Recommendations to CalGEM for Assessing the Economic Value of Social Benefits from a 2,500' Buffer Zone Between Oil & Gas Extraction Activities and Nearby Communities

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Introduction

The purpose of this memo is to recommend guidelines to CalGEM for evaluating the economic value of the social benefits and costs to people and the environment in requiring a 2,500 foot setback for oil and gas drilling (OGD) activities. The 2,500' setback distance should be considered a minimum required setback. The extensive technical literature, which we reference below, analyzes health benefits to populations when they live much farther away than 2,500', such as 1km to 5km, but 2,500' is a minimal setback in much of the literature. Economic analyses of the benefits and costs of setbacks should follow the technical literature and consider setbacks beyond 2,500' also.

The social benefits and costs derive primarily from reducing the negative impacts of OGD pollution of soil, water, and air on the well-being of nearby communities. The impacts include a long list of health conditions that are known to result from hazardous exposures in the vulnerable populations living nearby. The benefits and costs to the OGD industry of implementing a setback are more limited under the assumption that the proposed setback will not impact total production of oil and gas.

The comment letter submitted by Voices in Solidarity against Oil in Neighborhoods (VISIÓN) on November 30, 2020 lays out an inclusive approach to assessing the health and safety consequences to the communities living near oil and gas extraction activities. This memo addresses how CalGEM might analyze the economic value of the net social benefits from reducing the pollution suffered by nearby communities. In doing so, this memo provides detailed recommendations on one part of the broader holistic evaluation that CalGEM must use in deciding the setback rule.

This memo consists of two parts. The first part documents factors that CalGEM should take into account when evaluating the economic benefits and costs of the forthcoming proposed rule. These include factors like the adverse health impacts of pollution from OGD, the hazards causing them and their sources, and the way they manifest into social and economic costs. It also describes populations that are particularly vulnerable to pollution and its effects as well as geographic factors that impact outcomes.

The second part of this memo documents the direct and indirect economic benefits of the proposed rule. Here, the memo discusses the methods and data that should be leveraged to analyze economic benefits of reducing exposure to OGD pollution through setbacks. This includes the health benefits, impacts on worker productivity, opportunity costs of OGD activity within the proposed setback, and the fact that impacted communities are paying the external costs of OGD.

Summary of Factors that CalGEM Should Consider

Adverse Health Impacts

A recent review by Johnston *et al* (2018) identified *only* the following health impacts from exposure to oil extraction: cancer, liver damage, immunodeficiency, and neurological symptoms[1]. However, the adverse health impacts from the soil, air and water pollution were not included because of limited knowledge about exposure. Below we include a more comprehensive list of the health outcomes that are likely associated with this air, soil and air pollution. These range from premature mortality, acute hospitalizations, and increased emergency room and ambulatory care visits; poor birth outcomes, to absenteeism and low productivity at work and school to increased need for chronic care and reduction in life expectancy[2] [3].

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A single drill site typically operates for decades, and the extraction produces emissions of multiple health-hazardous air pollutants, including benzene, toluene, ethylbenzene, xylene, formaldehyde, hydrogen sulfide, and methylene chloride. Many of these compounds are known to be toxic to human health, carcinogenic, cause respiratory harm, or are endocrine disrupting chemicals and can cause long-term developmental or reproductive harm—a consideration for health across generations[4] [5] [6] [7]. These chemicals can migrate off-site due to fugitive emissions, spills, leaks, or accidents.

Scientific studies on upstream oil and gas extraction from many parts of the US and globally provide a substantive base of evidence documenting health impacts. In California, two recent studies demonstrate significant increases in adverse birth outcomes for pregnant women living within 1 km and 10 km of wells[8] [9]. Despite different extraction procedures, geology and varying local demographics, scientific studies have consistently demonstrated significant associations with adverse birth outcomes in

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Pennsylvania[10 11 12], Colorado[13 14], Texas[15], and Oklahoma[16]. Adverse perinatal effects are associated with maternal proximity of ½ mile to 3 miles from drill activity.

Residents near petroleum extraction sites report symptoms of throat and nasal irritation, eye burning, sinus problems, headaches, skin problems, severe fatigue, loss of smell, cough, nosebleeds, and psychological stress[17 18 19 20 21]. Among adults, risk factors for cardiovascular disease rise with the intensity of nearby oil and gas drilling [22]. These

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symptoms increased in incidence among individuals living near oil and gas facilities compared to those living farther away. Neurological symptoms, kidney damage and thyroid problems also increase among those living in oil extraction regions compared to those living farther away, while stress, including social and economic stress, can make these health conditions worse[23].

Cancer mortality is higher in communities exposed to oil extraction [24] [25] [26] [27]. For example, in Colorado, children with leukemia were 4.6 times more likely to live in an area with dense petroleum extraction[28].

