apcd air pollution control district
SANTA BARBARA COUNTY

MEMORANDUM

DATE: February 13, 2023

TO: Community Advisory Council (CAC) Members

FROM: Alex Economou, (805) 979-8333, AJE@sbcapcd.org

SUBJECT: AB 617 BARCT Analysis for Reciprocating Internal Combustion Engines

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Background

Assembly Bill (AB) 617, enacted in July 2017, has many requirements to address the disproportionate impacts of air pollution in environmental justice communities. One of the key components of AB 617 is to reduce air pollutant emissions from facilities that participate in the California Greenhouse Gas (GHG) Cap-and-Trade system. There are six of these industrial facilities within Santa Barbara County, and AB 617 requires these facilities to implement Best Available Retrofit Control Technology (BARCT) no later than December 31, 2023.

During the initial BARCT assessment in 2018, the District reviewed the permitted engines at the AB 617 industrial sources to see if additional controls would be feasible. The evaluation focused on those engines with a maximum rated brake horsepower of 50 or higher, which is the same applicability threshold established by District Rule 333. After review of the engines at the six facilities, the District's preliminary BARCT review showed that it may be feasible and cost-effective to establish new BARCT standards for prime, spark-ignited engines subject to AB 617 within Santa Barbara County, including those engines that were previously derated to less than 50 brake horsepower. Hence, District Rule 333 was included on the District's AB 617 BARCT schedule as a measure that needed to be fully evaluated for BARCT, and the BARCT schedule was adopted by the District Board in December 2018.

Out of the six AB 617 industrial facilities in Santa Barbara County, Pacific Coast Energy Company ("PCEC") – Orcutt Hill is the only facility that's currently affected by this BARCT analysis for reciprocating internal combustion engines. PCEC - Orcutt Hill is an onshore oil and gas production and processing facility that is located approximately 2.5 miles south of Orcutt.

Discussion

Over the past three years, District staff and PCEC representatives have discussed the feasibility of different BARCT standards for the 27 spark-ignited engines that are used at the Orcutt Hill stationary source. PCEC conducted various trials and installed different combinations of catalysts and air/fuel ratio controllers on a select number of cyclical and non-cyclical engines operating oil well and water injection pumps to determine the feasibility of a lower emission threshold for their reciprocating internal combustion engines.

After the trials, District staff compiled the draft BARCT analysis for internal combustion engines, as shown in Attachment A (Draft BARCT Analysis for Reciprocating Internal Combustion Engines), and PCEC submitted an Authority to Construct (ATC) application to comply with the AB 617 BARCT requirements. The ATC permit application was deemed complete, and once issued, the ATC permit will require the equipment modifications (catalyst and air-fuel ratio controller installations) to be implemented at the facility no later than December 31, 2023. This will ensure that the BARCT requirements are implemented prior to the mandated deadline in AB 617.

Since all BARCT requirements will be incorporated directly into PCEC's operating permit and the remaining five AB 617 industrial facilities in Santa Barbara County do not use spark-ignited engines, Staff affirms that it is no longer necessary to amend District Rule 333 with the BARCT requirements. Staff proposes to bring the BARCT analysis before the District Board of Directors to finalize this assessment. Once finalized, the BARCT analysis will continue to apply to PCEC's existing equipment units, as well as any new units permitted and installed in the future at any of the AB 617 industrial facilities to ensure that NOx emissions are effectively controlled. In addition, the BARCT analysis will be forwarded to the California Air Resources Board for inclusion into their AB 617 BARCT webpage (ww2.arb.ca.gov/expedited-barct). Staff worked with District Counsel and concluded that this approach effectively satisfied the AB 617 mandate because it accomplishes the emission reduction goals of the legislation.

For the CAC meeting on February 22, 2023, staff will provide a presentation on the key points of the BARCT analysis and PCEC's request to comply with the standards through enforceable permit conditions. This agenda item will be informational only (i.e., no formal CAC recommendation will be sought). The docketed materials are also available for review from the District's website, www.ourair.org/rules-under-development, and all six AB 617 industrial facilities have been noticed about this meeting.

If there are questions or concerns that you would like to discuss prior to the meeting, please contact me or Tim Mitro at (805) 979-8329 / e-mail: MitroT@sbcapcd.org.

ATTACHMENT:

A. Draft BARCT Analysis for Reciprocating Internal Combustion Engines

ATTACHMENT A

Draft BARCT Analysis for Reciprocating Internal Combustion Engines

February 22, 2023

Santa Barbara County Air Pollution Control District
Community Advisory Council

260 San Antonio Road, Suite A
Santa Barbara, California 93110

SANTA BARBARA COUNTY
AIR POLLUTION CONTROL DISTRICT

DRAFT
Assembly Bill 617 –
BARCT Analysis for Reciprocating Internal Combustion Engines

Date: February 13, 2023

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Our Mission

Our mission is to protect the people and the environment of Santa Barbara County from the effects of air pollution.

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1. BACKGROUND

1.1 Ozone and Health

Ground level ozone is a secondary pollutant formed from photochemical reactions of the precursor pollutants oxides of nitrogen (NOx) and reactive organic compounds (ROC) in the presence of heat and sunlight. Both short-term and long-term exposure to ozone can cause a number of health effects in broad segments of the population. Ozone can damage the respiratory system, causing inflammation and irritation, or symptoms such as coughing and wheezing. High levels of ozone are especially harmful for children, the elderly, and people with asthma or other respiratory problems. Ground-level ozone also impacts the economy by increasing hospital visits and medical expenses, loss of work time due to illness, and by damaging agricultural crops. Santa Barbara County is currently designated as nonattainment for the state ozone standards.

