions from motor vehicles. In more recent decades, it has led the way in reducing greenhouse gas emissions. Many of these progressive regulations migrate to other states over time, which adds significance to a Northern California environmental agency's recent decision to put stricter limits on emissions from refinery fluidized catalytic cracking units, or FCCUs. In today's blog, we discuss the new regulation and its potential implications.

On July 21, the Bay Area Air Quality Management District (BAAQMD) approved an amendment to Regulation 6, Particulate Matter, Rule 5 (Rule 6-5) that is expected to impact operating FCCUs in Northern California. The amendment specifically targets emissions associated with particulate matter (PM) and requires refiners to reduce their PM emissions within the next five years. While this regulation applies to all refineries in Northern California with FCCUs (four of the five facilities there), the BAAQMD has specifically identified two refineries in the Bay Area that it expects the regulation to impact directly. Before we dive into the new rule, let's cover some of the basics for readers who may be unfamiliar with FCCUs and how these units produce and control PM emissions.

What is an FCCU?

A FCCU is a process unit found in two out of every three U.S. refineries. In a refinery, a crude distillation unit (orange column in Figure 1) takes preheated crude oil feedstock and separates it into its various components based on their boiling points. The highest-boiling-point materials are routed to another distillation column, the vacuum distillation unit (green column), for further separation. It is in this unit where the FCCU feed is separated; the FCCU typically processes the vacuum gas oils (VGOs) sourced from the vacuum unit.

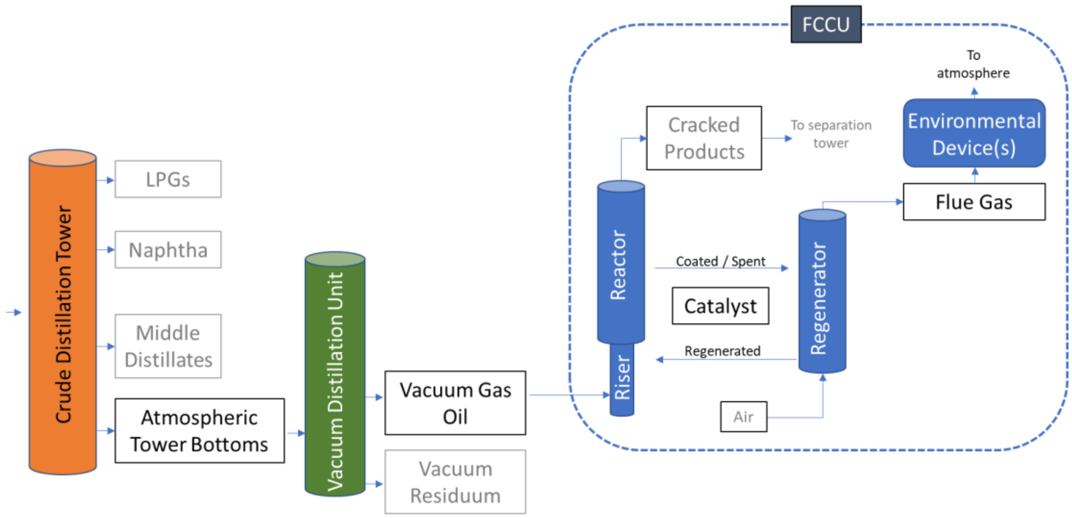


Figure 1. FCCU Diagram. Source: Baker & O'Brien

The fluidized catalytic cracker's name is essentially an amalgam of the unit's three most unique characteristics. The first is that the feedstocks processed by the FCCU are "cracked"; that is, the large hydrocarbon molecules of the VGOs are broken, or cracked, into smaller molecules. These smaller molecules are typically higher-value components such as those used for the production of gasoline, jet fuel, and diesel. The second characteristic is that cracking takes place in the presence of a fine powder catalyst. Lastly, this fine powder catalyst behaves like a fluid, which allows the catalyst to continuously flow from the regenerator to the reactor and back (which we cover in more detail below).

Focusing on the catalyst for a moment, after cracking the feedstocks, the catalyst loses some of its activity as the reaction deposits "coke" (that is the carbon-rich solid, not the sugar-rich soda). The coke-laden catalyst must be cleaned before it can participate in the reaction again, and this is where the fluidized characteristic is critically important. The catalyst flows from the reaction vessel to the FCCU regenerator. Here the process involves a controlled burn of the coke by introducing air to the mixture of coke and catalyst at around 1,300°F. With the coke burnt off and no longer inhibiting the catalyst, the catalyst is reactivated and ready for another pass in the reaction vessel, and the cycle continuously repeats.

