California
Department of Conservation

Geologic Energy Management Division

Standardized Regulatory Impact Assessment

Well Stimulation Treatment Permitting Phase-Out Regulations

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STANDARDIZED REGULATORY IMPACT ASSESSMENT

OIL AND GAS WELL STIMULATION TREATMENT PERMITTING PHASE OUT

Submitted to: California Department of Finance

Submitted by: California Department of Conservation
Geologic Energy Management Division

This document was prepared with the support of a contracted economic consultant.

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ABBREVIATIONS & ACRONYMS

BEAR – Berkeley Economic Advising and Research

BOE – Barrel of Oil Equivalent

CalGEM – California Geologic Energy Management Division

CARB – California Air Resources Board

CCR – California Code of Regulations

CGE – Computable General Equilibrium

CPI – Consumer Price Index

Department – California Department of Conservation

DOF – Department of Finance

EIA – U.S. Energy Information Administration

FTE – Full-Time Equivalent

FY – Fiscal Year

GDP – Gross Domestic Product

GSP – Gross State Product

OAL – Office of Administrative Law

OEHHA – Office of Environmental Health Hazard Assessment

PRC – Public Resources Code

PRS – Proposed Regulatory Scenario

SAM – California Social Accounting Matrix

SB 4 – Senate Bill 4

SEC – Securities and Exchange Commission

SRIA – Standardized Regulatory Impact Assessment

TFP – Total Factor Productivity

USGS – United States Geological Survey

WellSTAR – CalGEM's Well Statewide Tracking and Reporting recordkeeping system

WST – Well Stimulation Treatment

WTI – Western Texas Intermediate

EXECUTIVE SUMMARY

The Department of Conservation (Department), Geologic Energy Management Division (CalGEM), is proposing to phase out permits to conduct well stimulation treatments (WST) across California's Oil and Gas sector. The regulatory proposal aims to protect life; public health and safety; and environmental quality, including mitigating greenhouse emissions associated with the development of hydrocarbon resources. Current laws on WST require permits, which must include detailed information about the fluids to be used, as well as water monitoring and management plans.

Wells whose operational history includes WST made up roughly 11% of in-state oil production in 2021 and 15% of in-state gas production during the same year. After 2024, when operators would no longer be able to obtain new permits for WST, wells would likely produce less or may produce for a shorter length of time than if operators were still able to perform WST on those wells, and fewer wells will have been drilled. Specifically,

- Production after 10 years without WST permits would be 96% of baseline for oil and 96.1% of baseline for gas unless new technologies are developed.
- It is estimated that 1,442 fewer wells would be drilled in the 10-year timeframe following the end of WST permit issuance.

This analysis is based on 2022 baseline data as well as projections and production data that were available in early 2022. A preliminary review of the 2023 data and projections indicates that new baseline data would not change the analysis significantly. The SRIA contemplates the regulation taking effect in 2024.

Direct Costs & Benefits

The Department anticipates that the phase out of WST permitting will generate direct costs to Oil and Gas sector operators[1] and workers. Since 2018, there have been a total of five companies operating wells where they applied WST. One operator has secured two-thirds of all WST permits in the state. CalGEM anticipates the elimination of WST from oil and gas extraction practices will result in environmental and health benefits for

[1] Under Public Resources Code §3009, "operator" means a person who, by virtue of ownership, or under the authority of a lease or any other agreement, has the right to drill, operate, maintain, or control a well or production facility.

any individuals living proximate to well operations. In particular, while an end to WST permits does not require ceasing production at wells whose operational history includes WST, it would effectively ban new applications of WST. Thus, an end to WST permitting will likely cause shifts in both the revenues and operational expenditures of the Oil and Gas sector as a whole. These direct effects are expected to induce indirect costs and benefits within local economies and statewide.

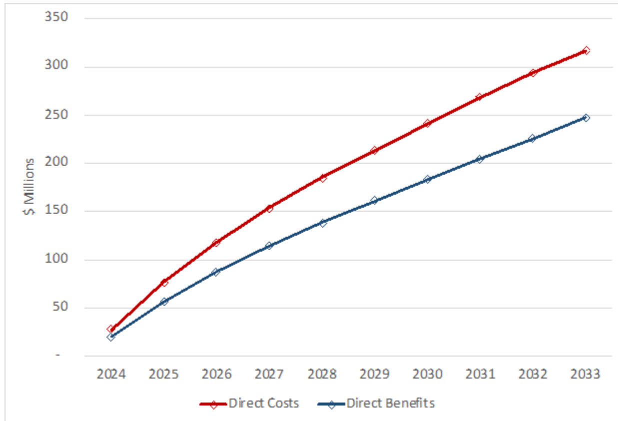
Direct costs include only those costs incurred by operators as a direct result of the regulation, in this case, the foregone revenues associated with reduced oil and gas production as a result of the inability to use WST. Direct benefits are similarly only those benefits incurred as a direct result of the regulation, which are the operators' avoided costs, also known as costs-not-incurred in the performance of WST. Public health and environmental benefits are considered indirect benefits, and are not included in the direct costs summarized below.

Table ES1: Direct Costs and Benefits of the Proposed Regulation ($Millions)

	1st year	3yr Annual	10yr Annual
Direct Costs	28	74	190
Direct Benefits	20	55	144

Figure ES1 shows annual estimated direct aggregate costs and benefits across the 10-year period following full implementation of the regulation with the permitting ban beginning in 2024, and this SRIA provides for impacts assessed during that period. The analysis demonstrates that there will be little to no impact on small businesses either in the industry or in affiliated sectors, and that the number of typical businesses (medium and large oil and gas operators), likely to be affected is less than twelve, which is the number of operators who have requested permits to perform WST in the last decade.

Figure ES1: Annual Direct Costs and Benefits of the Proposed Regulation ($Millions)



The unquantified benefits include public health improvements and reductions in greenhouse gas emissions. Their value is most likely to accrue to disproportionately vulnerable communities in Kern County. Most wells that have been stimulated since 2014 are located in census tracts designated by CalEnviroScreen as disadvantaged communities based on geographic, socioeconomic, public health, and environmental hazard criteria. The following benefits are anticipated for these communities and the California environment:

- Public health benefits from reduced pollution exposure
- Avoided workers injuries
- Water input savings
- Reduction in effects on water and soil quality
- Benefits to disproportionately impacted communities and reduction inpsychosocial harm
- Elimination of related seismicity potential
- Reduced impacts on wildlife habitat
- Reduction in greenhouse gas emissions and use of high carbon intensity crude

Fiscal Impacts

Fiscal impacts are impacts on government entities at the local, regional, state, and federal levels and are considered separate from the direct and indirect costs and benefits discussed above.