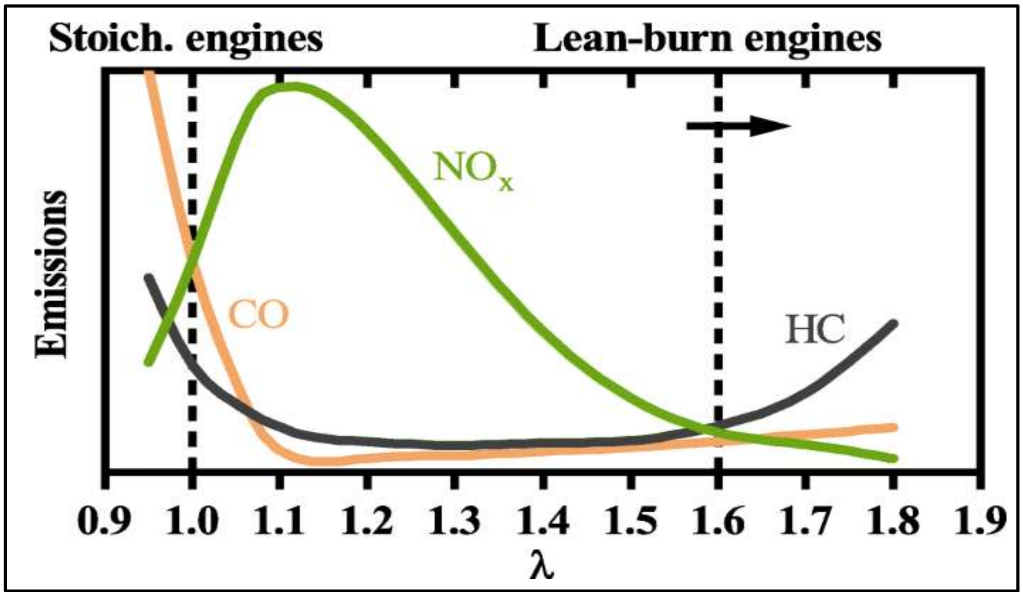
1.2 Reciprocating Internal Combustion Engines

Reciprocating internal combustion engines are engines that utilize the combustion of an air/fuel mixture inside enclosed cylinders in order to produce mechanical power. These engines are used for various functions such as generating electricity, operating water pumps, pumping oil from wells, and compressing gas. Depending on the fuel burned and the combustion method, the engines can be categorized as either compression ignition (CI) or spark-ignition (SI) engines. Compression ignition engines are typically fired on diesel fuel, and there are emission and operational limitations for these engines due to the state's Airborne Toxic Control Measures (ATCMs). Spark-ignited internal combustion engines burn fuels such as natural gas, field gas, propane, or landfill gases. An example of a spark-ignited engine at an oil well is shown below in Figure 1.1.

Figure 1.1 – Reciprocating Internal Combustion Engine

For spark-ignited engines, an important distinction is whether it is operating as a rich-burn or a lean-burn engine. Rich-burn engines are operated at or near stoichiometric conditions. On Figure 1.2 below, stoichiometric conditions are represented by a lambda (λ) value of 1.0. At this lambda value of 1.0, the air/fuel ratio provides exactly enough oxygen for the complete combustion of the fuel. As for lean-burn engines, they are operated with excess air, which typically has a lambda value around 1.6. When lean-burn engines operate with excess air, they can have increased fuel efficiency while reducing the amount of pollution emitted (before taking into account any additional control strategies). The excess air effectively reduces the combustion process temperature, which reduces the formation of NOx.

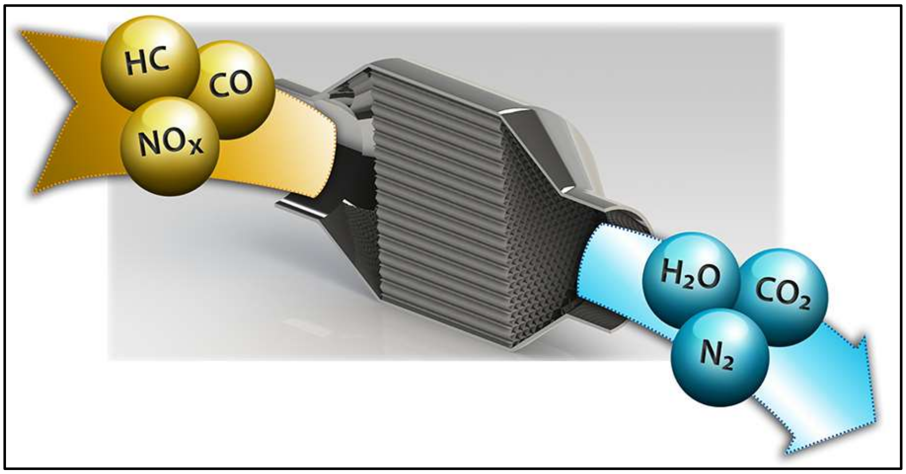
Figure 1.2 – Stoichiometry and the Effect of Air/Fuel Ratio on Pollutants



1.3 Non-Selective Catalytic Reduction (NSCR)

NSCR is a common air pollution control system used to reduce the emissions from rich-burn engines. These systems are referred to as “3-way catalyst” systems because they use precious metal catalyst to convert NOx, carbon monoxide (CO), and hydrocarbons (HC, including ROCs) to nitrogen (N_2), carbon dioxide (CO_2), and water vapor. When an NSCR catalyst is properly installed and maintained, pollutant concentrations can be reduced by more than 90 percent for NOx, 80 percent for CO, and 50 percent for ROC. An example of an NSCR catalyst is shown below in Figure 1.3.

Figure 1.3 – NSCR Catalyst



For an NSCR system to effectively control all 3 pollutants, the catalyst must operate in a narrow air/fuel ratio band that is close to stoichiometric conditions. Hence, NSCR is not effective on lean-burn engines that operate with excess air and oxygen. To consistently achieve the proper combustion levels on rich-burn engines, an automatic air/fuel ratio controller (AFRC) is typically used to regulate the fuel mixture. The AFRC makes operational adjustments based on input signals from an oxygen sensor located upstream from the catalyst bed. The controller ensures that the oxygen content of the engine exhaust remains near or below 0.5%, which allows the NSCR catalyst to achieve optimal conversion efficiencies.

To maintain high conversion efficiencies, the operating temperature in an NSCR catalyst must also be in the appropriate range. The ideal operating temperatures for NSCR systems range from approximately 750 to 1,250°F. Operating above the maximum temperature may damage the catalyst while operating below the minimum temperature will result in low conversion efficiencies. For many engines, this temperature requirement is met at all times except during startup and idling.

To prevent damage to NSCR catalysts (such as masking and chemical poisoning), care must be taken to ensure that the sulfur content of the fuel is not excessive. The sulfur content of pipeline-quality natural gas is very low, but some oil field gases can contain high concentrations. For this reason, oil field gases often need to be scrubbed before they can be combusted in an engine.

1.4 District Rule 333 and CARB's 2001 BARCT Analysis

District Rule 333, *Control of Emissions from Reciprocating Internal Combustion Engines,* was initially adopted in 1991, and it set NOx, CO, and ROC emission standards for engines with a maximum rated break horsepower of 50 or higher. The rule does not apply to compression ignition engines used in emergency applications or engines that are operated less than 200 hours per calendar year ("low-use" engines). The rule also does not apply to engines that have been derated to less than 50 brake horsepower.