Despite the advantages of having a fluidized catalyst, the nature of the fine powder does have some downsides; most notably, this same characteristic makes the FCCU the largest source of particulate matter emissions from a refinery. This occurs because some of this powdered catalyst breaks up into smaller particles (catalyst fines), along with some associated combustion products, and becomes entrained in the flue gas of the FCCU regenerator, leaving refiners with the obligation to incorporate additional emission control technology to capture and remove them.

What is Particulate Matter?

Now that we have a general understanding of what an FCCU is and where the major source of PM emissions come from in most U.S. refineries, let's take a closer look at PM. PM emissions are a mixture of suspended particles that can vary in size, composition, and toxicity. Generally speaking, PM emissions can contain carbon (soot), metals, and organic compounds, and can be found in diesel exhaust, wood smoke, and wind-blown soil. In other words, PM emissions include a long list of particles that are suspended in air. When discussing PM, it is often differentiated based on particle size, measured in microns (one one-thousandth of a millimeter):

- Total Suspended Particulate (TSP): Any airborne PM
- PM10: PM with an aerodynamic diameter equal to 10 microns or less
- PM2.5: PM with an aerodynamic diameter equal to 2.5 microns or less
- Ultrafine PM: Particles smaller than 0.1 micron in diameter

PM regulations have been around for a long time at both the federal and the state levels. In 1963, Congress passed the initial version of the Clean Air Act (CAA). In 1970, a much stronger version of the CAA was passed. That law, which has been amended a number of times over the past 50-plus years, requires the U.S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants, of which PM is one. Under the CAA, states are allowed to regulate PM emissions as long as their rules are at least as restrictive as the federal standards.

With the recent amendment to Rule 6-5 by the BAAQMD in Northern California, the agency is adopting a PM limit more aligned with that of the South Coast Air Quality Management District (SCAQMD) in Southern California that has been in place since 2003. The new amendment has a PM target of 10 grains per standard cubic foot corrected to 5% oxygen. We'll put that figure into context in a moment, but first, let's talk about what options refiners have to limit PM in the FCCU flue gas.

Emission Control Options

We've established what an FCCU is, what part of the FCCU produces the PM emissions, and what PM emissions are. From here, we'll take a closer look at two of the most prominent PM emission control options: an Electrostatic Precipitator (ESP) and a Wet Gas Scrubber (WGS).

Electrostatic Precipitator (ESP)

An ESP is an emissions control device that uses electrostatic energy to bind particles from the flue gas stream onto collector plates. The main components of the ESP (see Figure 2 rendering) include discharge electrodes, collection plates, and a plate-cleaning system. PM is removed from the gas stream through a series of steps: (1) a power supply energizes the discharge electrodes to establish an electric field; (2) the gas stream and particles are ionized and charged as they pass through the electric field; (3) the charged particles migrate out of the gas stream and towards collection plates, which are oppositely charged; and (4) the particles collected on the plates are removed for disposal, without re-entraining them into the gas stream.

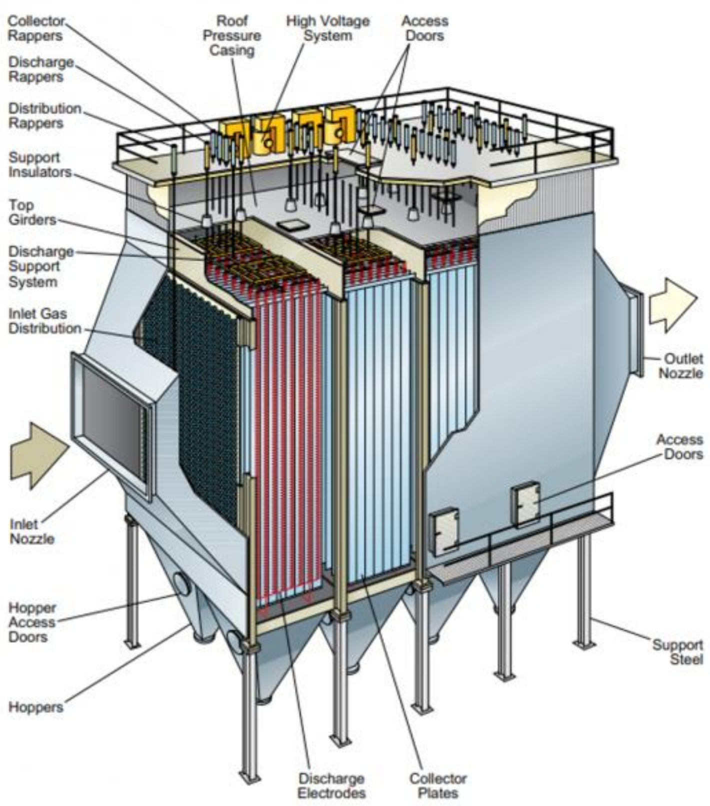


Figure 2. A Typical Electrostatic Precipitator. Source: Babcock & Wilcox

Wet Gas Scrubber (WGS)