Toxic emissions leak into the air surrounding oil and gas production especially during the production phase. With the lengthy operation timeframes, episodic peak emission events, and the largest number of hazardous air pollutants from the various equipment and operations, this period has the potential to emit the highest concentrations of hazardous air pollutant over the longest period of time[29]. The truck traffic to and from the drilling site and the operation of diesel equipment releases toxic air pollutants compromising air quality[30] [31]. Exposure to these air pollutants have been shown to be

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higher near drilling sites[32] [33] [34] [35] including in Los Angeles[36] [37]. Adverse human health impacts result from exposure to these chemicals[38]. Acute inhalation of petroleum hydrocarbons increases the incidence of eye irritation and migraine headaches[39] [40] [41] as well as asthma symptoms[42] [43] [44]. The high decibels of noise around drilling operations is an important co-exposure[45] [46] [47].

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Animals living in oil producing regions accumulate toxins in various organs, especially toxic metals, that lead to kidney damage [48] [49]. Elevated levels of toxic metals and petroleum hydrocarbons have been measured in soil and water near oil extraction sites[50] in Texas[51], China[52] [53] [54], Nigeria[55], and Iraq[56].

Hydrogen sulfide is an odoriferous gas associated with oil drilling. Most human organ systems are susceptible to the toxic effects of H2S, especially the central nervous system, the respiratory system, the cardiovascular system, the gastrointestinal system, and mucus membranes[57]. At ambient levels, odorant chemicals may irritate the eyes, nose and throat and induce symptoms such as nausea, vomiting, headaches, stress, negative mood, and stinging sensations[58] [59]. Odors that are perceived as unpleasant, embarrassing, or sickening may interfere with mood, beneficial land use, and social activities. Chronic exposure to elevated ambient concentrations contribute to harm to

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the respiratory system in adults and children and increase cough, headaches and wheezing[60 61].

Buffers or setbacks help to limit exposures to harmful contaminants that adversely impact human health[62 63 64 65]. From the public health perspective, given the overwhelming weight of evidence of adverse health effects from oil and gas development, it is essential to reduce exposures to these harmful pollutants in communities especially in homes, schools, and workplaces.

Hazards Contributing to Adverse Health Impacts

CalGEM's assessment of the proposed rule's health impacts should capture the effects of the following air pollutants: PM2.5, PM10, NOX, SO2, ozone, volatile organic compounds (VOCs, a broad category including benzenes, toluenes, hydrogen sulfide, poly aromatic hydrocarbons, and related chemicals), and other compounds used in fracking for which not much is known about toxicity. The emissions can come from engines, outgassing, flares, leaks, or proppants. Pollution of the soil and water are also essential to consider, as are psychological stressors such as light and noise.

Vulnerable Populations

Some population groups are especially vulnerable to these hazards and have increased risk of harm from exposure. These groups include young children and the elderly, pregnant women, poor and disadvantaged communities that often suffer food insecurity and inadequate health care, Black and Latinx community members, and those with pre-existing health conditions such as diabetes, lung disease, heart disease, and asthma. To ensure limited exposure, OGD should have at least a 2,500' setback from places where these vulnerable populations congregate such as schools, day care, senior and health care facilities, and residences.

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Sources of Exposure to Hazards

People living and working nearby OGD can be exposed to the above-mentioned hazards through air, water, and the environment, and the workers involved with OGD have occupational exposure.

- Toxic air pollution results from aerosolizing of the polyaromatic hydocarbons, fine and ultrafine particulate matter, and other chemicals from the wells themselves and from the engines in the vehicles and in the wells. The first few months of preparing a new well result in especially high levels of toxins and pollutants in the air from the traffic and engines required for initiating production. Then, over the relatively long periods of production, chemicals leak consistently in high cumulative volume. Even after production has ended, improperly plugged wells may continue to leak toxic chemicals into the air, soil, and water for many years.
- The chemicals used in OGD (some of which are unknown since they are protected by trade secrets) contaminate water through several avenues: contamination of aquifers above or below the wells, spills and leakage of excess water contaminated with petrochemicals into the soil around the wells, leakage from unlined excess water storage pools, use of excess water from wells for irrigation, among others.
- Environmental exposures that harm health include direct exposure to soil contaminated from leaks and spills, as well as indirect exposure to food grown on contaminated soil and/or irrigated with contaminated water. Excess light and noise from activity around wells increase anxiety.
- Humans are also exposed to hazards through the negative impacts of OGD on plants and wildlife, which include habitat loss and fragmentation.

Geographic Factors

It is important to consider the role of geography in determining the impacts of OGD. These factors include:

- The number and demographics of the population living, working, and engaging in activities within 2,500’ of oil and gas operations has a direct bearing on the negative effects of OGD. Special attention must be paid to vulnerable populations.
- The presence and proximity of aquifers, reservoirs or other bodies of water or watersheds affect the likelihood and severity of negative health impacts through water pollution.
- The density of wells in the area must be considered to determine the degree of negative impacts. It is insufficient to merely note the presence or absence of any wells.