In 2008, Rule 333 was amended to incorporate some of the recommended changes from CARB's 2001 Determination of Reasonably Available Control Technology (RACT) and Best Available Retrofit Control Technology (BARCT) for Stationary Spark-Ignited Internal Combustion Engines. Based on the District's attainment status for the federal ozone standard, the District was only required to adopt the RACT standard for these engines, and so Rule 333 does not reflect the 2001 BARCT emission standards. A summary of the current Rule 333 emission standards is presented below in Table 1.1.

Table 1.1 – District Rule 333 Emission Limits (Amended June 2008)

<table>
<tr><th colspan="2" rowspan="2">Engine Type</th><th colspan="3">Parts per Million by Volume (ppmv)
corrected to 15% Oxygen [1]</th></tr>
<tr><th>NOx</th><th>ROC</th><th>CO</th></tr>
<tr><td rowspan="2">Rich-burn, SI</td><td>Non-cyclical</td><td>50</td><td rowspan="2">250</td><td rowspan="5">4,500</td></tr>
<tr><td>Cyclical</td><td>300</td></tr>
<tr><td rowspan="2">Lean-burn, SI</td><td>50 to 100 hp</td><td>200</td><td rowspan="3">750</td></tr>
<tr><td>100 hp and greater</td><td>125</td></tr>
<tr><td>CI</td><td>All</td><td>700</td></tr>
</table>

For rich-burn engines, a distinction is made between cyclical and non-cyclical engines. "Non-cyclical" engines are engines that are designed to operate continuously under a constant power load, shutting down only when there is a breakdown, or when maintenance or repair work is required. Whereas "cyclical" engines have rapid fluctuations in power output and spend significant periods of time at idle. In the 2001 CARB RACT/BARCT determination, cyclical engines were allowed to have higher emission limits since they have additional challenges in using NSCR catalysts. These challenges are discussed further in Section 2.4 of this analysis.

1.5 The AB 617 BARCT Rule Development Schedule

Assembly Bill (AB) 617, enacted in July 2017, has many requirements to address the disproportionate impacts of air pollution in disadvantaged communities. One of the key components of AB 617 is to reduce air pollutant emissions from facilities that participate in the California Greenhouse Gas (GHG) Cap-and-Trade system. Cap-and-Trade is designed to limit GHG emissions and allows facilities to comply by either reducing GHG emissions at the source or by purchasing GHG emission allowances. Emissions of criteria pollutants and toxic air contaminants are often associated with large GHG-emitting sources, and these pollutants may impact local communities that are already experiencing a disproportionate burden from air pollution.

AB 617 helps alleviate the pollution burden near these communities by requiring each air district to adopt an expedited rule development schedule for BARCT by January 1, 2019. The District's AB 617 BARCT schedule was adopted at the December 2018 Board Hearing, and Rule 333 was included on the list of measures that needed to be evaluated for BARCT.[2] BARCT is an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy, and economic impacts. To meet the BARCT emission limits, a facility may need to install new air pollution controls on their existing unit(s) or replace the unit(s) in part or in whole. The BARCT requirements apply to the following six facilities within the District boundaries since they are industrial sources subject to the California Cap-and-Trade requirements:

[1] All references to ppmv within this document are corrected to a 15% oxygen content level.
[2] Additional information on the AB 617 BARCT Rule Development Schedule is available on the District's website at www.ourair.org/community-air.

1) Exxon Mobil – Las Flores Canyon,
2) Exxon Mobil – Pacific Offshore Pipeline Company (POPCO),
3) Pacific Coast Energy Company (PCEC) – Orcutt Hill,
4) Cat Canyon Resources, LLC – Cat Canyon West[1],
5) Imerys Filtrations Minerals, Inc., and
6) Windset Farms.

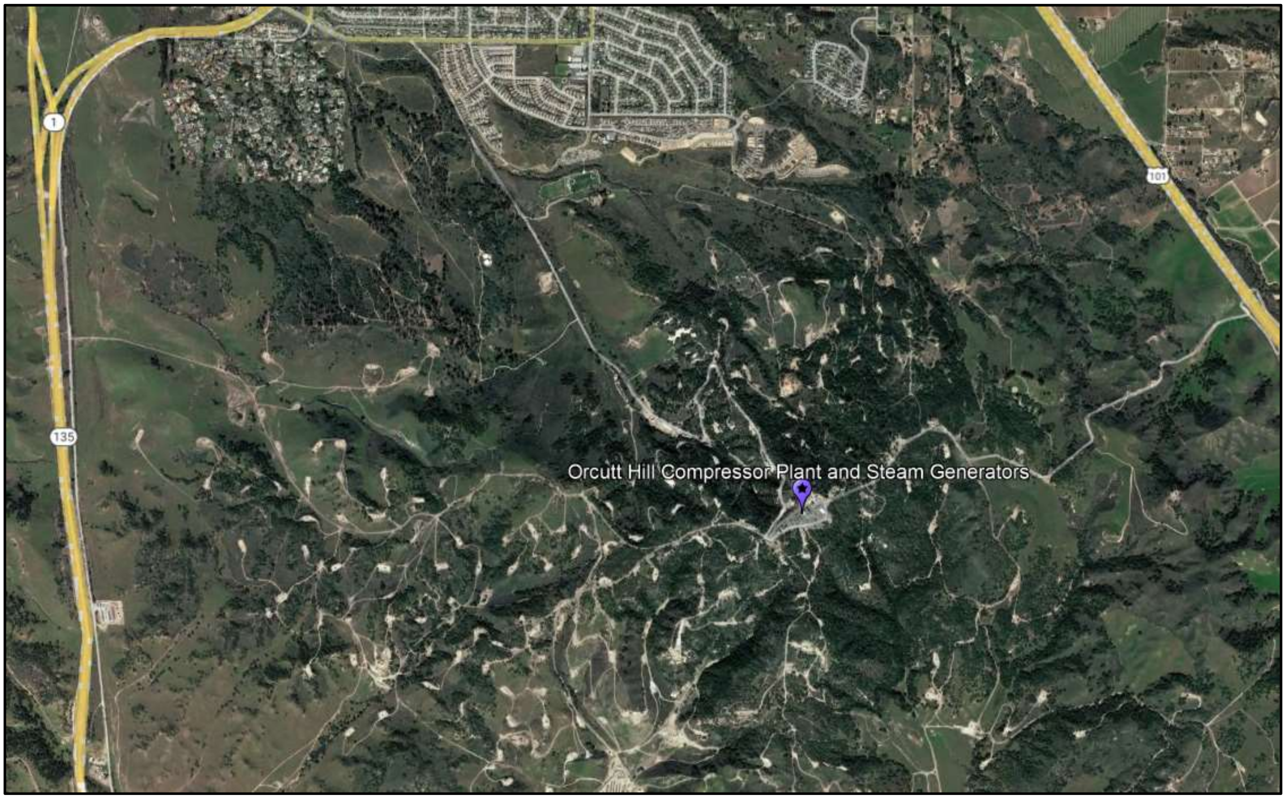
During the initial BARCT assessment in 2018, the District reviewed the permitted engines at the AB 617 industrial sources to see if additional controls would be feasible. The evaluation focused on those engines with a maximum rated brake horsepower of 50 or higher, which is the same applicability threshold established by District Rule 333. After reviewing the engines at these six facilities, the District showed that it may be feasible and cost-effective to establish new BARCT standards for prime, spark-ignited engines within Santa Barbara County, including those engines that were previously derated to less than 50 brake horsepower.

