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Socioeconomic Impact Analysis of Proposed Amendments to Rule 5, Regulation 6: Particulate Emissions from Petroleum Refinery Fluidized Catalytic Cracking Units

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APPLIED DEVELOPMENT ECONOMICS

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1. INTRODUCTION

The Bay Area Air Quality Management District (Air District) has developed amendments to Regulation 6: Particulate Matter, Rule 5: Particulate Emissions from Petroleum Refinery Fluidized Catalytic Cracking Units (Rule 6-5). The purpose of these amendments is to address particulate matter from refinery fluidized catalytic cracking units (FCCU), which are some of the largest individual sources of particulate matter emissions in the San Francisco Bay Area. The Bay Area does not currently attain all state and national ambient air quality standards for particulate matter, and further reductions of particulate matter emissions are needed to ensure attainment and maintenance of the standards. Furthermore, exposure to particulate matter has long been understood as a health hazard based on respiratory health effects, and research has linked particulate matter exposure to a wide range of cardiovascular diseases, impacts to cognitive function, and cancer.

Fluidized catalytic cracking units are the largest single source of particulate matter emissions at petroleum refineries. Prior regulation of FCCUs only considered particulate matter that could be captured using filter-based test methods—filterable particulate matter. The evolution in our understanding of particulate formation and measurement methods has shown that this previous approach neglects to include the particulate matter that can form when the emissions from the stack cool upon contact with the atmosphere—condensable particulate matter. In 2010, the United States Environmental Protection Agency completed updates to test methods that can measure total particulate matter (both filterable and condensable particulate matter) emissions from sources such as FCCUs. Application of these updated methods at FCCUs have further indicated that a substantial fraction of the total particulate matter can be missed when using only filter-based test methods. The adoption of Air District Rule 6-5 in 2015 marked the first regulatory step in addressing condensable particulate matter from these fluidized catalytic cracking units in the San Francisco Bay Area. In 2017, the Air District's Clean Air Plan included a control measure to evaluate ongoing progress in reducing these emissions, and to further control particulate matter emissions from fluidized catalytic cracking units. In 2018, the Air District adopted the Expedited Best Available Retrofit Control Technology (BARCT) Implementation Schedule, which identified potential rule development projects to evaluate and implement Best Available Retrofit Control Technology at certain industrial sector facilities pursuant to California Assembly Bill 617 (AB 617). The schedule identified that potentially substantial particulate matter emission reductions could be achieved at these fluidized catalytic cracking units, and further rule amendments should be evaluated and considered. This current rule development effort for amendments to Rule 6-5 follows these previous Air District rulemaking and planning actions to address emissions from these sources.

After this introduction, this report discusses in greater detail proposed amendments to Rule 6-5 (Section Two). After that discussion, the report describes the socioeconomic impact analysis methodology and data sources (Section Three). The report describes population and economic trends in the nine-county San Francisco Bay Area (Section Four), which serves as a backdrop against which the Air District is contemplating the rule. Finally, the socioeconomic impacts stemming from the proposed rule changes are discussed in Section Five. The report is prepared pursuant to Section 40728.5 of the California Health and Safety Code, which requires an assessment of socioeconomic impacts of proposed air quality rules and amendments. The findings in this report can assist Air District staff in understanding the socioeconomic impacts of the proposed requirements, and can assist staff in preparing a refined version of the rule.

2. BACKGROUND AND OVERVIEW OF AMENDMENTS TO RULE 6-5

INTRODUCTION

Proposed amendments to Rule 6-5 would apply to fluidized catalytic cracking units (FCCU) and associated carbon monoxide boilers at Bay Area petroleum refineries. Four of the five petroleum refineries in the San Francisco Bay Area operate fluidized catalytic cracking units. These are Chevron Products Company (BAAQMD Plant #10 in Richmond), PBF Energy Martinez Refinery (BAAQMD Plant #11 in Martinez), Marathon Petroleum Corporation (BAAQMD Plant #14628 in Martinez), and Valero Refining Company (BAAQMD Plant #12626 in Benicia). The Valero refinery is anticipated to be able to comply with the rule amendments without significant additional cost expenditures. The Marathon refinery is not currently in operation. However, if it were to resume operations, it would be subject to the proposed Rule 6-5 amendments.

FCCU PROCESS DESCRIPTION

The proposed amendments to Rule 6-5 establish and modify FCCU emission standards for ammonia slip, sulfur dioxide, and total particulate matter. FCCUs are complex processing units at refineries that convert heavy components of crude oil into lighter distillates, including gasoline and other high-octane products. FCCUs use a fine powdered catalyst that behaves as a fluid when aerated with a vapor. The fluidized catalyst is circulated continuously between a reaction vessel where the catalyst is used to promote the hydrocarbon cracking process and a regenerator where carbonaceous material deposited on the catalyst is burned off.

The heated catalyst vaporizes the crude oil feed and brings the materials up to the desired cracking reaction temperature. As the cracking reaction progresses, the catalyst surface is gradually coated with carbonaceous material (coke), reducing its efficacy. The cracked hydrocarbon vapors are separated from the catalyst particles by cyclones in the reactor, and the hydrocarbon vapors are sent to a distillation column for separation and further processing.