- The proximity of wells in the area must be considered to determine the degree of negative impacts. It is insufficient to merely note whether wells fall within the proposed 2,500’ setback.
- The well geology, production method, and history of the production company must be considered to estimate the risk of spill, leak, and inappropriate disposal or reuse of produced water containing chemicals.
- Where and how the exposures take place must be considered : air – inhaled, water – contamination of wells (rural) and aquifers (rural vs urban watershed), spills of oil and gas and/or the chemicals used for oil and gas development
- The level of toxic exposure in air (e.g., local AQI), water (presence of toxins), and environment must be considered to determine the marginal harm from additional exposures.

Economic Benefits of Proposed 2,500’ Setback Rule

Economic Value of Social and Health Benefits of a Proposed Setback Rule

As the above sections document, the adverse health impacts range from increased acute diseases (such as asthma and increased incidence and severity of COVID19) to chronic conditions such as cancer, reduced cardiopulmonary function, and the long-term consequences of poor birth outcomes on life expectancy. All of these impacts result in high social and economic costs to the impacted population (i.e., people living within 2,500’ of OGD). Social and economic costs of health deterioration resulting from exposure to toxic emissions for extraction activities include costs related to morbidity, such as increased health services, productivity losses from disease and absenteeism, long term care for low birth weight or preterm birth, and mortality, with the value of a statistical life estimated by the US Dept of Transportation in 2016 as $9.6 Million per death.[66]

Here we provide guidelines based on accepted practices for estimating the economic value of the health benefits of a policy rule.[67] Our proposed method for estimating the economic value of the health benefits from reduced ambient air pollution on the nearby communities is conservative because it includes the economic valuation of only a few of the known toxic air pollutants released by oil and gas extraction activities. Often the

[66] See US Department of Transportation, “Revised Departmental Guidance on Valuation of a Statistical Life in Economic Analysis.”

[67] See the United States Environmental Protection Agency’s *Guidelines for Preparing Economic Analyses.* https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses

local air pollution analysis involves only PM2.5, and also ozone in some studies. As the above literature review shows, these are only two air pollutants out of the many air, water, and environmental hazards of OGD known to cause negative health impacts. Therefore, the estimated total social benefit of the proposed rule that results from an analysis of only a few ambient air pollutants must be viewed as only a very small part of the actual total social benefits for the impacted population.

The economic valuation of the proposed 2,500' setback's effects on improved health for the impacted population through improving air quality (e.g., reducing PM2.5 and ozone) requires a rigorous analysis done by researchers who are familiar with undertaking statistical analysis of the publicly available data. Then, this economic analysis can be added to the CalGEM health impact analysis to systematically consider the full range of potential impacts of the proposal on health determinants, health status, and health equity.[68]

CalGEM should integrate the quantitative economic and health analyses into the qualitative data from stakeholders affected by the proposal, particularly impacted vulnerable populations who provided testimony in pre-rulemaking hearings and with materials directly submitted to CalGEM. This use of qualitative data is in line with the official standard for health impact analysis: "The lack of formal, scientific, quantitative, or published evidence should not preclude reasoned evaluation of health impacts. The expertise and experience of affected members of the public (local knowledge), whether obtained via the use of participatory methods, collected via formal qualitative research methods, or reflected in public testimony, comprise a legitimate source of evidence."[69]

The first step in evaluating the economic benefits of improved health due to improving air quality is to determine the improvement in air quality. To provide concrete recommendations on how CalGEM can do this, we discuss an ongoing research project being conducted at by David Gonzalez and colleagues at Stanford University[70] that uses panel data from California air pollution monitors to estimate the ambient air pollution emitted from nearby oil and gas wells. We think that this research can be useful to CalGEM because it uses California data, it estimates the increase in pollution from one additional well by using panel data over 21 years, and it uses a rigorous statistical method.

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[68] Ibid

[69] *Health Impact Analysis* https://hiasociety.org/resources/Documents/HIA-Practice-Standards-September-2014.pdf See the list of practice standards to be followed.

[70] Gonzalez, David J.X. Research Project on Extractive Industries and Health Equity in the Emmett Interdisciplinary Program in Environment and Resources at Stanford University.