1.6 Pacific Coast Energy Company (PCEC) – Orcutt Hill

Pacific Coast Energy Company ("PCEC") – Orcutt Hill is an onshore oil and gas production and processing facility that is located approximately 2.5 miles south of the community of Orcutt. The facility was originally developed by the Union Oil Company in the 1920s, and PCEC (and its predecessor BreitBurn Energy) has been the owner/operator of the field since 2004. The Orcutt Hill field is comprised of approximately 200 conventional oil and gas wells and 90 cyclic steam injection wells.[2] The extracted crude oil, gas, and water emulsion from the wells is separated by using tank batteries. After they're separated, the crude oil is shipped offsite via pipeline, the produced water is reinjected into the producing formation, and the produced gas is piped to the Orcutt Hill Compressor Plant. At the compressor plant, the produced gas is scrubbed to remove condensates and hydrogen sulfide (H_2S). The gas is then used as the primary fuel for the combustion equipment at the stationary source, such as the steam generators and the reciprocating internal combustion engines. A satellite image of the Orcutt Hill production field is shown below in Figure 1.4.

[1] Facility was previously operated by ERG Operating Company and has since been transferred to Cat Canyon Resources, LLC.
[2] www.conservation.ca.gov/calgem/Online_Data

Figure 1.4 – Orcutt Hill Production Field



The majority of the engines that are being operated at PCEC were originally manufactured in the 1970s and 1980s, and each engine has a maximum rated horsepower between 130 to 200, depending on the specific engine model. After Rule 333 was initially adopted in 1991, Unocal (the field operator at the time) complied with the rule by derating each engine to less than 50 horsepower using orifice plates.

An orifice plate, as shown in Figure 1.5, is a steel plate with a sharp-edged circular hole that is installed between the engine's carburetor and intake manifold. The orifice plate prevents the engine from operating at its maximum horsepower by restricting fuel to the engine. The derated horsepower for each engine model and orifice plate pairing was established through dynamometer testing performed by a third-party technician, and the results were approved by the District. To ensure that the orifice plates do not corrode or degrade over time, the facility's permit requires the orifice plates to be inspected on an annual basis.

Figure 1.5 – Orifice Plate

2. PROPOSED BARCT ANALYSIS FOR SPARK-IGNITED ENGINES

2.1 Overview of Proposed Analysis

Although there are a variety of engine configurations and fuel types, this BARCT analysis is focused on prime, rich-burn engines using natural gas or field gas since those are the engines currently being used at the AB 617 industrial sources. This BARCT analysis does not address lean-burn engines, compression-ignition engines, emergency and low-use engines, or engines fired on other fuels such as digester gas or landfill gas. The following requirements are needed to satisfy the BARCT provisions for AB 617:

- All prime engines that have a maximum rated horsepower greater than 50 shall comply with the BARCT standards, regardless of any previous deratings;
- Rich-burn engines shall meet the 11 ppmv NOx BARCT standard, and cyclical engines that have been derated to less than 50 horsepower shall meet the 25 ppmv NOx BARCT standard;
- Rich burn engines shall meet the 250 ppmv ROC standard and 2,000 ppmv CO standard; and
- The engines shall be tested and monitored in accordance with the existing provisions of District Rule 333.

These operating standards are based on the more recent BARCT determinations adopted by the South Coast Air Quality Management District under Rule 1110.2 and the San Joaquin Valley Air Pollution Control District under Rule 4702. All of the requirements to meet BARCT are described in further detail in their corresponding sections below, and an evaluation of the costs and impacts of the new requirements are listed in Section 5 of this report.

2.2 Requirement – Removal of Derated Engine Exemption

During the initial adoption of Rule 333 in 1991, an exemption was included to allow operators to derate their equipment to less than 50 brake horsepower instead of demonstrating compliance with the emission standards in the rule. In reviewing the more recent internal combustion engine rules adopted by other air districts within California, most districts do not allow for engine derating as a control strategy. Based on the District's assessment, derated engines can still be feasibly and cost-effectively controlled. Hence, for this BARCT analysis, all prime engines that have a maximum rated horsepower greater than 50 need to comply with the BARCT standards, regardless of being derated or not.

2.3 Requirement – Non-cyclical, Rich-burn Engines

Reciprocating engines can be used in several operational modes. In many cases, they are used continuously under a constant power load, shutting down only when there is a breakdown, or when maintenance or repair work is required. These engines are termed "non-cyclical" engines, and the current NOx emission limit for these engines in Rule 333 is 50 ppmv. The 50 ppmv NOx standard is typically achieved by using a NSCR catalyst.

In recent years, other air districts have demonstrated that greater NOx control efficiencies are possible. Both the South Coast AQMD and San Joaquin Valley APCD have adopted an 11 ppmv NOx standard for non-cyclical, rich-burn engines, which represents approximately 98% control compared to the uncontrolled baseline of 500 ppmv. This 11 ppmv standard has been feasibly implemented in these larger air districts for over 10 years, and it can be met through the use of a more precise AFRC or by using a larger catalyst module. To consistently reach this level of emissions, additional maintenance and recalibration may be needed on the emission control system to make sure that the various components don't fail or drift over time. Nevertheless, the 11 ppmv NOx standard is achievable on the spark-ignited engines that are currently installed within Santa Barbara County, and it represents BARCT for non-cyclical, rich-burn engines.

2.4 Requirement – Cyclical, Rich-burn Engines

Reciprocating engines can also operate cyclically, which means that the engine changes its power output on a regular, frequent schedule. As defined in Rule 333, "*Cyclically-loaded engine* means an engine that under normal operating conditions has an external load that varies by 40 percent or more of rated brake horsepower during any load cycle or is used to power a well reciprocating pump including beam-balanced or crank-balanced pumps. Engines powering air-balanced pumps are noncyclically-loaded engines."