The spent catalyst is steam stripped to remove remaining oil on the catalyst and cycled to the regenerator. The coke deposited on the catalyst is burned off in a controlled combustion process with preheated air, reactivating the spent catalyst. The catalyst is then recycled to be mixed with fresh hydrocarbon feed. Catalyst regenerators may be designed to burn the coke completely to carbon dioxide (CO_2) (full burn) or to only partially burn the coke to a mixture of carbon monoxide (CO) and carbon dioxide (partial burn). Because the flue gas from partial burn regenerators have high levels of carbon monoxide, the flue gas is vented to a carbon monoxide gas boiler where the carbon monoxide is further combusted to carbon dioxide.

The FCCU regenerator is a substantial source of emissions and fluidized catalytic cracking units are the largest single source of particulate matter emissions at petroleum refineries. During the regeneration process, some of the catalyst becomes entrained in the flue gas that exits the fluidized catalytic cracking unit regenerator. In addition to these "catalyst fines", the flue gas also contains other pollutants, including sulfur dioxide (SO_2), oxides of nitrogen (NOx), reactive organic gases (ROG), toxic air contaminants, and other particulate matter (PM) generated in the combustion process. This flue gas is then routed through a train of pollutant abatement devices. In many abatement trains, ammonia (NH_3) is also injected into the flue gas stream to enhance the efficiency of certain types of pollution control equipment. Ammonia that is not fully consumed in the process can also remain in the flue gas stream (also referred to as "ammonia slip") and may be emitted along with other pollutants in the flue gas. These gaseous pollutants can contribute to the formation of condensable particulate matter in the atmosphere. When released from the stack, these condensable components can form various particles, including ammonium nitrates and ammonium sulfates.

EMISSION CONTROL STRATEGIES FOR FCCU PARTICULATE MATTER

Reduction of Ammonia Injection and Ammonia Slip

Ammonia is commonly used as a conditioning agent to alter the resistivity and cohesiveness of particles in the gas stream, which can improve the effectiveness of electrostatic precipitators (ESP) in capturing catalyst fines. Excess ammonia that is not consumed in this process can remain in the FCCU flue gas stream (as ammonia slip) and can lead to the formation of condensable particulate matter. Therefore, reducing ammonia injection and ammonia slip can reduce emissions of condensable particulate matter. Potential strategies for achieving these reductions include:

- the optimization of ammonia injection
- the use of alternative non-ammonia conditioning agents
- and improved removal of particulate matter through electrostatic precipitators or wet gas scrubbing, which may reduce or eliminate the need for ammonia injection.

Some of these control strategies may also be used in combination to effectively reduce emissions of condensable particulate matter. The operation of electrostatic precipitators and wet gas scrubbers are described in more detail below. BAAQMD staff anticipate three of the affected refineries may need to install wet gas scrubbing to meet the proposed Rule 6-5 standards.

Electrostatic Precipitator

An electrostatic precipitator (ESP) is a control device designed to remove particulate matter from an exhaust gas stream by using electrical energy. The main components of the electrostatic precipitator include discharge electrodes, collection plates, and a plate cleaning system. Particulate matter is removed from the gas stream through a series of steps inside the electrostatic precipitator: 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. The removal of particles from the collection plates can be accomplished using different systems. In a dry electrostatic precipitator system, rapping systems are used to vibrate the collection plates and remove the collected particles. In a wet electrostatic precipitator system, particles are removed from the collection plates by rinsing the plates with water.

Ammonia is often injected into flue gas streams to improve the collection efficiency of the electrostatic precipitators, however excess ammonia in the flue gas stream can contribute to condensable particulate matter formation. An electrostatic precipitator system with sufficient collection efficiency and capacity may be able to reduce or eliminate the need for ammonia injection, therefore limiting the amount of potential condensable particulate matter formation. The collection efficiency of an electrostatic precipitator system can be improved by rebuilding the system with additional capacity or by adding additional cells to increase residence time and collection surface area. In addition, advancements in electrostatic precipitator technologies can increase performance of existing systems, especially as these units and components age and degrade. For treatment of high-volume flue gas streams, installations of electrostatic precipitators typically require a large amount of space, although advancements in precipitator design and technology can reduce the size and space needed. Costs of new and expanded electrostatic precipitators can vary based on the specific installation, design, capacity, and other constraints.

Wet Gas Scrubbing

Wet gas scrubbing is a process that is used to remove liquid or solid particles from a gas stream. The process removes these particles by transferring them to a liquid, which is typically water or a reagent solution. In a typical wet gas scrubbing system, the scrubbing liquid is sprayed into the spray tower, and the flue gas stream enters at the bottom of the tower and flows upwards through the scrubbing liquid. As the gas stream passes through the scrubbing liquid, particles from the stream are collected as they impact the liquid droplets. Some wet gas scrubbing systems are also designed to capture gaseous pollutants that can be absorbed into the scrubbing liquid. The scrubbing liquid is then collected by mist eliminators or separators for treatment and discharge, or for regeneration and further use. Costs of new wet gas scrubbing systems can vary based on specific design and site constraints, as well as additional equipment or infrastructure required for operation.

RULE AMENDMENTS

The purpose of the proposed amendments to Rule 6-5 is to further address particulate matter emissions, including condensable particulate matter emissions, from fluidized catalytic cracking units and associated carbon monoxide boilers. The proposed amendments include new and modified limits on ammonia and sulfur dioxide, as well as a direct limit on total PM_{10}, which includes both filterable and condensable particulate matter. The proposed amendments also include a new limit on total PM_{10} emissions, which include both filterable and condensable particulate matter. This direct limit on total PM_{10} would ensure that both filterable and condensable particulate matter emissions are adequately controlled, and that abatement systems are optimized to reduce overall total particulate matter emissions. The proposed amendments also include modifications to existing rule language to clarify provisions and improve monitoring requirements.