The Gonzalez *et al.* study examines the effects of upstream oil and gas preproduction (drilling sites) and production activities (total volume of oil and gas) on the concentrations of ambient air pollutants in California. The data comes from 360 monitors in the EPA Air Quality System over the time period 1999-2019, which provided approximately 1.6 million daily observations including daily concentrations of ambient air pollutants previously reported to be associated with oil and gas production (PM2.5, NO2, O3, SO2, VOCs). The research team obtained data on the preproduction sites and production by well from CalGEM. For each monitor-day, they assessed exposure to upwind drilling sites and total production volume of oil and gas within 1 km bins out to 1 km from the monitor. They estimate adjusted fixed effects linear regression models for each pollutant, controlling for geographic, seasonal, temporal, and meteorological factors.[71] They find that it is important to control for season, year, precipitation, wind speed, and presence of wildfire smoke plumes. Their preliminary findings show higher concentrations of PM2.5 with exposure to upwind drilling sites within 3 km, higher concentrations of O3 for drilling sites at 2-4 km, and higher concentrations of SO2 for drilling sites within 1 km.

A preliminary estimate of the social benefits that would accrue as a result of a decline in premature mortality from mandated setbacks of 2,500' would be calculated as follows using a conservative estimate based solely upon the excess PM2.5 generated by OGD within 2 km radius of wells. The excess $PM_{2.5}$ is approximately 1.8 µg/m^3 for an additional drilling site within a 2 km (6,561') radius, an estimate that can be reasonably applied to 2,500'.[72] Recent studies demonstrate that 10 microgram/M3 higher levels of PM2.5 are associated with a 7.3% increase in all cause mortality rate.[73] This increase in all-cause mortality rate doubles among those with low socioeconomic status and almost triples among Blacks. Those living near oil and gas wells are frequently of low socioeconomic status and many are Black, as discussed below.

If oil and gas wells are moved to at least 2,500' km away from where people live, go to school, work, and play, and inhabitants' exposure to $PM_{2.5}$ declines by only 1 µg/m^3, a conservative estimate based on the estimated effect of 1.8 µg/m^3, then mortality rates would decline by at least 0.73%. The overall mortality rate in 2018 in California was 609 per 100,000. For each 100,000 people living within 1 km of a well, 609 deaths

[71] The findings were tested for robustness by using alternative model specifications and by conducting placebo tests using exposure to wells that were downwind and in random wind directions from the monitors.

[72] Gonzalez, David J.X., Christina K. Francis, Michael Baiocchi, Mark Cullen, and Marshall Burke. Upstream oil and gas production and ambient air quality in California. Research Project in the Emmett Interdisciplinary Program in Environment and Resources at Stanford University, Work in progress (2020)

[73] Qian Di MS, Wang Y, Zanobetti A, Wang Y, Kourtrakis P, Choirate C, Dominici F, Schwartz J. 2017. Air Pollution and Mortality in the Medicare Population. N Engl J Med 2017 June 29;376(260:2513-2522). Berger RE, Ramaswami R, Solomon CG, Drazen JM. 2017. Air Pollution Still Kills. N Engl J Med 2017:376:2591-2592.

would occur in a year. If wells were moved so that the PM2.5 was 1 $\mu g/m^3$ less for these 100,000 people, then 4.5 premature deaths (0.73%) would be averted annually. With a Value of a Statistical Life of $10,000,000 estimated by the EPA in 2019, then averting 4.5 deaths leads to a social benefit of $**45M annually**. In 2018 **over 850,000 Californians live within 2,500' of an active oil well**,[74] and improving their mortality by decreasing their PM2.5 air pollution would provide social benefits at least **$382.5 million annually**. The social benefit may be greater for communities exposed to intensive oil production activities, where concentrations of PM2.5 would likely be higher. This size of the impacted population is increasing as new wells are drilled. In 2020, 2.17 million Californians live within 2,500' of operational wells (new, active, and idle wells).[75]

However OGD spews much more toxicity in air, soil, and water that cause poor health than just the increase in PM2.5 around wells. The health problems caused by OGD are listed above so that the social benefits from increasing setbacks from wells are much greater than the already high social benefits from decreasing PM2.5 emissions in nearby communities.

Next we look at the demographics of the population living near extraction activities. Public Data from FracTracker[4] provides GIS analysis overlaying oil and gas wells (idle, operational, new; within 2,500' and within 2,500'-5,280') by census block to American Community Survey (2013-2018) block group demographics data (age, non-white, Latinx, poverty rate, distribution of income) with CalEnviroScreen 3.0 by census tract.[76] Here CalEnviroScreen 3.0 is linked to the American Community Survey demographic data.

An aggregation of these data are provided for CalEnviroScreen 3.0 percentile groups (Table 1), and American Community Survey (2013-2018) census block group demographics data (Table 2).

Table 1 maps the distribution of wells in the census block groups with CalEnviroScreen 3.0 data on incidence of asthma (from lowest 0-20% percentile to highest 80-100% percentile groups), incidence of low birth weight, drinking water quality, PM2.5, and Ozone.[77] The relationship between location of wells and specific health problems is complex and must be carefully explained.