The cyclical definition is important because on an oil well pump, the engine operates at load for a time period varying from several seconds to about 20 seconds, followed by an equal amount of time operating at idle. Since the cyclical engine has rapid fluctuations in power output and spends significant periods of time at idle, it is more difficult to maintain the proper air/fuel ratio and exhaust gas temperatures. Due to the challenges, the current Rule 333 emission limit for cyclical engines is 300 ppmv NOx. Operators can meet the existing emission limits for cyclical engines by making sure that the engine is properly maintained and tuned, or by leaning the air/fuel mixture.

In reviewing the recent BARCT assessments made by other California air districts, both the South Coast AQMD and the San Joaquin Valley APCD have addressed cyclical engines. They found that many cyclically-loaded engines can still be equipped with NSCR catalysts if the catalyst system is designed with materials that achieve high efficiencies at lower temperatures or if the exhaust pipe and catalyst are thermally insulated to prevent heat loss. These methods would allow the engine to achieve high control efficiencies when the exhaust temperature is approximately 750 to 850°F. The South Coast AQMD determination for cyclical engines has been in effect since 2011, but the San Joaquin Valley APCD only recently adopted the cyclical determination in 2021 with the 11 ppmv NOx standard going into effect on December 31, 2023.

Based on the District's assessment, the BARCT emission standard for cyclically-loaded engines in Santa Barbara County is 11 ppmv NOx. However, additional consideration needs to be given to derated engines. An engine that has been derated to less than 50 horsepower will be combusting less fuel compared to an engine that is always operating above 50 horsepower. This means that the derated engine may have a more difficult time to consistently reach the necessary operating temperature to achieve high control efficiencies. Hence, a separate BARCT determination is needed for derated engines. Based on the District's assessment, the BARCT emission standard for cyclically-loaded engines that have been derated to less than 50 horsepower is 25 ppmv NOx.

2.5 Requirement – ROC and CO Emission Limits

Controls on reciprocating internal combustion engines are typically focused on reducing NOx emissions, but there are technologies (such as the NSCR catalyst) that can greatly reduce ROC and CO emissions at the same time. The current emission limits for rich-burn engines in Rule 333 are 250 ppmv ROC and 4,500 ppmv CO. These emission limits are mainly used as a backstop to prevent any increases in ROC and CO emissions, as certain NOx control techniques have the potential to greatly increase the ROC and CO emissions.

Based on our review of the CARB Technology Clearinghouse, District staff believes that it is appropriate to lower the CO emission limit to 2,000 ppmv and to retain the existing ROC limits in Rule 333 for the purposes of this BARCT evaluation. Although lower ROC and CO emission limits have been established in the South Coast AQMD and San Joaquin Valley, the engines subject to this BARCT assessment are older, derated engines that operate on field gas, which can be challenging to control using NSCR technology. Hence, using the 250 ppmv ROC limit and 2,000 ppmv CO limit, which is representative of BARCT for most other air districts, allows the emission control system to have the much-needed flexibility to achieve the lower NOx emissions under varying field conditions.

2.6 Requirement – Testing and Monitoring Conditions

As previously discussed in this assessment, there are a variety of operating parameters that lead to the successful implementation of an emission control system on reciprocating internal combustion engines. The equipment may be initially calibrated to maintain the emission limits, but the electronic sensors may drift over time and need to be recalibrated or replaced. Hence, a testing and monitoring program is necessary to ensure that the engines remain adjusted and operate in compliance with the emission standards in the BARCT analysis. This BARCT analysis will incorporate the existing testing and monitoring program prescribed in Rule 333, which includes the following:

1) Each engine shall be source tested every two years at the engine’s actual peak load or under the engine’s typical duty cycle;
2) Each engine shall be monitored every three months using a portable NOx analyzer; and
3) For facilities with more than 20 engines, the Control Officer may, on a case-by-base basis, approve a source’s written request to exclude one or more engines from the on-going biennial testing.

Portable NOx analyzers are fairly accurate monitoring tools that are useful to periodically check the emissions of an engine. Despite their usefulness, portable analyzers do not meet all of the rigorous procedures prescribed under the EPA and CARB test methods. Under the current Rule 333 language, a portable analyzer reading in excess of the permitted emission standards shall not be considered a violation so long as the engine is brought into compliance and a follow-up inspection is conducted within 15 days of the initial out-of-compliance reading. NOx analyzer tests shall then be performed on a monthly basis until the engine tests below the emission standards for three consecutive months.

This monitoring program strikes the appropriate balance between using the verifiable EPA source test methods and using a portable NOx analyzer to demonstrate compliance. It will ensure that the emission control system for each engine is properly tuned and calibrated, and that the lower NOx limits prescribed in this BARCT assessment are achieved.

3. COMPARISON TO OTHER CALIFORNIA AIR DISTRICTS

In considering what benchmarks to use for BARCT, it is important to evaluate other emission limits that have been imposed on the same categories of equipment. Most California air districts have based their internal combustion engine rules on the California Air Resources Board's RACT and BARCT determination for stationary spark-ignited engines, which established the 2001 BARCT standards. However, a few districts, such as the South Coast AQMD and the San Joaquin Valley APCD have established more stringent requirements for certain subcategories of engines. Table 3.1 presents a comparison of these determinations to the key requirements in the District's BARCT analysis.

Table 3.1 – Comparison to Air District Rules

ANALYSIS DESCRIPTION		Santa Barbara APCD BARCT IC Engines (Proposed)	South Coast AQMD Rule 1110.2 (2008)	San Joaquin Valley APCD Rule 4702 (2021)	San Diego APCD Rule 69.4.1 (2020)	Ventura APCD Rule 74.9 (2005)
Applicability		50+ horsepower	50+ horsepower	25+ horsepower *[Emission limits do not apply to 25-49 hp]*	50+ horsepower	50+ horsepower
		Stationary & Portable	Stationary & Portable	Stationary	Stationary	Stationary
Exemptions		< 200 hours/yr	Emergency with < 200 hrs/yr total	< 200 hours/yr	< 200 hours/yr	< 200 hours/yr
		--		Emergency with <100 hrs/yr M&T	Emergency with <100 hrs/yr M&T	Emergency with <50 hrs/yr M&T
		--	--	Engines derated before 2004	--	--
Rich-burn Engines	NOx Limit	*All Non-cyclical:* 11 ppmv *Non-derated, Cyc:* 11 ppmv *Derated, Cyc:* 25 ppmv	11 ppmv	11 ppmv	*New:* 11 ppmv *Existing:* 25 ppmv	25 ppmv
	ROC Limit	250 ppm	30 ppmv	90 ppmv	*New:* 60 ppmv *Existing:* 250 ppmv	250 ppmv
	CO Limit	2,000 ppm	250 ppmv	2,000 ppmv	*New:* 70 ppmv *Existing:* 2,000 ppmv	*New:* 2,000 ppmv *Existing:* 4,500 ppmv
Testing Frequency	NOx Analyzer	Quarterly	Weekly	Quarterly	Quarterly	Quarterly
	Source Test	Biennial	Biennial	Biennial	Biennial	Biennial