3. METHODOLOGY

Applied Development Economics (ADE) began this analysis by preparing a statistical description of the industry groups of which the affected sources are a part, analyzing data on the number of establishments, jobs, and payroll. We also estimated sales generated by impacted industries, as well as net profits for each affected industry.

This report relies heavily on the most current data available from a variety of sources, including Corporate reports filed with the Securities Exchange Commission (SEC), data from the US Census County Business Patterns and Census of Manufactures, the US Internal Revenue Service, and reports published by the California Energy Commission (CEC) that track gasoline prices and cost components as well as refinery production levels. ADE also utilized employment data from the California Employment Development Department – Labor Market Information Division (EDD LMID).

With the above information, ADE was able to estimate net after tax profit ratios for sources affected by the proposed rule. ADE calculated ratios of profit per dollar of revenue for affected industries. The result of the socioeconomic analysis shows what proportion of profits the compliance costs represent. Based on assumed thresholds of significance, ADE discusses in the report whether the affected sources are likely to reduce jobs as a means of recouping the cost of rule compliance or as a result of reducing business operations. In some instances, particularly where consumers are the ultimately end-users of goods and services provided by the affected sources, we also analyzed whether costs could be passed to households in the region.

When analyzing the socioeconomic impacts of proposed new rules and amendments, ADE attempts to work closely within the parameters of accepted methodologies discussed in a 1995 California Air Resources Board (ARB) report called "Development of a Methodology to Assess the Economic Impact Required by SB513/AB969" (by Peter Berck, PhD, UC Berkeley Department of Agricultural and Resources Economics, Contract No. 93-314, August, 1995). The author of this report reviewed a methodology to assess the impact that California Environmental Protection Agency proposed regulations would have on the ability of California businesses to compete. The ARB has incorporated the methodologies described in this report in its own assessment of socioeconomic impacts of rules generated by the ARB. One methodology relates to determining a level above or below which a rule and its associated costs is deemed to have significant impacts. When analyzing the degree to which its rules are significant or insignificant, the ARB employs a threshold of significance that ADE follows. Berck reviewed the threshold in his analysis and wrote, "The Air Resources Board's (ARB) use of a 10 percent change in [Return on Equity] ROE (i.e. a change in ROE from 10 percent to a ROE of 9 percent) as a threshold for a finding of no significant, adverse impact on either competitiveness or jobs seems reasonable or even conservative."

4. ECONOMIC AND DEMOGRAPHIC TRENDS

This section of the report discusses the larger context within which the Air District is contemplating the proposed Rule 6-5 amendments. This section begins with a broad overview of demographic and economic trends, with discussion then narrowing to industries and sources affected by the proposed rule changes.

REGIONAL POPULATION TRENDS

Table 1 tracks population growth in the nine-county San Francisco Bay Area between 2008 and 2019, including data for the year 2015. Between 2008 and 2015, the region grew by 0.6 per year, compared to 0.3 percent for the state as a whole. Since 2015, the Bay Area region has had the same growth rate as the state. Overall, there are 7,790,537 people in the region. At 1,961,969, Santa Clara County has the most people, while Napa has the least, at 139,088. Contra Costa grew the fastest between 2008 and 2019, at 1.2 percent a year, while Sonoma and Napa both grew the least, at 0.2 percent per year.

Table 1: Population Trends: Bay Area Counties, Region, and California, 2008-2019

Jurisdiction	2008	2015	2019	08-15 CAGR	15-19 CAGR	08-19 CAGR
California	38,292,687	39,131,307	39,782,870	0.3%	0.4%	0.5%
SF Bay Area	7,375,678	7,671,279	7,790,537	0.6%	0.4%	0.8%
Alameda	1,556,657	1,632,599	1,670,834	0.7%	0.6%	1.0%
Contra Costa	1,060,435	1,128,405	1,153,561	0.9%	0.6%	1.2%
Marin	258,618	263,327	260,831	0.3%	-0.2%	0.1%
Napa	137,571	141,607	139,088	0.4%	-0.4%	0.2%
San Francisco	845,559	872,723	897,806	0.5%	0.7%	0.9%
San Mateo	745,858	767,921	773,244	0.4%	0.2%	0.5%
Santa Clara	1,857,621	1,931,565	1,961,969	0.6%	0.4%	0.8%
Solano	426,729	430,530	440,224	0.1%	0.6%	0.4%
Sonoma	486,630	502,602	492,980	0.5%	-0.5%	0.2%

Source: ADE, Inc., based on California Dept. of Finance E-5 Reports (note: CAGR = compound annual growth rate)

REGIONAL ECONOMIC TRENDS

Data in Table 2 describe the larger economic context within which officials are contemplating the proposed Rule 6-5 amendments. Businesses in the region employ almost 4.1 million workers. The number of jobs in the region grew annually by 1.3 percent between 2008 and 2015, the period that included the Great Recession. This was almost twice the rate of job growth statewide during this period. Since 2015, the region's job growth has accelerated to 2.4 percent per year, compared to 2 percent for the state.