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[74] http://priceofoil.org/2018/05/22/skys-limit-california-oil-production-paris-climate-goals/ See also https://www.fractracker.org/2019/07/impact-of-a-2500-oil-and-gas-well-setback-in-california/
[75] https://www.fractracker.org/2020/12/people-and-production/ p 1.
[76] CalEnviroScreen 3.0 rankings were updated June 2018. https://oehha.ca.gov/calenviroscreen
[77] Database created and made available by Kyle Ferrar, Western Program Coordinator, FracTracker Alliance

The large number of wells located in the 60-80th percentile rather than the worst (80-100th percentile) is a result of spatial bias,[78] and the many factors that are aggregated to generate the CES Total Scores. These factors include relative affluence and other indicators of socio-economic status. The majority of the worst (80th-100 percentile for Total CES Score) census block groups are located in low-income urban census block groups, many in Northern California cities that do not host urban drilling operations.

For the asthma rankings, the majority of wells are located in the best CES 3.0 percentile (0-20th percentile) for Asthma. While there is much urban drilling in Los Angeles, the spatial bias in this type of analysis gives more weight to the majority of oil and gas wells that are located in rural areas, which historically have much lower asthma rates. This is a result of the very high incidence of asthma in cities without urban drilling such as the Bay Area and Sacramento (80-100th percentile).

	Operational Well Counts				
	0-20%ile	20-40%ile	40-60%ile	60-80%ile	80-100%ile
Asthma	40,247	19,827	18,902	4,867	19,792
Low Birth Weight	10,186	13,368	14,995	3,236	58,036
Drinking Water	1,019	1,675	53,452	6,214	41,206
PM2.5	5,708	4,237	16,614	70,859	69,987
Ozone	2,238	5,435	6,107	9,898	79,957
Total CES 3.0	1,583	5,756	15,671	65,356	12,985

Table 1. Oil and Gas Wells in CES 3.0 Percentile Groups (2018)

	Distance from an operational oil and gas well		
Demographics	Within 2,500'	2,500' - 1 Mile	Beyond 1 Mile (Statewide)
Non-white	44.44%	43.56%	39.16%
Latinx	43.25%	44.97%	37.79%
Age 0-5	6.08%	6.12%	6.37%
Age <18	21.54%	22.12%	23.39%
Age 65+	13.17%	13.11%	13.68%
Poverty: Under .5 Income to Poverty Ratio	6.51%	6.40%	6.21%
Poverty: .5-.99 Income to Poverty Ratio	8.50%	8.58%	7.92%
Median Annual Household Income < $40k	30.09%	30.73%	28.72%
Median Annual Household Income <$75k	53.53%	54.36%	51.76%

Table 2. California Demographics at Specific Distances from Oil and Gas Wells (U.S. Census Bureau, ACS 2013-2018 5-year Summaries)

[78] This spatial bias results from edge effects of census block groups, where communities living near oil and gas extraction operations may not live in the same census block groups as the oil and gas wells, and are therefore not counted.

Further descriptive analysis of this database can demonstrate the observed demographics by age, race and income of the vulnerable population, and the observed health outcomes for asthma and birthweight. As Table 2 shows, populations living within 2,500' of operational wells tend to be more non-white and Latinx, under age 5 years, and living in poverty than populations beyond 1-mile.

To simplify the data collection and analysis, the three counties (LA, Orange, and Kern), which have 95% of the population living within 2,500' of extraction operations, can be used with the assumption that the findings can be generalized to the rest of the state. The percentage of the population in these three counties living within 2,500' range from 8.5% in Kern to 5.5% in LA.

One recent study on preterm births used an inverse distance-squared weighted index for new and active wells within 10 km of the maternal residence as the predictor variable.[79] Another recent study used exposure to wells as the inactive well count (no inactive wells, 1 well, 2-5 wells, 6+ wells) and production volume from active wells in barrels of oil (no BOE, 1-100 BOE/day, >100 BOE/day).[80]

CalGEM can integrate the economic valuation with evidence of other social benefits related to less polluted water and soil, to reduce noise and light, to alternative uses of the land, along with qualitative data from impacted communities. The broad impact analysis provides the basis for knowing how the proposed 2,500' setback rule would affect people's daily lives and their health both today and in the future.

Impact of Air Pollution on Productivity

In its assessment of the benefits of the proposed 2,500' setback, CalGEM should consider the negative impact of air pollution on worker productivity. Recent studies have found that exposure to PM2.5 and ozone air pollution results in economically significant harm to the productivity of indoor and outdoor workers across a variety of job types. Zivin and Neidell (2012) study the effect of ozone pollution on the productivity of outdoor agricultural workers in California. They find that "ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decrease in ozone concentrations increases worker productivity by 5.5 percent." The authors note that "it seems plausible that efforts to reduce pollution could in fact also be viewed as an investment in human capital, and thus a tool for promoting, rather than

[79] Gonzalez DJX, Sherris AR, Yang W, Stevenson DK, Padula AM, Baiocchi M, et al. Oil and gas production and spontaneous preterm birth in the San Joaquin Valley, CA: A case- control study. Environ Epidemiol. 2020;4(4):e099. Epub 2020/08/25.