4. APPLICABILITY OF FEDERAL PROHIBITORY REGULATIONS

4.1 NSPS Subpart JJJJ (40 CFR Part 60)

New Source Performance Standard (NSPS) Subpart JJJJ requires manufacturers of stationary spark-ignition engines to certify that the engines they produce comply with the applicable emission standards and requires owners and operators of stationary spark-ignition engines to install and operate the engines in accordance with the emission standards. NSPS Subpart JJJJ was initially promulgated in 2008, and the emission limits do not apply to existing engines that were manufactured before the applicable compliance date.

District staff evaluated the requirements of NSPS Subpart JJJJ and determined that none of the existing engines that are addressed in this evaluation are subject to the Subpart JJJJ requirements based on the date of their installation. For newly installed engines, the proposed BARCT requirements do not conflict with or create inconsistencies with this federal regulation.

4.2 NESHAP Subpart ZZZZ (40 CFR Part 63)

National Emission Standard for Hazardous Air Pollutants (NESHAP) Subpart ZZZZ establishes emission and operating limitations for hazardous air pollutants (HAPs) emitted from stationary reciprocating internal combustion engines located at major and area sources of HAP emissions. As defined in Subpart ZZZZ, a major source of HAP emissions is a facility that has the potential to emit 10 or more tons per year of any single HAP, or 25 tons per year or more of any combination of HAPs. An area source of HAPs is any facility that is not considered a major source of HAPs.

In general, new or reconstructed stationary reciprocating internal combustion engines comply with NESHAP Subpart ZZZZ by complying with the applicable NSPS Subpart JJJJ requirements. As for existing engines, they must comply with the applicable emission requirements and/or management practices specified in NESHAP Subpart ZZZZ. The existing engines addressed in this evaluation are considered non-emergency, four-stroke, rich-burn spark-ignition engines rated at less than 500 break horsepower at an area source of HAP emissions. The operator of these engines is required to comply with the following:

1) Change the oil and filter on each engine every 1,440 hours of operation or annually, whichever comes first;
2) Inspect the spark plugs on each engine every 1,440 hours of operation or annually, whichever comes first; and
3) Inspect all hoses and belts on each engine every 1,440 hours of operation or annually, whichever comes first.

The proposed BARCT requirements do not conflict with or create inconsistencies with the requirements listed in this federal regulation.

5. IMPACTS OF THE PROPOSED ANALYSIS

5.1 Emission Impacts

The BARCT analysis will affect all new and existing reciprocating internal combustion engines at the AB 617 industrial sources. The only facility that is expected to be impacted by this analysis is PCEC – Orcutt Hill. PCEC currently uses 27 different derated spark-ignition engines at its facility to extract oil and inject the produced water back into the underground formations. A listing of those engines is shown below in Table 5.1.

Table 5.1 – Existing Engines at PCEC - Orcutt Hill

#	Device	Engine Make & Model	Original Horsepower	Derated Horsepower	Cyclic/ Non-cyclic
1	Oil Well Pump	Waukesha 145	131	49.5	Cyclic
2	Oil Well Pump	Waukesha 145	131	49.5	Cyclic
3	Oil Well Pump	Waukesha 145	131	49.5	Cyclic
4	Oil Well Pump	Waukesha 145	131	49.5	Cyclic
5	Oil Well Pump	Waukesha 145	131	49.5	Cyclic
6	Oil Well Pump	Waukesha 1197	195	49.9	Cyclic
7	Oil Well Pump	Waukesha 1197	195	49.9	Cyclic
8	Oil Well Pump	Minneapolis Moline 800	175	48	Cyclic
9	Oil Well Pump	Minneapolis Moline 800	175	48	Cyclic
10	Oil Well Pump	Minneapolis Moline 800	175	48	Cyclic
11	Oil Well Pump	Minneapolis Moline 800	175	48	Cyclic
12	Oil Well Pump	Minneapolis Moline 800	175	48	Non-Cyclic
13	Oil Well Pump	Minneapolis Moline 800	175	48	Non-Cyclic
14	Oil Well Pump	Waukesha 145	131	49.5	Non-Cyclic
15	Oil Well Pump	Waukesha 145	131	49.5	Non-Cyclic
16	Oil Well Pump	Waukesha 145	131	49.5	Non-Cyclic
17	Oil Well Pump	Waukesha 145	131	49.5	Non-Cyclic
18	Oil Well Pump	Waukesha 145	131	49.5	Non-Cyclic
19	Oil Well Pump	Waukesha 817	131	49.5	Non-Cyclic
20	Oil Well Pump	Waukesha 817	131	49.5	Non-Cyclic
21	Oil Well Pump	Waukesha 1197	195	49.5	Non-Cyclic
22	Water Injection Pump	Waukesha 145	131	49.5	Non-Cyclic
23	Water Injection Pump	Waukesha 145	131	49.5	Non-Cyclic
24	Water Injection Pump	Waukesha 145	131	49.5	Non-Cyclic
25	Water Injection Pump	Waukesha 145	131	49.5	Non-Cyclic
26	Water Injection Pump	Waukesha 145	131	49.5	Non-Cyclic
27	Compressor Plant Pump	Waukesha 195	195	42	Non-Cyclic

These derated engines do not have any emission controls, but they could be retrofitted with NSCR control systems and air/fuel ratio controllers to reduce their emissions of criteria pollutants and toxic air contaminants. To evaluate the estimated emission impacts of these engines complying with the BARCT requirements, the historical operating records of the engines were reviewed and an average operating capacity factor was determined. The estimated emission reductions for this project are shown below in Table 5.2.