The economic sectors in Table 2 are sorted by the share of total employment in 2019. The top-five sectors in the Bay Area in terms of total number of workers are Professional and Business Services (NAICS 54-55) (699,300 workers) which includes many technology businesses, Educational and Health Services (NAICS 61-62) (615,127 workers), Government (483,343), which also includes public sector health and education jobs, Leisure and Hospitality (NAICS 71-72) (444,809), and Manufacturing (NAICS 31-33), which includes the petroleum refineries subject to Rule 6-5.

Table 2: San Francisco Bay Area Employment Trends By Sector: 2008 - 2019

Industry Sector		2008	2015	2019	2019	2019 CA	SFBA CAGR* 08-15	SFBA CAGR 15-19	CA CAGR 08-15	CA CAGR 15-19
Total, All Industries		**3,377,300**	**3,692,400**	**4,066,566**	**100.0%**	**100.0%**	**1.3%**	**2.4%**	**0.7%**	**2.0%**
54-55	Professional & Business Services	593,200	699,300	779,697	19.2%	15.2%	2.4%	2.8%	1.5%	2.2%
61-62	Educational & Health Services	455,600	550,500	615,127	15.1%	15.7%	2.7%	2.8%	2.7%	3.3%
90	Government	478,400	466,200	483,343	11.9%	14.6%	-0.4%	0.9%	-0.3%	1.4%
71-72	Leisure & Hospitality	336,300	405,700	444,809	10.9%	11.4%	2.7%	2.3%	2.2%	2.7%
31-33	Manufacturing	342,900	334,300	364,122	9.0%	7.4%	-0.4%	2.2%	-1.3%	0.4%
44-45	Retail Trade	333,500	341,400	341,627	8.4%	9.3%	0.3%	0.0%	0.2%	0.0%
51	Information	118,100	166,000	233,607	5.7%	3.2%	5.0%	8.9%	0.4%	3.6%
21,23	Mining, Logging, and Construction	179,600	174,300	209,758	5.2%	5.1%	-0.4%	4.7%	-1.0%	4.5%
52-53	Financial Activities	188,100	187,400	200,793	4.9%	4.7%	-0.1%	1.7%	-0.7%	1.2%
81	Other Services	112,900	122,900	130,946	3.2%	3.2%	1.2%	1.6%	0.9%	1.5%
22,48	Transportation, Warehousing & Utilities	93,300	99,700	121,850	3.0%	3.9%	1.0%	5.1%	1.4%	5.9%
42	Wholesale Trade	125,600	125,200	121,205	3.0%	3.9%	0.0%	-0.8%	0.0%	0.1%
11	Farm	20,000	19,900	20,280	0.5%	2.4%	-0.1%	0.5%	1.2%	0.1%

*Source: Applied Development Economics, based on State of California, Employment Development Department Labor Market Information Division, "Quarterly Census of Employment and Wages" *Note: CAGR = compound annual growth rate; **Note: Public sector education and public sector health included in government.*

The fastest job growth rates since 2015 have been in Information Services, which includes many internet businesses, followed by Transportation, Warehousing and Utilities, Construction, Professional and Business Services and Health Care.

The table demonstrates the advanced nature of the regional economy, as one quarter of all workers are in the combined Professional, Business and Information Services, compared 18.4 percent for the state. Interestingly, at 2.2 percent per year between 2015 and 2019, manufacturing employment growth in the Bay Area five times faster than statewide manufacturing growth rates (0.4 percent), underscoring the diversity of the regional economy.

TRENDS FOR INDUSTRIES SUBJECT TO PROPOSED RULE 6-5 AMENDMENTS

Proposed amendments to Rule 6-5 affect petroleum refineries (NAICS 324110) of which there are five in the Bay Area. The most recent employment data available for the refineries indicates there were 3,536 workers directly employed at the facilities in 2018 (Table 3). Refinery jobs have been growing slowly since 2014, but have not recovered to the 2009 level of nearly 4,000 jobs at the beginning of the Great Recession.

Table 3: Employment Trends for Large Refineries in the San Francisco Bay Area: 2009-2018

YEAR	JOBS
2009	3,976
2010	3,622
2011	3,620
2012	3,542
2013	3,726
2014	3,269
2015	3,440
2016	3,464
2017	3,503
2018	3,536

Source: Applied Development Economics, based on US Census County Business Patterns 2009-2018.

With the current recession starting in 2020 due to the Covid-19 pandemic, it may be expected that refinery production levels will be affected, with associated financial impacts and job reductions at the facilities. Shelter in place orders that have reduced commute and shopping travel have dramatically reduced demand for gasoline. ADE researched refinery operations during past recessions to see how this industry has been affected. In the past 20 years there have been two major recessions, in 2001 and 2009.

According to the National Bureau of Economic Research (NBER), the 2001 recession began in March, 2001 and was short-lived, reaching its lowest point in November 2001. On a national level, between 2000 and 2001, the number of refineries declined by 17.5%, from 565 to 466. The number of refineries with positive net income declined even more, by 69.8%, from 538 to 162. By 2002, the number of refineries began to climb back to pre-2001 totals, reaching 524 refineries. However, in 2002, net income dropped to 4.2 percent of sales, down from 8.1 percent the prior year (Table 4).