Now that we've seen the ESP, let's discuss another popular emissions control device: the WGS. A WGS removes PM from a gas stream by physical contact with liquid, typically a mildly caustic water solution (see Figure 3 graphic). In a typical WGS, the scrubbing liquid is sprayed into the WGS tower, which contacts the flue gas stream, which enters at the bottom of the tower and flows upwards through the scrubbing liquid. The cleaned exhaust vapors exit at the top of the tower and are released to the atmosphere.

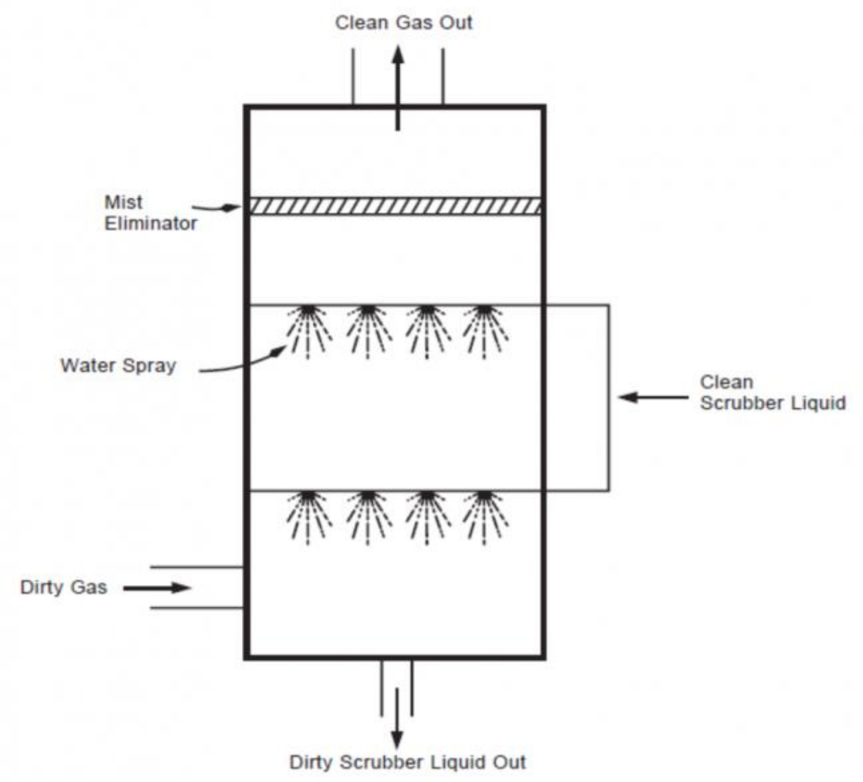


Figure 3. Wet Gas Scrubbing Unit. Source: EPA

ESP and WGS each have their own pros and cons, including PM removal effectiveness, and other environmental objectives like sulfur-oxides (SOx) reduction, the physical plot space required, water usage, capital and operating costs, and operational safety aspects, to name just a few. A detailed analysis is required to determine the best option for a particular refinery, depending on the various limits on air pollutants and other factors.

Current Deployment of ESP and WGS on FCCU in U.S. Refineries

The FCCU allows refiners to upgrade VGOs to higher value products used in the production of gasoline, jet fuel, and diesel. As such, it should come as no surprise that nearly two out of every three U.S. refineries have at least one operational FCCU. Refiners have some discretion in how they choose to meet emissions targets unless the device is mandated in a Consent Decree with the EPA.