<u>Income Taxes</u>: It is estimated the proposed regulation will reduce state income tax revenues by an average of $53 million per year between 2024 and 2032, which is 0.04% of the personal income tax that the Department of Finance forecast in the May Revision for fiscal year 2022-23. Similarly, as a consequence of the regulation, federal income tax revenues will drop by an average of $26 million per year during the same period, almost half the state income tax revenue impacts.

<u>Kern County</u>: There will be disproportionate impacts in Kern County because all WST permits since 2015 have been for WST activity there, a pattern that is likely to continue, making it the only county in California likely to experience WST in the immediate future without the regulation and thus, the only county likely to experience production impacts from the regulation.

According to a report by the Kern County Assessor's Office, Kern County receives a significant portion of its annual budget from income taxes paid by oil and gas corporations and their employees, revenues from sales taxes for oil and gas purchases, and related market activity, and is expected to decline at roughly the same rate as production declines. Because production after 10 years without WST permits would be 96% of baseline for oil and 96.1% of baseline for gas unless new technologies are developed, it is anticipated that these Kern County revenues associated with production would also decrease to 96% of baseline over the same time period.

Roughly 15% of total property tax in Kern is paid by the oil and gas industry; potential devaluation of operator assets as a result of the inability to use WST could reduce property taxes to Kern governments. Macroeconomic modeling suggests that existing production assets in Kern County are likely to lose less than 10% of their current value, with a property tax revenue decline of less than 1% of total county tax revenue annually.

Other counties in California are unlikely to be affected, as WST has been primarily performed in Kern County.

<u>State Agencies</u>: Total savings to state agencies as a result of the WST permitting phase out is anticipated to equal between $11.6 million and $12.3 million per year beginning year 3 after the regulations become effective and during each following year that WST would have been permitted but is not.

- CalGEM anticipates a reduction or reallocation in needed positions equal to between $9.7 million and $10.4 Million. (56 positions)

- CARB anticipates that their existing 6 positions will be needed for the first year that permits are not issued (Year 2), but they will only need 2 positions going forward (Year 3+) for a savings of $759,000 per year.

- State Water Resources Control Board estimates that 5 positions, with average operating expense of approximately $1.1 million, will no longer be needed.

California Economywide Impacts

Relative to baseline economic activity in the state, the WST regulation will reduce the real Gross State Product (GSP), measuring the value added from all industries in the state, by about $2 billion (0.04% of baseline GSP) per year between 2024 and 2032. Similarly, the proposed regulation will reduce total value of production—measured by real output—by about $3.3 billion (0.04% of baseline real output) and investments by $807 million (0.10% of baseline investments) respectively per year over the same period.

- As part of the economywide analysis, it is estimated that the proposed rule will result in approximately 300 fewer new jobs a year across all sectors of the California economy over the decade after the regulation is effective, as represented in the "Employment FTE" rows of Table ES2. These jobs would represent less than 0.01% of total new jobs anticipated per year economywide between 2024 and 2032 and do not reverse baseline job growth in the oil and gas industry or across California.

  The 300 new jobs annually over ten years that will not be created if the WST prohibition is implemented include jobs that would have been created in the oil and gas industry as well as across sectors. It is important to remember that job creation associated with WST is not just limited to the jobs needed to perform the stimulation itself, but because WST ultimately increases oil and gas production from the well where stimulation is performed, it also includes jobs associated with increased oil and gas production. Further, the 300 new jobs that would have been created annually includes not just new jobs in the oil and gas sector, but in other sectors as well. The model relied on suggests that the majority of jobs would have been created in impacted non-oil-and-gas industry sectors, including supply chain partners and sectors impacted by worker spending. It is also important to note, however, that this analysis does not account for potential trends in the industry, such as decreased in-state demand for oil driven by shifting consumer preferences and other policies, that may have limited the creation of these new jobs even without the regulation.

Price effects: The magnitude of price effects would be very unlikely to trigger behavioral changes in the expenditures of businesses and consumers in California.

- Fuel Prices: it is estimated that the proposed regulation will marginally reduce California oil production and result in the substitution of in-state oil and gas production with imports in the immediate term. Economically speaking, this observed "trade effect" of competing out-of-state oil supplies is interpreted as marginal. Imports are very close substitutes for in-state production, and global markets are huge compared to the supply changes that would result from the regulation. Additionally, as California progresses further towards carbon neutrality, the amounts of oil both produced in state and imported are projected to decline. Specifically, the California Air Resources Board (CARB) anticipates a 94% reduction in fossil fuel demand by 2045[2]. While this analysis covers a 10-year period, it does not cover a significant portion of the reduction in demand that will occur with the increased market penetration of Zero Emissions and Plug-in Hybrid Electric Vehicles (ZEVs and PHEVs).

- Economywide price effects: Using very conservative estimates that do not account for increased provision of renewable electrical generation and reduction in demand for transportation fuels, pass-through price effects on all goods and services in the economy could conservatively average 0.1% per year between 2024 and 2032. If this 0.1% average price impact were applied to current[3] gas prices, it would equate to less than half a cent per gallon and would continue to decrease as per capita gasoline consumption is projected to fall[4]. Given other international sources of fossil fuel price volatility, any price impacts associated with this regulation would not likely be observable by California consumers and, as a result, would not result in any behavioral changes.

This $2 billion in net economic impact includes the direct costs to operators discussed above, as well as the indirect and induced costs to complementary businesses and local economies that proceed from the changing economic situation and fiscal impacts to local and state government. It similarly includes direct, indirect, and induced benefits, calculated using an economic model that applies multipliers to known quantities based on historic modeling as well as anticipated fiscal savings. As will be

[2] CARB approves unprecedented climate action plan to shift world's 4th largest economy from fossil fuels to clean and renewable energy: https://ww2.arb.ca.gov/news/carb-approves-unprecedented-climate-action-plan-shift-worlds-4th-largest-economy-fossil-fuels#:~:text=By%202045%2C%20this%20economy%2Dwide,forming%20air%20pollution%20by%2071%25 (link here)

[3] "Current" in this context refers to December 2023

[4] EIA forecasts global oil supply to increase and per capita gasoline consumption to fall in 2024. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

emphasized throughout this assessment, this $2 billion net impact number is completely overwhelmed by baseline aggregate growth, meaning the result is negative only relative to no WST policy, and we expect the state's multi-trillion-dollar economy to continue the robust average growth it has enjoyed for two generations.