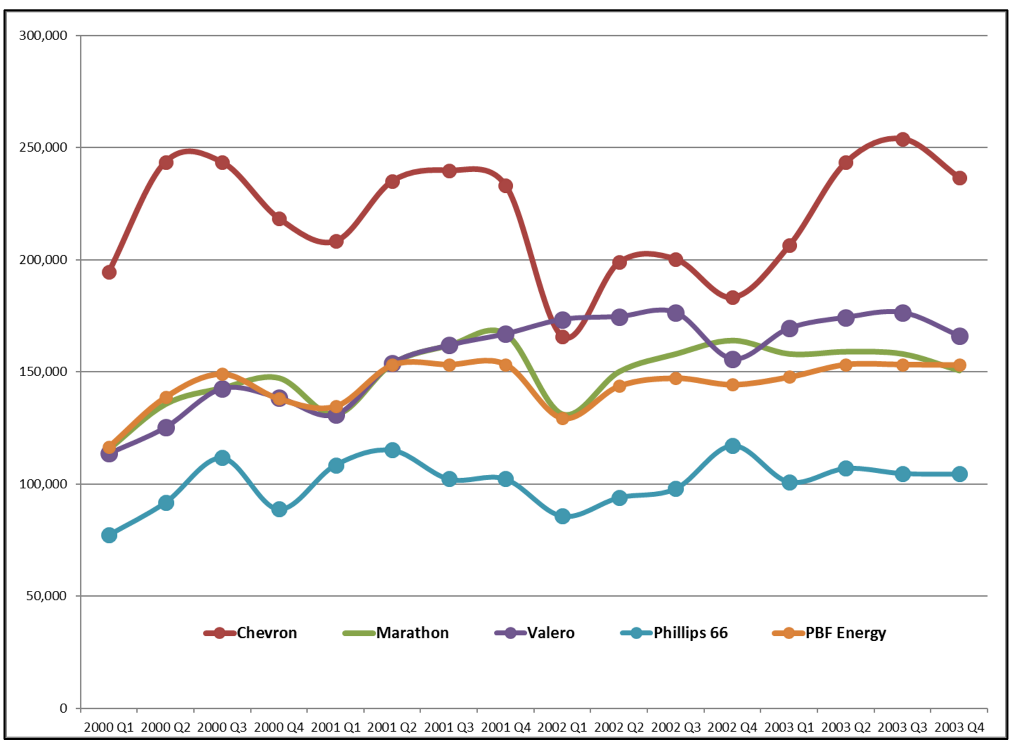
In the Bay Area, the five major refineries continued to operate, but the levels of production dipped in the first quarter of 2002 for all the refineries except Valero (Figure 1). Chevron and Valero both reduced production at the end of 2002, but by 2003 all of the refineries appear to have resumed normal production levels.

Table 4: Financial Data for US Refineries, 2000-2015

Year	Number of Returns		Total Receipts		Net Income ($000)	Net Income as % Of Receipts for All Returns
	Total	With Net Income	All Returns ($000)	Returns with Net Income ($000)		
2000	565	538	$708,474,441		$62,708,199	8.9%
2001	466	162	$633,789,676	$605,081,480	$51,230,377	8.1%
2002	524	210	$669,958,738	$547,826,711	$28,399,114	4.2%
2003	321	33	$878,169,484	$762,432,630	$59,495,577	6.8%
2004	715	43	$1,233,451,434	$1,208,031,229	$101,033,255	8.2%
2005	1067	408	$1,586,371,810	$1,582,603,337	$136,076,434	8.6%
2006	928	171	$1,772,672,777	$1,760,205,082	$141,961,956	8.0%
2007	661	160	$1,885,776,974	$1,858,951,329	$139,936,842	7.4%
2008	569	150	$2,317,367,592	$2,272,108,356	$145,966,007	6.3%
2009	241	159	$1,467,910,148	$1,010,993,626	$103,847,446	7.1%
2010	246	169	$1,884,313,300	$1,471,175,784	$133,408,355	7.1%
2011	202	162	$2,405,497,424	$2,323,700,453	$128,065,951	5.3%
2012	217	159	$2,396,760,591	$2,113,571,335	$152,741,615	6.4%
2013	207	67	$2,202,152,058	$1,894,102,850	$123,956,446	5.6%
2014	203	161	$2,085,986,718	$1,781,343,053	$103,077,549	4.9%
2015	143	116	$1,329,920,999	NA	$67,026,843	5.0%