[80] Tran KV, Casey JA, Cushing LJ, Morello-Frosch R. Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006- 2015 Births. Environ Health Perspect. 2020;128(6):67001. Epub 2020/06/04.

retarding, economic growth." Chang *et al* (2016) study the effect of outdoor PM2.5 pollution levels on indoor agricultural workers at a pear packing facility in California and find "an increase in PM2.5 pollution of 10 micrograms per cubic meter (μg/m3) reduces the productivity of workers by … approximately 6 percent of average hourly earnings." This work is consistent with other studies on pollution and productivity for physically demanding occupations, including Chang et al. (2014); Hanna and Oliva (2015); Archsmith, Heyes, and Saberian (2018); He, Liu, and Salvo (2016); Adhvaryu, Kala, and Nyshadham (2016); and Fu, Viard, and Zhang (2017).

To study air pollution's effect on the productivity of higher-skilled indoor workers, Chang *et al* (2019) examine outdoor PM10 pollution levels (which includes PM2.5) and service sector workers at an indoor call center in China, finding a statistically significant reduction in the number of calls handled per shift. Air pollution's adverse cognitive effects have even been measured on stock market returns. Heyes *et al* (2016) study S&P 500 returns, finding that "a one standard deviation increase in daily ambient PM2.5 concentrations causes a statistically significant 11.9% reduction in daily percentage returns."

CalGEM should also consider pollution's negative impacts on productivity defined more broadly to include non-market productivity like unpaid household work and education outcomes. For education outcomes, there is evidence that early-life exposure to air pollution is associated with negative impacts on neurodevelopment and behavior in infants and young children, autism diagnosis, and attention-deficit/hyperactivity disorder.[81] As noted by Stingone *et al* (2017), there is "evidence that air pollutants contribute to deficits in neurodevelopment that persist into later childhood… affecting cognitive outcomes such as academic achievement."

When considering any alleged costs to the OGD industry, CalGEM must also consider the potential for such costs to be offset by worker productivity gains across industries due to a reduction in OGD pollution as well as productivity gains defined more broadly to include unpaid household work and education outcomes.

Employment Costs of the Proposed Setback

Few jobs are required in the field once wells are actively operating, with only occasional maintenance or repair work by blue-collar workers. Employment of blue-collar workers is mostly for drilling new wells or reworking wells as they become less productive or have been idle. Professional and managerial employees work at desks in company headquarters. However all oil and gas workers face a cyclical industry that varies with

[81] See Stingone et al (2017) and references therein.

the price of oil and gas. The latest severe downturn occurred with the over-supply of oil just as the pandemic was causing demand to fall.[82]

A recent analysis of employment characteristics in a report by researchers at the University of California Santa Barbara (UCSB report, Section 3)[83] commissioned by CalEPA uses average total compensation for all workers, which is not the correct data for evaluating the pay for blue-collar workers in the extraction sector. Average wages and annual earnings by employment in the blue-collar occupations for the oil and gas extraction industry in California by year is publicly available from the US BLS. Data for 2019 is shown in Table 3.

Table 3: Number of Employees and Median Wages for Blue-Collar Occupations in Oil Extraction Operations[84]

	Employees	Median Wage	Avg. Earnings
Rotary drill operators	1,680 (.27)	$30.58	$68,930
Service unit operators	2,340 (.37)	$26.67	$57,260
Roustabouts	1,350 (.22)	$15.75	$38,730
Derrick operators	890 (.14)	$25.02	$52,310
Total	6,260 (1.00)	--	$55,642

Note that the average annual earnings for these occupations in O&G extraction of $55,642 are much lower than the annual total compensation shown in the UCSB report, which was $161,443 in LA County; $122,344 in Contra Costa County, and $97,765 in Orange county ($2020; avg total compensation over 2016 to 2018), Table 2, p. 74.) You can see that using the UCSB estimated compensation, which is for all occupations and education, is much higher than average earnings for blue collar workers, and is even much higher than the $98,693 for HS or less for the relevant FF workforce (Table on p 79).

Once CalGEM knows the number and occupation of blue-collar jobs per active well, then it must know to what extent phasing out extraction activities in the set-back area reduces jobs and to what extent this is offset by increasing output in the non-impacted area.Then it can calculate the cost of job loss using the OES average earnings data.