Table ES2: Economy-Wide Impacts of WST Regulations

$M Impact	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	-19	-116	-339	-712	-1,268	-2,046	-3,093	-4,462	-6,218	-2,030
Employment (FTE)	-54	-104	-88	-57	-62	-142	-334	-676	-1,208	-303
Real Output	-57	-248	-617	-1,206	-2,073	-3,287	-4,924	-7,075	-9,847	-3,259
Investment	4	-24	-121	-288	-529	-851	-1,265	-1,781	-2,412	-807
Percent Impact	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	Average
Gross State Product ($M)	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.04%	-0.05%	-0.07%	-0.09%	-0.04%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real Output	0.00%	0.00%	-0.01%	-0.02%	-0.03%	-0.04%	-0.06%	-0.08%	-0.10%	-0.04%
Investment	0.00%	0.00%	-0.02%	-0.04%	-0.06%	-0.10%	-0.14%	-0.19%	-0.25%	-0.10%

Note: All results are annual average differences from Baseline over Years 1 through 9. All figures in 2020 $ millions or Full-time Equivalent (FTE) employment headcounts.

Alternative Regulatory Scenarios

In addition to the Baseline and Proposed Regulatory Scenario (PRS), the Department of Finance's (DOF's) guidelines require agencies to evaluate two feasible alternatives to the PRS. These include one policy alternative with lower direct costs (and lower benefits) compared to the proposed regulation, representing a "second best" option. The second alternative should be considered more stringent, with higher direct costs and perhaps higher direct benefits.

For the WST regulation, we consider a less stringent alternative to be a five-year extension of the deadline for ending WST permits. While direct costs and benefits would remain the same, their realization would be deferred five years, offering the industry more time to make productivity compensating investments before losing the yield benefits of WST. To examine a more stringent alternative, we evaluate an immediate moratorium on WST in California, ending permitting and WST activity that would again realize the same direct costs and benefits, but on an accelerated timeframe. Meaning, the costs and benefits of each scenario are generally the same as baseline in real cost, but are accelerated or delayed according to the stringency of the scenario. It should be emphasized that both alternative scenarios are completely hypothetical and in no way reflect policy intention. They are only included to elucidate the economic process under alternative regulatory constraints.

The results in Table ES3 highlight some advantages of the PRS from a statewide economic perspective, but do not reflect others. Aggregate average changes across key economic metrics are displayed over Years 1 through 9, as in the last column of the previous table. Absolute magnitudes of the output-based aggregates are consistent with the stringency of each regulation, but we see different adjustment pathways. Relative to the PRS (first scenario, "S1"), delays in implementation (second scenario, "S2") reduce costs to industry by deferring WST retirement until five years after the PRS. Gross state income and employment are again lower than Baseline trends, but still growing in absolute terms. Across all the macroeconomic aggregates, the PRS impact is very negligible (generally less than one-hundredth of one percent.) Although the economic costs of the less stringent policy seem lower, it must be emphasized that it would delay the environmental, public health, and other mitigation expected from WST cessation, and would similarly delay the value of the benefits that would accrue to disadvantaged communities. The cost of the public health and environmental harm caused by these delays could certainly exceed the difference between the PRS and Less Stringent alternative.

The more stringent alternative policy goes into effect earlier. Its cumulative impact is more adverse a decade from now, with average annual real GDP reductions of $2.7B and approximately 50% higher job losses, though it is worth mentioning that this jobs model did not account for the potential effect of decreasing in-state demand for oil and gasoline on jobs in the sector regardless. Again, the environmental and health benefits of accelerated WST retirement could be significant here, but the PRS was chosen to accommodate sectoral adjustment needs, while meeting stated objectives for environmental quality.

Table ES3: Macroeconomic Impacts of WST Regulatory Alternatives

Less Stringent Alternative

$M Impact	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	0	0	0	0	0	-40	-209	-571	-1,162	-220
Employment (FTE)	0	0	0	0	0	-33	-59	-50	-62	-23

Real Output	0	0	0	0	0	-88	-394	-992	-1,947	-380
Investment	0	0	0	0	0	-7	-67	-213	-448	-82
Percent Impact	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Average**
Gross State Product ($M)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	0.00%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real Output	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	0.00%
Investment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	-0.05%	-0.01%

More Stringent Alternative

$M Impact	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	-16	-101	-303	-643	-1,152	-1,865	-2,827	-4,086	-5,703	-7,742	-2,714
Employment (FTE)	-59	-116	-101	-66	-61	-124	-292	-600	-1,087	-1,795	-471
Real Output	-52	-227	-562	-1,097	-1,885	-2,989	-4,482	-6,446	-8,981	-12,193	-4,318
Investment	-16	-104	-259	-485	-788	-1,179	-1,667	-2,265	-2,987	-9,745	-2,164
Percent Impact	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Average**
Gross State Product ($M)	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.03%	-0.05%	-0.07%	-0.09%	-0.12%	-0.04%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.00%
Real Output	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.04%	-0.05%	-0.07%	-0.10%	-0.12%	-0.04%
Investment	0.00%	0.00%	-0.01%	-0.03%	-0.06%	-0.10%	-0.14%	-0.18%	-0.24%	-0.30%	-0.12%

Note: Differences from Baseline scenario. All figures in 2020 $ millions or percentage unless otherwise noted.

On an annual average basis, the PRS (Table ES2) seems to balance these countervailing forces, yielding intermediate average annual employment benefits and economic costs. Since this study was not able to make full account of many other recognized benefits of WST cessation, regulatory prudence would suggest the intermediate scenario meets the primary goal of WST cessation without undue compliance cost or a continuation of adverse but avoidable public health impacts.

STANDARDIZED REGULATORY IMPACT ASSESSMENT (SRIA)
WELL STIMULATION PERMITTING PHASE OUT

1. INTRODUCTION

The Department of Conservation (Department), Geologic Energy Management Division (CalGEM), is proposing to phase out permits to conduct well stimulation treatments (WST) across California's Oil and Gas sector. The regulatory proposal aims to protect life; public health and safety; and environmental quality, including mitigating greenhouse emissions associated with the development of hydrocarbon resources. Current laws grant the State Oil and Gas Supervisor discretion to issue permits for WST; permit applications must include detailed information about the fluids to be used, as well as water monitoring and management plans. The proposed regulatory change would establish, as a matter of general policy, that the Supervisor would no longer entertain WST permit applications. Based on a preliminary analysis, the Department concluded the economic impact of the regulatory change will surpass $50 million during a 12-month period after its full implementation, making it a major regulation by the threshold for Standardized Regulatory Impact Assessments (SRIA) defined in Senate Bill 617 (Calderon, Chapter 496, Statutes of 2011).

The Department anticipates that the phase out of WST-facilitated production of Oil and Gas will generate direct costs and benefits to operators and workers. These direct effects can also be expected to induce indirect costs and benefits within local economies and statewide.