Source: Internal Revenue Service

Figure 1: Bay Area Refinery Production Levels, 2001 Recession

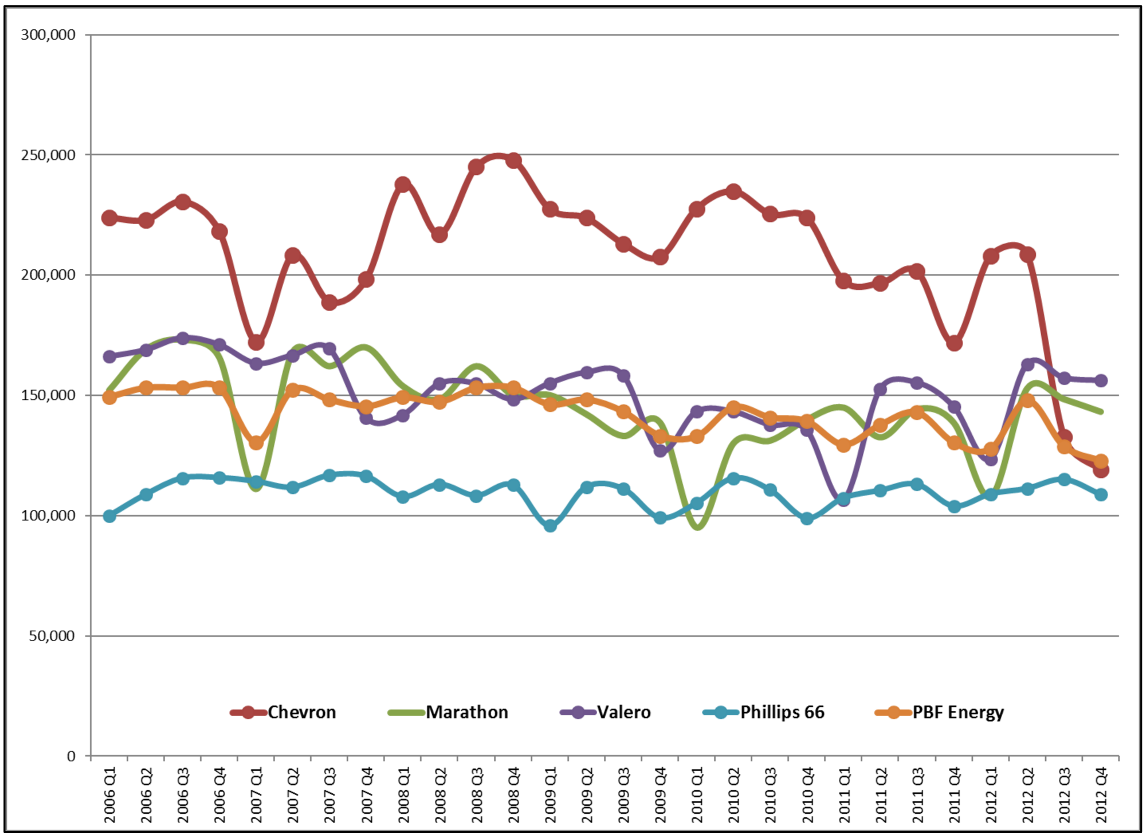


Source: ADE, based on data from corporate reports. Note, the names shown for the refineries reflect current ownership, not necessarily the ownership in 2000-2003.

According to the NBER, the 2008 Great Recession began officially in December 2007, and extended downward to its lowest point in in June 2009. But the actual recovery after June 2009 was "flat", in contrast to the earlier 2001 recession. The full effect of the recession that began in December 2007 became evident in 2009, when there were 241 US refineries as compared to 569 in 2008, for a loss of 57.6% (Table 4). Average net income per refinery went from $973 million to $653 million for a 32.8% decline, although net income as a percent of sales did not decline as much as in 2002. In 2008 it was 6.3 percent, down from 8.0 percent in 2006. However, this figure has never again reached 8.0 percent on a national level. Also, in the years immediately prior to and including 2008, there were 928 US refineries in 2006 and 661 in 2007. Since 2009, there have consistently been less than 300.

At the Bay Area refineries, production levels had dropped at the beginning of 2007 and did not really show the effects of the recession until late 2009, with additional dips in 2012 (Figure 2).

Figure 2: Production Levels at Bay Area Refineries, 2006-2012



Source: ADE, based on data from corporate reports. Note, the names shown for the refineries reflect current ownership, not necessarily the ownership in 2006-2012.

In 2017, the US Bureau of the Census counted 18 refineries in California. In aggregate, the net income for these facilities was 4.1 percent of sales (Table 5), slightly lower than the national figure of 5.0 percent in 2015.

Table 5: Operating Characteristics for California Refineries, 2017

OPERATING PARAMETER	2017 VALUE
Number of firms	11
Number of establishments	18
Sales, value of shipments, or revenue ($1,000)	$56,216,881
Annual payroll ($1,000)	$1,174,919
Total fringe benefits ($1,000)	$398,409
Total cost of supplies and/or materials ($1,000)	$46,126,161
Total capital expenditures for buildings, structures, machinery, and equipment (new and used) ($1,000)	$1,709,789
Total depreciation during year ($1,000)	$1,423,320
Total rental payments or lease payments ($1,000)	$118,057
Total other operating expenses ($1,000)	$2,950,272
Net operating income	$2,315,954
Percent of sales	4.1%

Source: ADE, Inc. based on 2017 Economic Census

Table 6 below identifies the businesses in the Bay Area that are full-scale refineries. The California Energy Commission (CEC) tracks each refinery's throughput capacity. Of the five operating refineries in the region, Chevron is the largest, with the capacity to refine 245,271 42-gallon barrels of crude oil per day (BPD). At 120,200, Phillips 66 has the lowest throughput capacity. The five affected sources employ approximately 3,500 workers, who make an average wage of $127,000, not including benefits, based on the data in Table 5.

Table 6: Bay Area Refineries (California Energy Commission) and Crude Oil Capacity

REFINERY	BARRELS PER DAY
Chevron U.S.A. Inc., Richmond Refinery	245,271
Marathon Petroleum Corp., Golden Eagle (Avon/Rodeo) Refinery	161,500
PBF Energy, Martinez Refinery	156,400
Valero Benicia Refinery	145,000
Phillips 66, Rodeo San Francisco Refinery	120,200

Source: Applied Development Economics, Inc., based on California Energy Commission

The five affected sources' combined throughput capacity is approximately 828,371 42-gallon barrels per day (BPD). Based on average utilization rates for refineries as provided in the US Census of Manufactures, we estimate the actual effective throughput of the refineries is about 740,150 BPD.