[82] See https://www.latimes.com/business/la-fi-bakersfield-oil-20160207-story.html

[83] See "Carbon Neutrality Studies: Reducing Transportation Fossil Fuel Demand and Emissions, and Managing the Decline in Transportation Fossil Fuel Supply" updated 10/21/2020. https://calepa.ca.gov/climate/carbon-neutrality-studies/

[84] Source: California OES Data May 2019, https://www.bls.gov/oes/current/oes_ca.htm#47-0000

Opportunity Costs of Oil and Gas Drilling within the Proposed 2,500' Setback

Any alleged social costs of a reduction in OGD activity within the proposed 2,500' setback are offset by the opportunity costs of that activity. Critically, because investment decisions are made based on private benefits, the social benefits of their opportunity costs may exceed the social benefits of the investments themselves. These opportunity costs include but are not limited to: alternative land uses for OGD wells and access roads within the proposed setback; alternative investments for the capital that would otherwise be used to fund OGD projects within the proposed setback; and the public spending or tax savings that are foregone as a result of the wasteful federal and California tax subsidies enjoyed by the OGD industry for projects within the proposed setback.

To assess the opportunity cost of land used by OGD within the proposed setback, CalGEM should first evaluate the total land area of OGD wells and access roads that would be impacted by the proposed setback. For example, in its 2015 environmental impact report for oil and gas permitting, Kern County calculated the average acreage of land disturbance per producible well for the top 10 oil fields in each of the Western, Central, and Eastern Subareas, accounting for an estimated 97-99% of total production.[85] The report estimates final disturbance factors of 2, 3, and 1.2 acres per producible well for the Western, Central, and Eastern Subareas, respectively.[86] Multiplied by the 52,592 producible wells, these estimates imply approximately 92,000 acres of land disturbed by oil and gas in Kern County. Using similar estimates for Orange and Los Angeles Counties as well as estimates of the number of impacted wells in each county, CalGEM can estimate the opportunity cost of land used by OGD within the proposed setback in terms of acres. Then, a first-order estimate of the associated economic value would be the non-OGD market value of that land.

In addition to the total land use and its value, CalGEM may consider the opportunity cost of land used by OGD within the proposed setback in terms of specific use cases with high social priority. For example, parks and green spaces are well known to impart social and economic benefits through increased property values, health outcomes, living space, recreation, and tourism.[87] In a study of parks in Roanoke, Virginia, Poudyal *et al*

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[85] See *Draft Environmental Impact Report for Revisions to the Kern County Zoning Ordinance – 2015. Appendix F.* Kern County Planning and Community Development Department. Bakersfield, CA. July 2015.
Focused on Oil and Gas Local Permitting https://kernplanning.com/environmental-doc/environmental-impact-report-revisions-kern-county-zoning-ordinance-2015-c-focused-oil-gas-local-permitting/
[86] Ibid Table 11.
[87] See Sherer, Paul M. "The Benefits of Parks: Why American Needs More City Parks and Open Space." *The Trust for Public Land*, 2006.

(2008) find that increasing the size of parks by 20% from their current levels resulted in a consumer surplus increase of $160 per household. Parks are particularly valuable in park-poor places like the city of Los Angeles. “Only 30 percent of its residents live within a quarter mile of a park, compared with between 80 percent and 90 percent in Boston and New York, respectively. If these residents are Latinx, Black, or Asian Pacific, they have even less access to green space.”[88] This contrasts sharply with the fact that in 2019, Los Angeles County was home to 2,478 active wells within 2,500’ of a residence.[89]

The land footprint of OGD also has a high opportunity cost in terms of wildlife habitat and ecosystem services. Allred *et al* (2015) document and measure these costs for wells built in North America from 2000 to 2012, covering “~3 million ha, the equivalent land area of three Yellowstone National Parks.” The costs include the amount of carbon fixed by plants and accumulated as biomass (net primary production, NPP). The authors calculate the NPP loss over this time frame as ~4.5 Tg of carbon. Lost rangelands total “more than half of the annual available grazing on public lands managed by the U.S. Bureau of Land Management. The amount of biomass lost in croplands is the equivalent of 120.2 million bushels of wheat, ~6% of the wheat produced in 2013 within the region and 13% of the wheat exported by the United States.” Moreover, OGD land use harms additional ecosystem functions like wildlife habitat and landscape connectivity, which results in “increasing fragmentation that can sever migratory pathways, alter wildlife behavior and mortality, and increase susceptibility to ecologically disruptive invasive species.”

Other high priority alternative uses of OGD land include the expansion of the housing supply and space for non-OGD local businesses. Expanding the housing supply is a particularly valuable use of land in dense urban environments like Los Angeles County.

To account for another important opportunity cost, CalGEM must consider that the capital that would otherwise be used to fund OGD projects within the proposed setback will be redeployed to other projects. The economic value of those alternative projects, which in some cases may still be OGD projects, should weigh against any costs of the proposed rule alleged by the OGD industry. Importantly, as the investment decision is private and does not capture all social costs and benefits, alternative investments may offer greater net social benefit all by themselves, e.g., through greater employment benefits and more tax revenue, even before consideration of the negative health and environmental effects of OGD.