This document provides an economic impact assessment of the costs and benefits of the proposed WST regulation. The methodological approach has been peer-reviewed and its implementation is in compliance with Department of Finance (DOF) Baseline calibration standards. This analysis is based on 2022 baseline data as well as projections and production data that were available in early 2022. A preliminary review of the 2023 data and projections indicates that new baseline data would not change the analysis significantly.

1.1. Background of the Proposed Regulation

CalGEM supervises the drilling, operation, maintenance, and plugging and abandonment of onshore and offshore oil, gas, and geothermal wells. CalGEM carries out its regulatory authority under a legislative mandate to encourage the wise development of oil and gas resources, while preventing damage to life, health, property, and natural resources, including underground and surface waters suitable for domestic or irrigation purposes. (See Pub. Resources Code, § 3106.)

On September 20, 2013, Governor Brown signed into law Senate Bill 4 (Pavley, Chapter 313, Statutes of 2013) (SB 4). In the context of widespread public concern about hydraulic fracturing and other WST practices employed to facilitate oil and gas production, SB 4 imposed a wide range of new standards and requirements applicable to WST operations, including the requirement for a discretionary permit from CalGEM prior to conducting WST. (See Pub. Resources Code, § 3160, subd. (d).) As required under SB 4, CalGEM undertook rulemaking to establish an extensive regulatory framework intended to meet the various mandates of Public Resources Code section 3160, which include:

- Ensuring integrity of wells, well casings, and the geologic and hydrologic isolation of the oil and gas formation during and following well stimulation treatments
- Requiring full disclosure of the composition and disposition of well stimulation fluids, including hydraulic fracturing fluids, acid well stimulation fluids, and flowback fluids
- Express statutory requirements regarding well stimulation permit applications, public disclosures, neighbor notification, and water well testing

On July 15, 2015, CalGEM's WST regulations, California Code of Regulations, title 14, division 2, chapter 4, subchapter 2, article 4, became effective. The current regulatory requirements form a complex framework of testing, documentation, public outreach, administrative procedure, performance standards, and prescriptive requirements. CalGEM's WST regulations implement the mandates of Public Resources Code section 3160 and respond to the widespread public concern about WST operations by doing the following:

- Detail the data and analysis that must be provided to CalGEM and the various engineering reviews that must occur in connection with a WST permit application in advance of WST. (Sections 1782, 1783, 1783.1, 1784, 1784.1, 1784.2, 1785, 1787.)
- Implement the statutorily required neighbor notification, water well testing, and disclosure by requiring operators to complete neighbor notification using a bilingual (English/Spanish) template form, provide an explanation that neighbors have the right to request that their water wells be tested before and after well stimulation is utilized, and comply with public disclosure requirements after completing a WST. (Sections 1783.2, 1783.3.)

- Require pressure testing and specified evaluation of the well and the geology in the area near the well prior to the well stimulation treatment to ensure that the WST will not damage the well, and that the well stimulation fluids will be confined to the intended zone. The objective of pressure testing and cement evaluation of a well prior to a well stimulation treatment is to make sure the well through which the WST occurs is competent to withstand the pressures created by the well stimulation treatment. The objective of evaluating the well and the area around the well is to identify geologic features or other wells in the vicinity of the WST that may act as a conduit out of the intended zone. (Sections 1783.1, 1784.1, 1784.2.)

- Require monitoring during and after a WST for any indication of well failure and specify how an operator must respond in the case of a well failure. (Section 1785.)

- Require monitoring to determine the volume of WST fluid flowback.

- Require monitoring during and after WST for any earthquake larger than magnitude 2.7 that occurs within the vicinity of a well stimulation treatment. (Section 1785.1.)

- Address storage and handling of well stimulation fluids, including storage of fluid in containers and requirements for response to spill and other unauthorized releases. (Sections 1782, 1786.)

- Require public disclosure before and after WST operations and detailing various aspects of the operations, in particular chemical usage. (Sections 1777.4, 1783, 1783.1, 1783.2, 1783.3, 1784, 1784.1, 1784.2, 1785, 1785.1, 1787, 1788, 1789.)

On October 12, 2019, Governor Newsom signed into law Assembly Bill 1057 (Limón, Chapter 771, Statutes of 2019) (AB 1057). AB 1057 added Public Resources Code 3011, which expanded CalGEM's express statutory duties to include the protection of public health and safety and environmental quality, including reduction and mitigation of greenhouse gas emissions associated with the development of hydrocarbon resources.

On September 23, 2020, Governor Newsom issued Executive Order N-79-20. The order set into action policies related to environmental protections and expressed commitment to a broader statewide shift away from fossil fuel production and consumption. In April 2021, the Governor directed CalGEM to initiate a rulemaking process that would permanently phase out WST permits by 2024 (Office of Governor Newsom, 2021a).

On May 21, 2021, the Department published a proposed modification to the California Code of Regulations (CCR), Title 14, Section 1780. Reproduced below, this regulatory amendment would cease the issuance of WST permits for Oil and Gas wells operating in California beginning in 2024. Added text is shown in bold and underline.

> *1780. Purpose, Scope, ~~and~~ Applicability**<u>, and Permitting Restriction.</u>***
>
> *(a) The purpose of this article is to set forth regulations governing well stimulation treatments, as defined in Section 1761(a)(1), for wells located both onshore and offshore.*
>
> *(b) Well stimulation treatments are not subsurface injection or disposal projects and are not subject to Sections 1724.6 through 1724.10 or Sections 1748 through 1748.3. This article does not apply to underground injection projects. If well stimulation treatment is done on a well that is part of an underground injection project, then regulations regarding well stimulation treatment apply to the well stimulation treatment and regulations regarding underground injection projects apply to the underground injection project operations.*
>
> *(c) For purposes of this article, a well stimulation treatment commences when well stimulation fluid is pumped into the well, and ends when the well stimulation treatment equipment is disconnected from the well.*
>
> ***<u>(d) The Division, including the supervisor and district deputies, will not approve applications for permits to conduct well stimulation treatments.</u>***
>
> *Authority: Sections 3013 and 3160, Public Resources Code. Reference: Sections 3106**<u>, 3011,</u>** and 3160, Public Resources Code.*

1.2. Major Regulation Determination

California Code of Regulations (1 CCR § 2000) defines “Major regulation” as any proposed rulemaking action adopting, amending, or repealing a regulation subject to review by the Office of Administrative Law (OAL) that will have an economic impact on California business enterprises and individuals in an amount exceeding fifty million dollars ($50,000,000) in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through 12 months after the major regulation is estimated to be fully implemented, computed without regard to any offsetting benefits or costs that might result directly or indirectly from that adoption, amendment, or repeal. Because WST permits have a one-year life before expiry, but costs and benefits of an individual stimulus can last several years, the threshold was assessed for the annual average of calendar years 2024-2026. Calendar year 2023 was not included in the assessment because it has a likely zero direct cost impact. In addition, looking only at the first year of implementation would seriously understate direct costs as well as benefits. For the annual average of the first three years and the next decade, the magnitudes of direct implementation costs and direct benefits of the proposed regulation are each expected to exceed the SRIA threshold.