Table 5.2 – Estimated Emission Reductions

Description	**Maximum Heat Input** (MMBtu/hr)	**Initial NOx EF** (lbs/MMscf)	**Final NOx EF** (lbs/MMscf)	**Average Capacity Factor**	**Number of engines**	**Total NOx Reductions** (tons/yr)
Cyclical Engine	0.48	2,000	98.7	0.70	11	**73**
Non-Cyclical Engine	0.48	2,000	43.4	0.70	16	

Where:

- Maximum Heat Input represents an engine derated to approximately 48 hp.
- Initial NOx Emission Factor (EF) = approximately 500 ppmv NOx
  - Based on a 1990 District Hearing Board decision for uncontrolled SI engines.
- Final NOx Emission Factor
  - Derated, Cyclical: equivalent to 25 ppmv NOx
  - Non-cyclical: equivalent to 11 ppmv NOx
- Avg. Capacity Factor = (Normal Annual Fuel Use) / (Max Potential Annual Fuel Use)

- NOx Reductions = (Max Heat Input) * (Δ Emission Factor) * (Avg. Capacity Factor) * (8,760 hours/year) * (Number of Engines) / (2,000 lbs/ton) / (1,050 Btu/scf)

Based on the equation above, the implementation of BARCT may reduce approximately 2.6 to 2.7 tons of NOx per year for each engine controlled, or a collective 73 tons of NOx per year for all 27 engines. District staff acknowledges that alternative methodologies could be used to estimate the emission reductions. However, the method prescribed above is consistent with the cost-effectiveness methodology that is used for rule projects and BARCT analyses.

5.2 Cost-Effectiveness

For cost-effectiveness calculations, the District uses the Levelized Cash Flow (LCF) method. In the LCF method, a capital recovery factor (CRF) is used to transform any capital costs into an equivalent annual cost. The CRF is necessary because the one-time capital expenditures reduce emissions over the entire duration of the project life. Hence, the CRF is a function of the real interest rate and equipment life.

Staff evaluated a scenario where a derated engine would be retrofitted with a NSCR catalyst and an AFRC to comply with the BARCT standards. It is anticipated that the same type of controls would be used for both the cyclical and non-cyclical engines, and so no modifications are made to the analysis to reflect the costs between 11 ppmv and 25 ppmv NOx. On-going costs for the additional maintenance requirements on the catalyst and the monitoring requirements on the engine (quarterly NOx analyzer tests and biennial source testing) were also incorporated into the calculations. Since the facility already cleans up the field gas by removing the moisture and sulfur prior to combustion, no additional costs are included to account for the scrubbing process. The estimated cost-effectiveness for this project is shown below in Table 5.3.

Table 5.3 – Estimated Cost-Effectiveness for BARCT Analysis

	Costs		Cost-Effectiveness		
Description	**Capital and Install Costs** (per engine)	**Annual Operation and Testing Costs** (per engine)	**CRF**	**Annualized Cost** (per engine)	**Cost-Effectiveness** ($/ton)
Cyclical Engine	$60,000	$12,000	0.103	$18,180	**$6,800**
Non-Cyclical Engine	$60,000	$12,000	0.103	$18,180	**$6,600**

Where:

- Cost-Effectiveness = (Annualized Cost) / (Emission Reductions)
- Annualized Cost = (Capital Costs * CRF) + (Annual Operational Costs)
- $$\text{CRF} = \frac{i * (1 + i)^n}{(1 + i)^n - 1} = \frac{0.06 * (1 + 0.06)^{15}}{(1 + 0.06)^{15} - 1} = 0.103$$

  i = Real Interest Rate (6%)
  n = Project Life (15 years)

The cost-effectiveness values shown in Table 5.3 are within the acceptable range of previously adopted prohibitory rules, and so the BARCT requirement to reach 11 or 25 ppmv, depending on the type of engine, is considered to be cost-effective. These costs are incurred in the interest of bringing the facility operations up to current control technology standards and complying with state legislation.

<u>Electrification or Engine Replacement</u>

Another method of reducing NOx is to replace an existing IC engine with an electric motor or a new engine designed to emit very low NOx emissions. Although there may be minor increases in power plant emissions to supply the electricity, an electric motor essentially eliminates all on-site NOx emissions associated with the removed engine. Replacing an older, uncontrolled engine with a new engine that has emission controls built into its design can also reduce NOx by a substantial amount. These alternatives typically cost more than retrofitting the existing equipment, but the alternatives may be viable and cost-effective depending on the location of the well site and the associated equipment coupled to the engine or motor.

5.3 Trial Period and Implementation Timeline

Over the course of the last three years, PCEC conducted various trials by installing different combinations of catalysts and air/fuel ratio controllers on a select number of cyclical and non-cyclical engines operating oil well and water injection pumps. These trials were conducted to determine if the BARCT standards are feasible on PCEC's derated engines. Throughout the trials, a portable NOx analyzer was used to determine the effectiveness of the controls and to evaluate if any adjustments needed to be made to the engines over time. Afterwards, PCEC concluded that they were encouraged by the resultant low NOx values from using the emission control equipment, and PCEC decided to pursue this control strategy on their derated engines to comply with the BARCT analysis.

In October 2022, PCEC submitted an Authority to Construct permit application to modify the engines at its facility to comply with the BARCT analysis for Internal Combustion Engines. The equipment modifications included in the permit application are required to be implemented no later than December 31, 2023, in accordance with AB 617. Any device that fails to implement BARCT will need to be shut down on December 31, 2023 and may only be operated once the necessary modifications are complete.

6. REFERENCES

1) California Air Resources Board – *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Stationary Spark-Ignited Internal Combustion Engines,* November 2001.
2) South Coast Air Quality Management District – *Rule 1110.2, Emissions from Gaseous- and Liquid-Fueled Engines,* Amended November 1, 2019.
3) San Joaquin Valley Unified Air Pollution Control District – *Rule 4702, Internal Combustion Engines,* Amended August 19, 2021.
4) Ventura County Air Pollution Control District – *Rule 74.9, Stationary Internal Combustion Engines,* Amended November 8, 2005.
5) Bay Area Air Quality Management District – *Regulation 9, Rule 8, Nitrogen Oxides and Carbon Monoxide from Stationary Internal Combustion Engines,* Amended July 25, 2007.
6) San Diego County Air Pollution Control District – *Rule 69.4.1, Stationary Internal Combustion Engines,* Amended July 8, 2020.
7) Feather River Air Quality Management District – *Rule 3.22, Stationary Internal Combustion Engines,* Amended August 3, 2020.
8) Yolo-Solano Air Quality Management District – *Addendum to Expedited BARCT Schedule for Industrial Facilities Subject to Cap and Trade,* October 14, 2020.
9) Santa Barbara County Air Pollution Control District – *Assembly Bill 617 Best Available Retrofit Control Technology Rule Development Schedule,* Adopted December 20, 2018.
10) U.S. Environmental Protection Agency – *Alternative Control Techniques Document – NOx Emissions from Stationary Reciprocating Internal Combustion Engines (EPA-453/R-93-032)*, July 1993.
11) U.S. Environmental Protection Agency – *Code of Federal Regulations Part 60, Subpart JJJJ – Standards of Performance for Stationary Spark Ignition Internal Combustion Engines*.
12) U.S. Environmental Protection Agency – *Code of Federal Regulations Part 63, Subpart ZZZZ – National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines*.