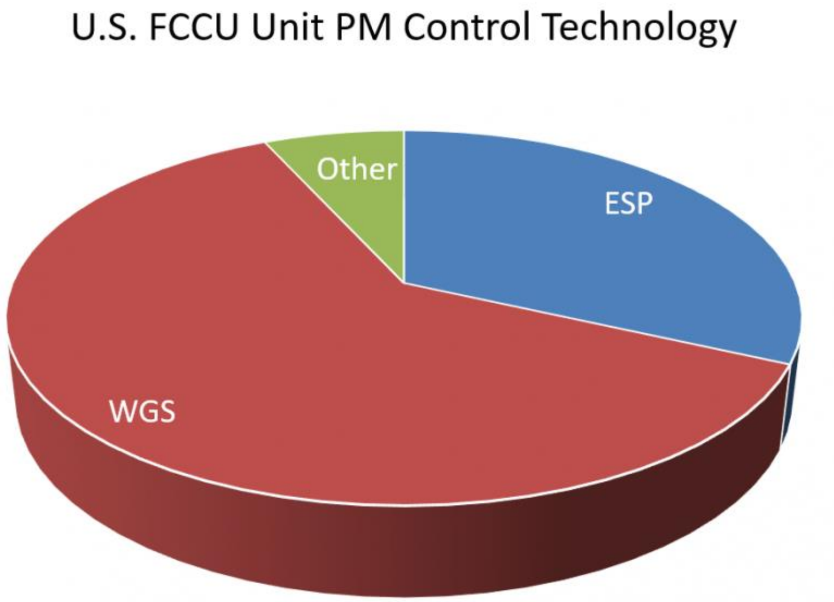
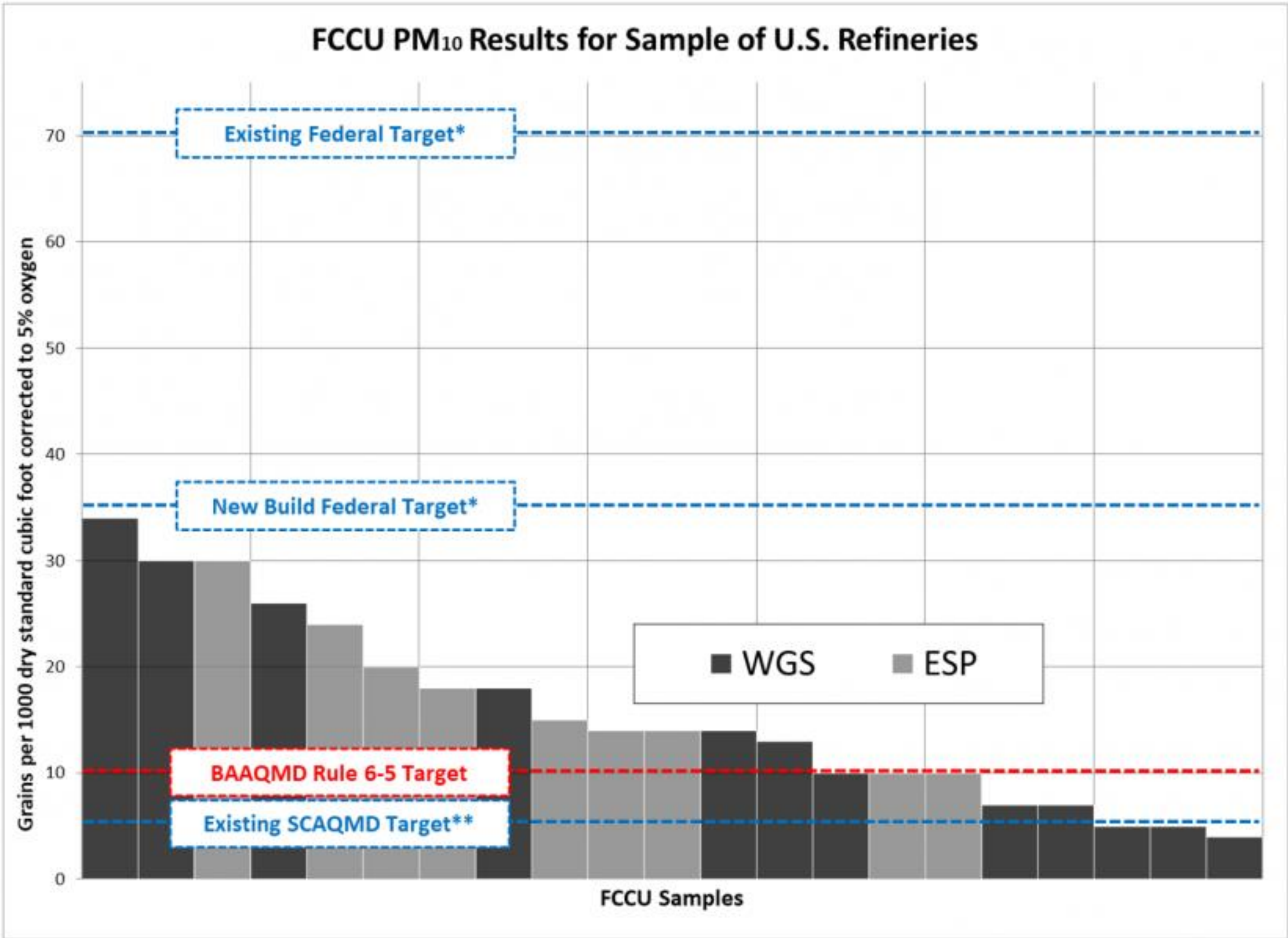