Table 1: Average Annualized Direct Costs and Benefits of the Proposed Regulation ($millions)

	1st year	3yr Annual	10yr Annual
Direct Costs	28	74	190
Direct Benefits	20	55	144

Direct costs are impacts on oil and gas operators comprised of lost revenues associated with declines in Oil and Gas production and will likely accrue to those medium and large, companies, corporations and limited liability companies (LLC) rather than individuals, operating in Kern County that have stimulated a well within the last five years. These medium and large companies own at least 4,500 wells each and those that have requested permits within the last five years together own more than 60% of the wells in California. As Table 1 indicates, the first-year direct costs are estimated to be approximately $28 million. Oil and Gas production declines resulting from additional years without WST accumulating over time. For this reason, the annual average direct cost over three years would be substantially higher at $74 million and over the next decade (2023-32) this average rises to $190 million per year. Similarly, on the benefit side we see growth over time from WST implementation costs not incurred. The three-year average direct benefit, comprising mainly avoided costs of WST implementation, is estimated to be approximately $55 million per year. The corresponding ten-year average decade estimate is $144 million annually. Therefore, Department implementation of the WST rule qualifies as a major regulation, requiring a complete SRIA.

1.3. Public Outreach and Input

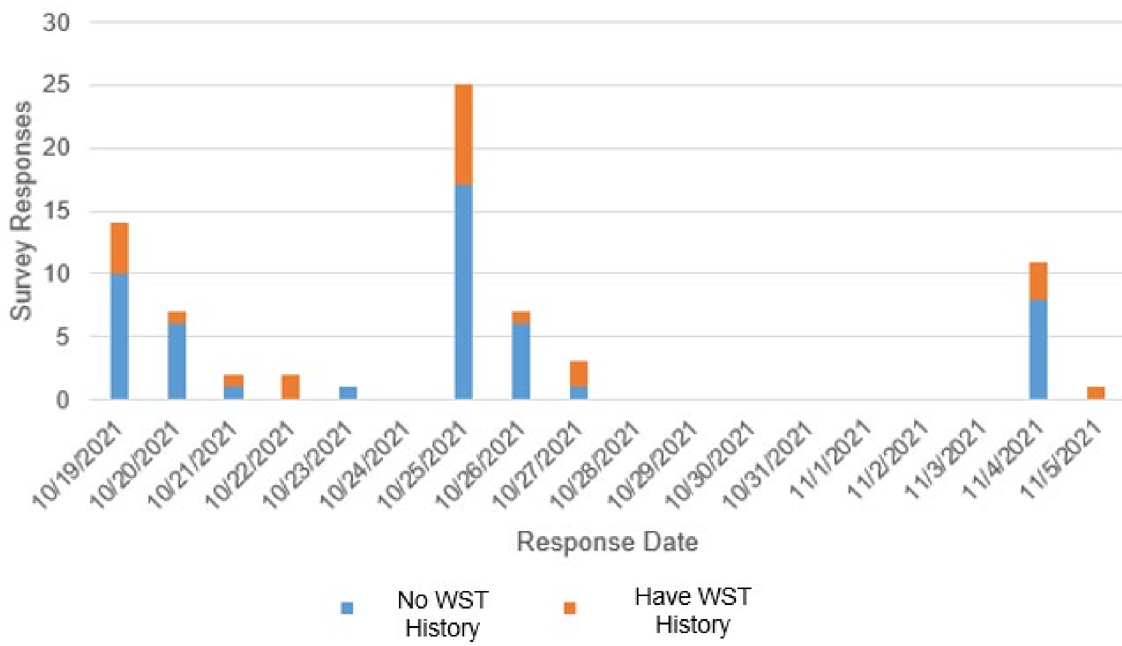
The Department solicited input on the proposed regulation by way of a pre-rulemaking public comment period from May 21st to July 9th, 2021 (Department, 2021b). Interested parties were invited to review preliminary rulemaking text and submit written comments to the Department. During this period, 221 comment letters were submitted (including a petition with nearly 5,000 signatures); the overwhelming majority of these submissions expressed support for the proposed regulation. In addition to these public outreach efforts, the Department has been engaging industry and other private sector stakeholders on WST issues for some time.

To better understand industry perspectives, this analytical process included survey outreach to Oil and Gas firms operating in California.[5] The brief survey (see Appendix 3 for a full list of questions, answer options, and skip logic) asked firms about their current California Oil and Gas operations, their perspectives on future in-state production, and how they anticipate a WST permitting phase out would affect their own wells and the industry more broadly. Potential respondents were drawn from CalGEM and WellSTAR records and included firms that actively produced oil or gas in California at some point since 2010.

Figure 1 illustrates how survey response collection breaks down according to the responding firm's history of WST use in their in-state Oil and Gas production. All told, about 32% of all responses came from firms whose California wells had any history of WST application. As the figure shows, the inflow of these responses (and the proportion of WST-utilizing firms among them) varied over time. (Note: a full accounting of survey questions is located in Appendix 3; a brief overview can be found below).

[5] Survey results were used to inform SRIA narrative, but responses were not incorporated as inputs or otherwise modifiers to the quantitative analysis discussed elsewhere (e.g., production forecasting or macroeconomic estimation).

Figure 1: Responses to the Industry Survey by WST Status



Results indicate meaningful diversity among firms with a history of WST use in terms of the scope and process of stimulation at their in-state wells. Some of these firms have only one or two wells with a history of WST, while others claim oversight of hundreds of stimulated wells. The centrality of WST in these firms' California operations likewise varied dramatically: on average these respondents described 33% of their in-state production being facilitated by WST – while for other WST users this rate was much smaller or much higher. About half of firms with a history of WST use describe well production occurring only after stimulation; the other half describe WST being applied to already-producing wells, or their WST applications following no typical pattern. Respondents with a history of WST use do find common ground in repeated application of the technology, with nearly three quarters describing WST as occurring at wells in regular intervals after its first application.

Responding firms with a history of WST use and those with no WST history shared some commonalities in their survey answers: for example, in describing trends in their in-state oil and natural gas production generally, about 75% of both types of respondents cited declining oil production; 50% cited declining natural gas production.