7. ATTACHMENTS

7.1 Attachment #1. Industry Comments and Responses

ATTACHMENT #1

Industry Comments and Responses

#	Section	Comment	District Response
1)	1.2	Is there a scale for the Y axis? *[In regard to Figure 1.2 – Stoichiometry and the Effect of Air/Fuel Ratio on Pollutants]*	Figure 1.2 does not have a specific scale that addresses all 3 pollutants (NOx, CO, and total hydrocarbons). The Y-axis is used to show the approximate change in emission concentration for each of the pollutants as a 4-stroke natural gas engine operates between stoichiometric and lean-burn conditions.
2)	1.5	Are you saying there are no prime NG engines in SB?	Out of the six AB 617 Industrial Sources, PCEC is the only affected facility with prime natural gas engines. There are other prime natural gas engines within Santa Barbara County, but those engines are not covered by this analysis. The referenced paragraph in the analysis has been restructured to clarify the applicability to the six AB 617 Industrial Sources.
3)	1.6	PCEC owned and operated the field since 2012 - prior operator was BreitBurn Energy.	The text in the analysis has been updated to clarify that: "PCEC (and its predecessor BreitBurn Energy) has been the owner/operator of the field since 2004." Based on the District's records and the operating permits for the source, the change in December 2011 from BreitBurn Energy to PCEC was a name change only.
4)	2.4	This [cyclical definition] should be defined in Section 2.1 in the overview.	Your comment has been noted. No modification was made to the District's analysis.
5)	2.6	PCEC has discussed with the District that after the first round of testing, a percentage of engines are tested every two years - not every engine. It will take 15 days of testing if the world is perfect and nearly $90,000 to complete this testing requirement.	This BARCT analysis incorporates the existing testing and monitoring program prescribed in Rule 333. Specifically, Section I of Rule 333 allows the Control Officer to, on a case-by-case basis, approve a facility's written request to exclude one or more engines from the on-going biennial testing. This provision only applies if the facility has more than 20 engines subject to the source testing requirements. Additional text has been added to Section 2.6 to clarify this provision and the District's Engineering Division will work with PCEC to incorporate the necessary language into the affected permit.
6)	3.0	Do CI engines belong in this table? *[Table 3.1]*	The reference to "CI engines" has been removed from Table 3.1 since the BARCT analysis is primarily focused on rich-burn spark-ignited engines using natural gas or field gas.
7)	4.2	PCEC has a successful program and is in compliance with ZZZZ.	Your comment has been noted.

#	Section	Comment	District Response
8)	5.1	PCEC has not tested for TAC reductions nor have we sourced control equipment to guarantee any toxic emission control efficiency. I am not comfortable making this statement to the board. *Language in the draft analysis – For Reference: "These derated engines do not have any emission controls, but they could be retrofitted with non-selective catalytic control systems and air/fuel ratio controllers to reduce their emissions of criteria pollutants and toxic air contaminants."*	Even though there are no Toxic Air Contaminant (TAC) emission standards or TAC source testing requirements in the BARCT analysis, the District is comfortable in making a general statement that the use of NSCR will reduce toxic air contaminants. There is sufficient EPA, CARB, and catalyst manufacturer information that discuss the VOC and TAC/HAP reduction capabilities of NSCR catalysts. Some of the toxic pollutants controlled include formaldehyde, acrolein, methanol, and acetaldehyde. No modification was made to the District's analysis.
9)	5.1	Should ROC and CO reductions be included in this table? *[Table 5.2 – Estimated Emission Reductions]* Be consistent - either include all three pollutants or only discuss NOx. There is a real inconsistency throughout the document.	For stationary internal combustion engines, the primary pollutant of concern is NOx. NOx emission control strategies can lead to a reduction in ROC and CO emissions [e.g. using an NSCR catalyst], but some control strategies may lead to slight increases in ROC and CO emissions [e.g. combustion modifications]. The purpose of the ROC and CO emission limits in the BARCT analysis is to prevent the NOx control strategies from causing excessive increases in ROC and CO emissions. Since PCEC is anticipating to use NSCR catalysts to comply with the BARCT standards, the District could tailor the evaluation to show the anticipated ROC and CO emission reductions. However, according to guidance provided by CARB, the emission reduction and cost-effectiveness calculations should only be conducted for those pollutants that pertain to the standard or objective to be met. Hence, the District will continue to focus on NOx, the primary pollutant of concern from these engines.
10)	5.2	Did you add the cost for catalyst bed replacement and new O_2 Sensors? The cost of the catalysts should be included. The costs have doubled in the couple of years we have been working on this project.	The annual operation costs listed in "Table 5.3 – Estimated Cost-Effectiveness for BARCT Analysis" initially allocated $2,500 per year for the on-going catalyst and oxygen sensor replacements. This value was based on assumptions used by the South Coast AQMD, such as the catalyst being replaced every 3 years and the oxygen sensor being replaced every quarter. After further review, the estimated cost for these replacements has been increased to $4,000 per year to provide for a more conservative estimate.

#	Section	Comment	District Response
11)	5.3	This is not a realistic time schedule. Even if we receive a permit in the first quarter of 2023, there are still supply chain issues that could interfere with the schedule. PCEC will not accept the shutdown clause, we have worked closely with the APCD throughout this process. Also it is unclear if all testing needs to be complete by 12-31-23, this is a very aggressive and unrealistic schedule. If AB 617 will allow for a longer period to achieve compliance, please make this deadline a minimum of June 2024. This will also help with the staggered source test request.	Assembly Bill 617 requires the implementation of BARCT at the affected industrial sources no later than December 31, 2023.[1] Given the purposes of AB 617, its directive language, and legislative history, the District understands this requirement to mean that the full installation of the BARCT controls must be performed by December 31, 2023.[2] Hence, the engines must be modified to include the NSCR catalysts and air/fuel ratio controllers to operate on or after January 1, 2024, and District staff cannot grant an extension for this requirement. As for the initial source testing of the engines, the District's Engineering Division will work with PCEC to incorporate a reasonable timeline into the affected permit. For the purpose of this analysis, we will not require all engines to be source tested to be considered "implemented."

[1] Codified under California Health and Safety Code §40920.6.
[2] Informational CARB webpage on Expedited BARCT: https://ww2.arb.ca.gov/Permitting-Questions [*accessed January 12, 2023]*