Figure 4. How FCCU-Equipped Refineries Control PM Emissions. Source: Baker & O'Brien. (Note: This figure is based upon a count of refineries with either a WGS or ESP installed on at least one of their FCCUs.)

As you can see above, the WGS is the most popular. Jumping ahead a bit, it may come as no surprise that the WGS boasts the best-in-class PM emission control, but that is hardly the whole story. In addition to PM emission targets, other FCCU emissions targets have also grown increasingly stringent, and the WGS has increased in popularity due to other attractive attributes, including sulfur dioxide (SO2) emission control and process safety benefits relative to the ESP.

In the interest of demonstrating the feasibility of the proposed PM target, the BAAQMD acquired and presented emissions data for 21 U.S. FCCUs. The data set included FCCUs of varying size, geographic location, and emissions control technology. Although the WGS popularity above should be a good indication of the technology's merit, the BAAQMD emission data provide the missing context, allowing us to see how the ESP and WGS perform when compared to industry targets. The top blue line in Figure 5 shows the federal target for existing refiners at 70 grains of PM10 per 1,000 standard cubic foot. The federal target for new build FCCU's is half that and the new BAAQMD 6-5 rule would mandate no more than 10 grains per standard cubic foot (dashed red line).



*Note *	Federal targets for new construction and existing FCCUs are based upon a filterable PM per mass of coke burn. This value requires combustion assumptions to convert to grains per dry standard cubic foot value at 5% oxygen. Further, the existing federal target has exemptions for existing, unmodified FCCUs for which the target does not apply.*

*Note **	SCAQMD allows refineries multiple pathways to achieve PM targets. The line above is the only directly comparable value although it is important to note that the SCAQMD is based upon filterable PM whereas the BAAQMD applies a variation of the test method based upon total PM10.*

Figure 5. Sample of FCCU PM10 results for various U.S. refineries compared to emission targets.
Sources: BAAQMD, Baker & O'Brien

Setting aside the targets for now, the BAAQMD data show that the WGS leads the way with the five lowest PM emissions rates (black bars to far right) for refineries in the sample. But there's more to the story, however, because three of the worst four in the data set are also applying WGS emission controls (black bars to far left). The upshot is this: those with WGS have demonstrated best-in-class PM reductions. However, just because a refinery has a WGS does not mean it is best-in-class.

Incorporating the emissions targets into the discussion, the BAAQMD target is more closely aligned with that of its neighbor to the south. In fact, the SCAQMD still leads the way on PM emission requirements (albeit with slightly different adherence guidelines). The BAAQMD target is more stringent than the federal target(s), but it would seem that the BAAQMD target is potentially

achievable using existing technology — again, each refinery is unique. Before our astute readers jump to the conclusion that the best-in-class performers are simply FCCUs governed by the SCAQMD's target, it is worth mentioning that only one of the eight FCCUs that does meet the BAAQMD target is governed by SCAQMD; the other seven are spread around the U.S.

As a parting comment on the BAAQMD sample data, it is interesting to note that two refineries with ESP emission controls were able to achieve Rule 6-5 PM target levels. Will the refineries in Northern California manage to clear this hurdle with their existing ESP's or will they be destined to explore alternatives? At the very least, it should offer a glimmer of hope that it can be done. Only time will tell.

Note: The article was authored by Amy Kalt of Baker & O'Brien and published on RBN Energy's Daily Energy Post on August 26, 2021.

"What's Next" was written by Drake, Jonathan Demario Priester, and Maneesh Bidaye. It appears as the first song on Drake's fourth EP, Scary Hours 2. Released as a single in March 2021, the record went to #1 on the Billboard Hot 100 Singles chart. Personnel on the record were: Drake (lead vocals), Jonathan Demario Priester (production), Maneesh Bidaye (production), Noel Cadastre (recording), and Noah Shebib (mixing).