However, based on their WST history, firms differed starkly in their future in-state drilling plans: while 24% of firms with no WST history described plans to drill new wells within the next 10 years, 85% of WST-using firms asserted new drilling plans. Moreover, unsurprisingly given the differing presence of WST in their in-state operations, respondents envisioned a much bleaker future in California in a WST permitting phase out scenario if they had historically made use of WST. For example, among firms with no WST history, 54% anticipated their in-state oil production would fall modestly or significantly in a permit phase out scenario, and 34% predicted their natural gas production would similarly decline; among firms with a history of WST, these rates were 100% and 90%, respectively. Accordingly, while only 27% of firms with no history of WST stated they would drill fewer wells in a permit phase out scenario, 90% of WST-using firms anticipated a reduction in well drilling. Ultimately, while 32% of non-WST using firms expressed concern that the profitability of their in-state operations would decline with a permit phase-out, this sentiment was universal among firms with a history of WST.

1.4. Regulatory Baseline

All economic impacts estimated in this SRIA are evaluated relative to an official Baseline reference scenario, calibrated against the May 2022 California Department of Finance Macroeconomic Projections for the California economy (see Appendix 1 for details). This "Business as Usual" dynamic reference scenario is required for SRIAs to make them comparable and compatible with state policy expectations and to consistently support public-private policy dialog. Conceptually, the Baseline projects economic activity assuming that the proposed (and alternate) regulations are not implemented and new permits for WST will continue to be issued as they have been in previous years.

This analysis is based on 2022 baseline data. A preliminary review of the 2023 data indicates that new baseline data would not change the analysis significantly.

1.5. Interaction of Proposed Regulation with Existing or Forthcoming Regulation

California has not seen new offshore Oil and Gas wells since the 1980s, though production has continued through the present at existing offshore wells. Governor Newsom has directed the CARB to explore pathways towards a phase out of in-state Oil and Gas extraction entirely over the next two decades (Office of Governor Newsom, 2021a).

The drilling of new wells would be impacted by the recently suspended prohibition on new Notices of Intention in areas close to sensitive receptors such as schools and homes (Senate Bill 1137, Gonzalez, Ch. 365, Stats. of 2022) (SB 1137), which would go into effect if approved by the voters through a referendum on the law in the 2024 general election. SB 1137 prohibits the issuance of permits that require a Notice of Intention within 3,200 feet of homes, schools, hospitals, nursing homes, and other sensitive receptors and would interact with both the proposed WST phase out and any ban on offshore drilling by limiting the community health impacts of new well development. While most wells receiving WST are already sited in remote areas away from residential populations, a small fraction of WST application occurs near people. With the implementation of the 3,200-foot health protection zone, future well stimulation activities at new wells would present further limited risk to public health since most hazards have been found to occur within the 3,200 feet surrounding wells. The statute also includes language mandating new operational protocols for existing wells sited within the 3,200 feet threshold. Oil and gas wells proximate to sensitive receptors will be obliged to adopt a range of engineering controls. These include, among others, plans for ongoing leak detection, sound, light, and noise controls, as well as water quality testing before and after drilling. The controls would reduce health risk to the general public. Additionally, for firms managing any wells affected by this regulation, compliance would raise production costs at these sites. Depending on the impact of these requirements on a firm's well portfolio, and on their particular financial picture, some firms could choose to shut down specific well operations or exit the sector entirely.

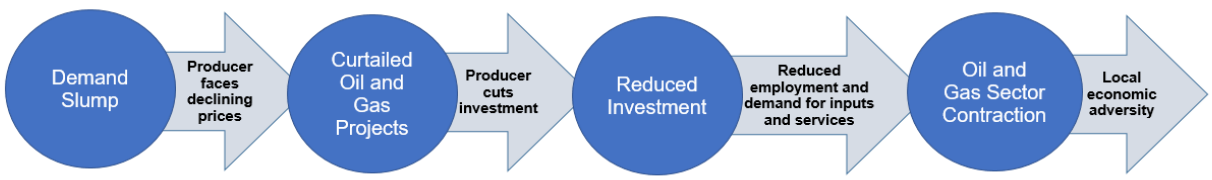
On February 3, 2023, the Secretary of State confirmed that proponents of a referendum on SB 1137 had secured enough valid signatures to qualify it for the November 2024 ballot, which suspended the implementation of SB 1137 until the vote. As such, in the absence of the WST permit ban, WST could continue to be implemented in areas around sensitive receptors, making the ban vital in protecting sensitive receptors within 3,200 feet of wells from the impact of WST until such time as the referendum is resolved.

1.6. Sector Impacts

The baseline demand scenarios were influenced by the short-term impact of the COVID 19 pandemic on the Oil and Gas sector which saw a 25% decrease in consumption, slowly recovering to pre-pandemic levels and even higher (McKinsey, 2020). However, the economic impact analysis is not heavily influenced by those interruptions in prior trends. Both U.S. and international Oil and Gas production has seen even greater declines in exploration and extraction investments (30% to 40%), including new Midwest gas and Gulf oil, where new commitments fell from over 800 in 2019 to 265 in 2021 (Offshore Technology, 2021).

Meanwhile, climate policies and innovation continue to challenge competitiveness for Oil and Gas compared to other energy carriers (especially wind and solar), while electric vehicle adoption continues to gain momentum. These circumstances have an indirect sequence of effects for suppliers, workers, and investors in the sector, where less capital to invest in future production offers fewer opportunities to sector workers and suppliers, reducing income for their own households and local communities. Figure 3 illustrates how logistic disruptions could play out in the Oil and Gas sector. A demand slump leads to a curtailment of Oil and Gas projects; sector investment declines leading to reduced employment and demand for supply chain inputs, contracting the overall sector.

Figure 3: Indirect Sequence of Effects, Logistics Disruptions



Source: Berkeley Economic Research and Advising (Contracted Consultants)

Current evidence indicates that California's Oil and Gas sector has been relatively resilient against these supply and demand shocks. Relative proximity to its destination market (compared to the Middle East and even the Midwest) makes California Oil and Gas less vulnerable to downstream supply chain shocks, while the same disruption for out of state competitors benefits them. Similarly, recent Oil and Gas price increases, largely a response to international production cutbacks and higher distribution costs, directly benefit California producers.