Refined products exceeded the crude oil inputs by about 3.5 percent in 2019, resulting in an estimate of 766,055 BPD of refined products produced by the Bay Area refineries.[1]

Three of the refineries, Chevron, Marathon and PBF Energy, would potentially see increased costs from implementation of proposed amendments to Rule 6-5. For these refineries, we have estimated annual sales (revenues) and profit levels, for use in analysis of the economic impacts of the rule in the next section of the report (Table 7). The Marathon refinery is not currently in operation. However, if it were to resume operations, it would be subject to the Rule 6-5 amendments. We have analyzed the impact of the rule amendments on that refinery using the 2019 level of operations.

The effective BPD for each of the refineries shown in Table 7 is based on the factors described above. The revenue information is based on an estimate of the wholesale value of gasoline at $121.04, based on 2019 data provided by the CEC.[2] The net profits estimates are based on data from corporate reports for each of the petroleum companies, described further below. As discussed above, profit ratios for refineries have been declining since the Great Recession. The analysis described below suggests that for the Bay Area refineries, profit levels slipped below 3 percent by 2019. It may be expected that profits will drop further due to the Covid-19 pandemic. It is difficult to predict the time frame for recovery from this recession, as there remains much uncertainty on the ability of consumers and businesses to resume previous levels of economic activity given the significant loss of income. However, the requirements of the proposed amendments to Rule 6-5 would not take effect until approximately 2026. For purposes of this analysis, we use the 2019 financial performance of the refineries as a benchmark for the effects of the compliance costs in 2026.

Chevron Richmond. In its 2019 annual report, Chevron reports $1.559 billion in earnings from its US downstream refining operations. This was down from $2.1 billion in 2018, which Chevron ascribes to lower margins on sales for refined products, but also was affected by a higher depreciation expense of $100 million following first production at the new hydrogen plant at the Richmond refinery. Chevron reported sales of 1.250 (MBPD) of gasoline and other refined products. We estimate, then, that Chevron earned $1,247 per barrel per day (BPD) of refined product. This amount is applied to the output estimate in Table 7 of 226,820 BPD, resulting in an estimate of the net income from the Richmond refinery of $282.8 million. This is down from a 2017 estimate of $332.6 million, which was 4.1 percent of sales for that year. The current estimate is 2.8 percent of sales.

PBF Energy Martinez. PBF completed the purchase of this refinery from Shell in February 2020, so there is no 2019 operating or financial data for the refinery under PBF ownership. Consequently, we have reviewed the Shell annual report for 2019 to estimate the operating performance of the Martinez refinery.

Shell reported downstream refinery net earnings of $6.7 billion for all its refining operations, and indicates that 19 percent of its refined products sales occurred from US operations, so we have

[1] California Energy Commission, Weekly Fuels Watch, 2019.

[2] California Energy Commission, Estimated 2019 Gasoline Price Breakdown and Margins Details.

prorated net earnings to $1.27 billion for US refineries. Shell reports that total US refining capacity was 1,117,000 barrels per day (BPD), which yields a return of $1,136 per BPD capacity, slightly below the comparable figure for Chevron.

Based on these factors, we estimate the net income from the Martinez refinery was $177.7 million, which is also lower than the 2017 estimate of $212.1 million for that facility. The 2019 net income represents 2.8 percent of estimated sales revenue.

The Martinez Refinery Company has indicated in written comments that the refinery and its parent company, PBF Energy, have experienced a significant downturn in demand in 2020 as a result of the Covid-19 pandemic, with substantial economic dislocations and revenue losses. We expect this is true for much of the refining industry. However, the implementation costs associated with amendments to Rule 6-5 are not scheduled to occur for several years, at which time the economy is projected to recover to near pre-pandemic levels. The present socioeconomic analysis, therefore, is based on financial indicators from the refinery in 2019.

Marathon Martinez. Marathon does not report net income per barrel in the same way as Chevron and Shell, but its 2019 Annual Report indicates that for all its refineries, sales revenue totaled $106,742 million and income from operations was $2,367 million. The net income ratio from these figures is 2.2 percent, which has been applied to the sales estimate in Table 7 to derive the net income figure for that refinery.

Table 7: Estimated Revenues and Net Profits for Refineries Affected by Rule 6-5 Amendments

	CHEVRON	MARATHON	PBF ENERGY
Refined Barrels Per Day	226,820	149,350	144,600
Est. Revenues	$10.0 billion	$6.6 billion	$6.4 billion
Est. Net Profits	$282.8 million	$146.5 million	$177.7 million

Source: ADE, Inc.

5. SOCIOECONOMIC IMPACT ANALYSIS OF PROPOSED AMENDMENTS TO RULE 6-5

This section of the report analyzes socioeconomic impacts stemming from proposed amendments to Rule 6-5. Air District staff identified two potential control scenarios in developing amendments to Rule 6-5: the Proposed Amendments and a Less Stringent Control Option. Estimated compliance costs associated with each of these control scenarios are described below.

Proposed Amendments to Rule 6-5 would impact FCCUs at the Chevron Richmond, Marathon Martinez, and PBF Martinez refineries. Staff anticipates that each of these refineries would be required to install a wet gas scrubbing (WGS) system to control emissions from their FCCUs. Estimated capital costs for installation and total annualized costs (including amortized capital costs [20-year lifetime at 6% interest], tax, insurance, general and administrative, and operating and maintenance costs) for the Proposed Amendments are shown in Table 8.