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88 See Sherer p. 9

89 See “Urban Oil and Gas Production in Los Angeles County.” https://arcg.is/1jm1Xj

Finally, OGD projects in California enjoy substantial tax subsidies at the expense of federal and California state taxpayers. It is wasteful and unfair to provide public subsidies to an industry with both outsized private benefits and external costs. Before subsidies, the private benefits already result in greater than the socially optimal level of oil and gas production, a point underscored by the near-universal agreement among economists on the need for a carbon tax to slow climate change.[90] Providing exceptional tax subsidies beyond what other industries enjoy, like percentage depletion and expensing of exploration, makes OGD investment decisions even more inefficient. The proposed setback rule will not significantly impact these massive distortions, which the CALPIRG Charitable Trust estimated as $129 million in California in 1997.[91] However, it may result in lower foregone public spending or greater tax savings associated with the phasing out of OGD projects within the proposed setback, opportunity costs, which, again, must be weighed against any alleged costs of the proposed rule to the OGD industry.

External Costs from Oil and Gas Drilling Should not Be Paid by the Impacted Communities

From a societal viewpoint, we note that the costs of the pollution to the air, water and land impacts the nearby communities, who are paying with their health and well-being for the oil and gas to be extracted from wells within 2,500'. The companies and the state of California are not paying for these social costs.

The state of California needs to recognize that the impacted communities are paying an enormous amount with their health and well-being so oil and gas companies can extract oil and gas for profit. The impacted communities are directly subsidizing the oil and gas companies, and thereby the end users of the oil and gas extracted. The state should not continue to make the impacted communities subsidize oil and gas produced in California.

More broadly, however, the population of the state and the world is also paying for extraction and burning of oil and gas globally. If future California policies reduce production of oil and gas for burning, then the social benefits extend far beyond the nearby impacted communities, and the Social Cost of Carbon can be used to estimate these benefits.

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[90] See "This is not controversial: Bipartisan group of economists calls for carbon tax" by Heather Long. *The Washington Post*. January 16, 2019. https://www.washingtonpost.com/business/2019/01/17/this-is-not-controversial-bipartisan-group-economists-calls-carbon-tax/

[91] See "Crude Policy: Subsidy to the Oil and Gas Industry by California Taxpayers." *CALPIRG Charitable Trust*. December 1997. http://cdn.publicinterestnetwork.org/assets/qM_id3naUNoDMeVTArJdow/Crude_Policy.pdf

Conclusion

As this memo demonstrates, a large literature documents how the health of the people living near oil and gas extraction operations is adversely impacted by the large array of toxins that are emitted into the air, water, and soil. Our focus is on how Californians living near oil and gas wells suffer health problems from exposure to the pollution from these wells. The health impacts have high social and economic costs because they range from shorter life expectancy, preterm and low birth weight, and a variety of acute and chronic diseases affecting essentially all of the organ systems of the body. The activities of going to school and to work and engaging in daily life are adversely impacted, along with the overall health of the people over a shortened life expectancy.

CalGEM is required to estimate the social benefits from a proposed setback rule that reduces the air, water, and soil pollution in the nearby communities. A holistic evaluation integrates the large literature that already exists on the health impacts from the toxic pollution. It can be supplemented with an analysis of the health benefits from reducing ambient air pollution on people living near extraction activities, such as the research study being done by Gonzalez and colleagues at Stanford. Preliminary findings indicate that the health benefits from improved mortality when PM2.5 is reduced for inhabitants living within 2,500' of extraction activities would be at least $360 million annually. The large social benefits from reducing the other toxins caused by extraction activities should be added to the benefits from reduced PM2.5.

The proposed setback rule is also likely to have a positive impact on worker and household productivity through reducing air pollution, which some economic experts suggest promotes rather than retard economic growth.

The cost of blue-collar job loss depends how many blue-collar jobs are required per active well. Employment of blue-collar workers is mostly for drilling new wells or reworking wells as they become less productive or have been idle. The blue-collar jobs in the extraction sector in California are not high-paying jobs, with the median hourly wage ranging from $16 to $30 (OES data). The job loss will depend on how many active wells are shut-down and to the extent this is offset by an expected increase in employment to plug and safely abandon California's growing inventory of idle and orphan wells.

The social benefits to the impacted communities includes the other potential uses of the land and resources. The opportunity costs of land use, investment capital, and extraordinary industry tax subsidies must count against any alleged costs to the oil and gas industry. Most importantly, because investment decisions are private, these opportunity costs may exceed the social benefit of the impacted wells even before counting the other benefits of the rule.

The local pollution from oil and gas extraction activities affect the nearby communities, and the people are paying the external social costs with their health and well-being for the oil and gas to be extracted from wells within 2,500’. CalGEM’s setback rule should protect the health of the nearby communities, and end their subsidizing the costs of oil and gas produced in California. This is one part of the overall social cost of producing and consuming oil and gas for energy, and future rules can address how to phase out fossil fuel production in California so the state reaches its climate goals.