2. IMPACTS ON CALIFORNIA BUSINESSES

2.1. Who is affected by the WST rule?

Well Stimulation Treatments (WST) are methods used to generate penetrating fractures into reservoirs with low permeability for the purpose of increasing flow pathways to an oil or gas well. Common stimulation methods include hydraulic fracturing, acid fracturing, and matrix acidizing. Operators perform these treatments by injecting a fracturing fluid into a well at sufficient pressure to fracture the target formation and then injecting materials into the fractures to ensure they remain open (CCST & LBNL 2015a). While these methods are highly effective at increasing well productivity, there are potential environmental effects associated with WST, and health effects associated with Oil and Gas production generally, and thus the practice is overseen by CalGEM which requires operators to secure a permit for each WST application.

The operators that would be affected by the proposed phase out of WST permits are those that would like to use WST in the future at wells operating in California. Many in-state Oil and Gas firms have at least some wells with a history of WST in their operational portfolio, including the current top producing firms. Almost all WST application in California occurs at onshore wells in the San Joaquin Basin. Only a small portion of WST carried out in the state has occurred at offshore wells or in other parts of the state.

In the last five years only five companies have reported the performance of WST, and they are all medium and large companies within the oil and gas industry. This is primarily because WST requires the ability to invest large amounts of capital and resources that small operators cannot often bring together. These five companies include some of the largest producers in California, each owning at least 4,500 wells and together owning more than 60% of the wells in the state. These companies will be the most affected and together will experience 100% of the likely direct costs and benefits.

In addition to impacts being limited to a few specific medium and large operators, the vast majority of treatments have been carried out in Kern County and most at wells in one of three fields (Belridge North, Belridge South, or Lost Hills). Thus, benefits of the regulation are likely to be limited geographically to Kern County. While Kings, Orange, and Ventura Counties each have 1-3 wells that have received WST permits in recent years, Kern County has more than 1,886 of these wells.[6] In total, since January 1, 2016, when CalGEM started issuing WST permits, to the end of 2021, 710 wells were treated. During the same time period, CalGEM denied 166 permit applications.[7]

WST induced production represents about 15-20% of total oil and gas production in California over the past 5 years. For 2020, CalGEM estimates that 12.1% of total oil and 16.6% of total gas in California came from wells that had received WST at some time in the past. Wells that have received WST pursuant to permits issued by CalGEM under SB 4 and associated regulations (i.e., after 2015) accounted for only 2% of total state production in 2020. CalGEM experts and third-party assessors concur that these regional

[6] Source: WellStar (https://wellstar-public.conservation.ca.gov/WellStimulation/WellStimulation/Index)

[7] Source: WellStar (https://wellstar-public.conservation.ca.gov/WellStimulation/WellStimulation/Index)

patterns would be likely to continue into the future, absent the proposed permitting phase out regulation (CCST & LBNL 2015b).

2.2. Direct Costs

The primary direct costs of the proposed regulation are foregone revenues associated with production declines induced by the elimination of WST-facilitated Oil and Gas development and would be borne by medium and large operators as discussed above. In the absence of this technology application, certain oil and natural gas production would not occur and associated revenues would not be accrued. Here we utilize Department estimates of foregone revenue that were calculated by first estimating the yearly, future foregone Oil and Gas production that would have been derived from WST-facilitated production and then estimating the yearly, future revenues associated with this foregone production. Direct cost estimates likely reflect a conservative overestimate, as future projections assume that operators will not find alternative technologies to produce all or some portions of planned WST-facilitated production. If alternative technologies are developed, then production decline estimates utilized in this SRIA would be overestimating impacts of the proposed regulation.

Regulatory impacts on production are forecast based on a model calibrated to historical data on WST-facilitated production in California.[8] To characterize total changes in production we convert natural gas production from thousand cubic feet (mcf) to barrel of oil equivalent (BOE)[9] and combine it with changes in oil production. Table 2 shows the estimated production impacts of phasing out WST in California. Under the PRS, one year after full implementation, oil production is estimated to be 99.1% of baseline, and natural gas is 99.1% of baseline. Ten years after implementation of the regulation, oil production is estimated to be 95.8% of baseline, and natural gas production is 95.2% of baseline. In total, the proposed WST phase-out is estimated to result in 1,442 fewer oil wells being drilled over the period from 2024 to 2033.

Table 2: Estimated Regulatory Impact on Oil and Gas Production

Year	Oil (Barrels)	Gas (mcf)	Gas (BOE)	Oil + Gas (BOE)	New WST Wells	All WST Wells
Year 1	-417,876	-370,038	-61,673	-431,711	-133	-148

[8] See Appendix 4 for details.

[9] We convert mcf to BOE using the following equation: BOE = mcf/6. 6 mcf of natural gas equals 1 BOE (Barrel of Oil Equivalent)

Year 2	-1,135,990	-1,051,286	-175,214	-1,226,501	-143	-160
Year 3	-1,705,603	-1,623,706	-270,618	-1,894,324	-145	-161
Year 4	-2,161,459	-2,083,650	-347,275	-2,430,925	-147	-164
Year 5	-2,551,899	-2,474,969	-412,495	-2,887,464	-151	-168
Year 6	-2,905,009	-2,818,193	-469,699	-3,287,892	-153	-171
Year 7	-3,226,261	-3,132,634	-522,106	-3,654,739	-155	-173
Year 8	-3,519,717	-3,421,387	-570,231	-3,991,618	-157	-175
Year 9	-3,790,878	-3,687,658	-614,610	-4,302,267	-160	-178
Year 10	-4,042,682	-3,932,811	-655,469	-4,588,280	-163	-181

The decline in Oil and Gas production leads to associated declines in revenue for operators and mineral rights holders. Foregone revenues are estimated by combining Oil and Gas production forecasts from the Department with price per unit of production projections from the U.S. Energy Information Administration (EIA)(US EIA, 2021).[10] These foregone revenues, shown in Table 3, are a direct result of oil production losses attributable to the proposed WST permitting phase out and are thus classified as direct costs for medium and large oil and gas companies who are reliant on WST. They are the only quantifiable direct costs of the proposed regulation. Thus the one, three, and ten-year averages shown in Table 1 correspond to the relevant averages of foregone revenues shown in Table 3. As noted above, these may be conservative overestimates.

[10] Oil and Natural Gas production are valued separately before being combined into total costs, revenues, etc. See Appendix 4 for technical details on these calculations.

Table 3: Total Direct Costs ($Value)

Year	Foregone Revenues
Year 1	-27,950,377
Year 2	-76,805,029
Year 3	-117,561,942
Year 4	-153,326,320
Year 5	-185,008,405
Year 6	-213,911,533
Year 7	-241,369,960
Year 8	-268,890,450
Year 9	-294,181,203
Year 10	-317,201,053

2.3. Assumptions and Uncertainty

Future projections of Oil and Gas production rely on historical data reported by the EIA. The Baseline projections assume that production from 2022 to 2033 follows the average historical rate of decline in California. The historical rate of production decline in California between the years 2000 and 2019 is approximately 2.7% for oil production and 3.2% for natural gas production. In addition, future WST production is based on the historical relationship between WST and Oil and Gas production in California. If WST becomes more effective at increasing production in future years, then we would be underestimating impacts of the proposed regulation on production.