Table 8: Estimated Costs for Proposed Amendments to Rule 6-5 ($millions)

FACILITY	CAPITAL COSTS	TOTAL ANNUALIZED COSTS
Chevron Products Richmond	$241	$39
Marathon Martinez Refinery	$235	$38
PBF Martinez Refinery	$255	$40
Valero Benicia Refinery	–	–

Source: BAAQMD

The Less Stringent Control Option would impact FCCUs at the Chevron Richmond and PBF Martinez refineries. Staff anticipates that Chevron Richmond would be required to add additional electrostatic precipitator (ESP) capacity to the existing system. Staff anticipates that PBF would be required to add additional ESP capacity, and would also be required to improve existing systems to reduce SO_2 emissions. Staff anticipates this would include improvements to the current hydrotreater for FCCU feed, as well as improved SO_2-reducing additive operations using newer catalyst additive technologies. Estimated capital costs for installation and total annualized costs (including amortized capital costs [20-year lifetime at 6% interest], tax, insurance, general and administrative, and operating and maintenance costs) for the Less Stringent Control Option are shown in Table 9.

Table 9: Estimated Costs for Less Stringent Control Option ($millions)

Facility	Capital Costs	Total Annualized Costs
Chevron Products Richmond	$30	$4.4
Marathon Martinez Refinery	–	–
PBF Martinez Refinery	$80	$14
Valero Benicia Refinery	–	–

Source: BAAQMD

The methodology section above explains that compliance costs that exceed ten percent of return on equity have the potential to create significant adverse socioeconomic impacts on the affected facilities. The cost for the Less Stringent Control Option fall below this threshold, at 1.6 percent of net income for the Chevron refinery and 8.1 percent of the PBF Energy refinery, with no impact to the Marathon facility. However, the cost for the Proposed Amendments exceeds the threshold for all three refineries, reaching 13.7 percent of net income at Chevron, 25.8 percent for Marathon and 22.3 percent for PBF Energy (Table 10).[3]

Table 10: Impact of Rule 6-5 Amendments Annual Compliance Costs on Refinery Net Income

Refinery	Rule 6-5 Annual Cost Scenarios ($millions)		Annual Net Income ($millions)	Rule 6-5 Costs as a Percent of Net Income	
	Less Stringent Control Option	Proposed Amendments		Less Stringent Control Option	Proposed Amendments
Chevron U.S.A. Inc., Richmond	$4.4	$38.8	$282.8	1.6%	13.7%
Marathon, Golden Eagle (Avon/Rodeo)	–	$37.8	$146.5	0.0%	25.8%
PBF Energy, Martinez	$14.4	$39.6	$177.7	8.1%	22.3%

Source: ADE Inc.

Under the Proposed Amendments, the refineries would be expected to attempt to reduce other costs or increase revenues to restore the cost impact below ten percent of net income. The annual amounts necessary to achieve this result range from $10.5 million per year for Chevron to $23.1 million per year for Marathon.

Chevron U.S.A. Inc., Richmond	$10.5 million
Marathon, Golden Eagle (Avon/Rodeo)	$23.1 million
PBF Energy, Martinez	$21.8 million

There are several ways the companies could consider making these adjustments, although it is not clear if any are feasible at these plants. If the companies reduced labor costs in these amounts, it

[3] The portion of the annualized costs that relate to capital expenditures could be depreciated to reduce corporate taxes, which would reduce the impact of those expenditures by about 20 percent based on the average corporate tax rate.

would be equivalent to reducing employment by 62 jobs at Chevron, 136 jobs at Marathon and 128 jobs at PBF Energy. This may be feasible at Chevron, but such cuts would amount to an estimated 19-20 percent labor reduction at Marathon and PBF Energy. It is not clear whether the plants could operate at capacity with this level of staff reductions.

On the revenue side, the highest cost impact, which would occur at the PBF Energy refinery, would amount to 0.62 percent of estimated annual revenue at the plant (about six tenths of one percent or production over 2.25 days). Translated to the wholesale price for gasoline, this equals about $0.75 per barrel or $0.02 per gallon. While individual refineries are limited in their ability to increase prices unilaterally, particularly during a period of falling demand, it seems more likely the costs of the Proposed Amendments would result in an increase in gas prices rather than a significant loss of refinery jobs. The price increases required to reduce the significance of the emission reduction costs are well within the level of gas price fluctuations that normally occur due to changes in demand and supply factors annually.

Therefore, while the costs for the Proposed Amendments are potentially significant for the affected facilities, it is likely they can be mitigated to less than significant levels. The increase in gasoline prices would have multiplier effects in the regional economy as consumers shift spending from other sectors to increased transportation costs. However, it should be noted that the cost to purchase and install the required control technologies would translate to added jobs and income in the Bay Area region, offsetting much if not all of the impact of the increased gas prices on the regional economy.

Small Business Disproportionate Impacts

According to the State of California, among other things, small businesses generate annual sales of less than $10 million.[4] Of the eight sources affected by the proposed draft rule, none are small businesses. As a result, small businesses are not disproportionately impacted by proposed amendments to Rule 6-5.

[4] http://www.leginfo.ca.gov/cgi-bin/displaycode?section=gov&group=14001-15000&file=14835-14843