California's oil production declined 9.4% in 2020. Thus, to catch up with historical trends, the analysis equally splits a 6.6% rebound for years 2022 and 2023. This rebound would equal 0.6%, considering that 2022 and 2023 would have declined 2.7% in the absence of COVID-19. Similar calculations apply to the natural gas forecast.

The regulation will have no impact on the revenues of CalGEM as it pertains to the oil and gas assessment, because the assessment is adjusted to meet budgetary needs irrespective of the existence of WST permitting.

This analysis also assumes that idle well fees and the number of orphan wells will not be affected by the regulation. The companies that have historically used WST primarily use idle well management plans and do not pay idle well fees, so there will be no change in fees paid by these companies. In addition, because these companies are medium and large businesses, generally economically robust and owning a large percentage of wells in the state, they are unlikely to orphan or desert wells as they would lose rights to receive permits to operate their remaining wells, so no such costs will accrue.

For complete details on data and estimation procedures see Appendix 4.

2.3.1. Regulated Entity Behavior

One impact of a proposed permitting phase out for a specific industry technique can be a sudden increase in permit requests immediately prior to the cutoff date. In this case, however, such a permit run is unlikely to occur. Permit issuances for WST have steadily declined over the past 10 years.

2.4. Incentives for Innovation

The WST permitting phase out regulation, like much technical rulemaking adopted in California (e.g., electric appliance efficiency, vehicle fuel efficiency), can create an incentive for the adoption of new technology, in effect creating an innovation incubator the size of the world's fifth-largest economy. Firms know that establishing marketable innovations here can prepare them for global export competitiveness. Raising the relative cost of polluting activities may discourage them directly, but indirectly it incentivizes investment in discovery, underscoring a central tenet of California's knowledge-intensive growth model – that induced growth from technology innovation benefits the overall economy, rewarding even those people who neither develop nor adopt it.

2.5. Small Business Impacts

WST activities, and Oil and Gas operations more generally, exist within an extensive supply chain: upstream suppliers include manufacturers of capital goods relevant to well exploration and development; midstream actors include construction firms focusing on pipeline and storage facility creation; and downstream actors include natural gas distributors and fuel dealers, among others (Sedgwick et al, 2019). However, California labor market data suggests that these business entities – particularly the upstream and midstream actors – are underrepresented by small businesses relative to other sectors in the state and national economy (CEDD, 2021). Large capital requirements for these technologies and their production systems present significant barriers to small business entry, and this is clearly reflected in industry statistics.

The U.S. Census Bureau maintains detailed information on the size distribution of enterprises in each state, according to the highly detailed North American Industry Classification System (NAICS).[11] We have collated these data with our 60-sector BEAR model at the 6-digit industry level of detail, and the results clearly show that Oil and Gas is more highly concentrated than most industries in the state. Across the California economy, small businesses represent 97% of the enterprise population, but in Oil and Gas only 77%. As emphasized above, the Oil and Gas sector has a very high percentage of intermediate demand and supply linkage to sectors with similarly high industry concentration (machinery and fuel supply, respectively). This means indirect and induced effects of the proposed regulation will also have limited impact on small businesses. Even locally funded estimates find relatively modest in-state "multiplier" impacts (averaging about 1.8) because of weak linkages between this extraction activity and local enterprises.[12] Taken together, this means that small business impacts will be a fraction of the very small percentage changes in economic aggregates estimated in Section 4 below.

Some small business impacts from a WST permitting phase out may arise in spatial proximity to wells where stimulation would have otherwise occurred. These businesses may have no formal relation to Oil and Gas operations and are instead represented by goods and service vendors (e.g., retail, restaurants) whose clientele happen to include Oil and Gas industry workers. Relative to the baseline case of WST as it presently permitted, these businesses may see reduced patronage if Oil and Gas firms engage in less robust local operations that call for fewer employees in the area. Having said this, the population density data reviewed below (e.g. Figures 4 and 5) make it clear that these operations are quite isolated, meaning spillovers to local commerce will be limited.

In terms of Oil and Gas operators themselves, most of the WST-facilitated production in California is carried out by relatively large, economically robust firms. While some WST activity has been carried out by smaller, more marginal firms, such firms are not representative of WST operators generally. Among Oil and Gas firms owning fewer than 100 wells, WST disclosure activity is almost non-existent, with 3 reported WST applications from such operators between 2008 and 2015, and 1 disclosure in 2002. Only 34 additional instances of 2008-2015 WST disclosure are added if one includes any operator with fewer than 1,000 wells. Indeed, operators owning more than 10,000 wells

[11] See e.g. http://www.census.gov/naics

[12] See "The Economic Contribution of the Oil and Gas Industry in Kern County," Kern Economic Development Foundation.

(i.e., Aera and Chevron) are responsible for roughly 80% of all historical in-state WST disclosures.

Oil and gas production operations generally are not among the types of business activities categorized as a "small business" under the statutory definition applicable to this rulemaking determination. (See Gov. Code, § 11342.610; Cal. Code Regs., tit. 1, § 4.) That said, in terms of oil and gas operators themselves, most of the WST-facilitated production in California is carried out by relatively large, economically robust firms. While some WST activity has been carried out by smaller, more marginal firms, such firms are not representative of the operator community that typically employs WST.

Firms that provide specialized WST services to oil and gas production operators must overcome hurdles of large capital expense and technical expertise that act as a barrier to any business with gross receipts and employee numbers sufficiently low enough to meet the applicable statutory definition of "small business" definition.

Some impacts to small businesses other than the regulated community of oil and gas operators or firms engaged in providing specific WST services may arise in spatial proximity to wells where stimulation would have otherwise occurred. These businesses may have no formal relation to oil and gas operations and are instead composed of the goods and service vendors (e.g., retail, restaurants) whose clientele happen to include oil and gas industry workers. Relative to the baseline case of WST as it is presently permitted, these businesses may see reduced patronage if oil and gas firms engage in less robust local operations that call for fewer employees in the area. Additionally, small businesses in general, may be disproportionately affected by changes in fuel and other energy product costs – though, as discussed in the section below, price effects stemming from the proposed regulation are projected to be very small (e.g. less than half a cent per gallon of gasoline if applied to current[13] prices[14]), if any. Finally, small businesses across California could be adversely affected by changes in fuel and other energy product costs to the extent that price changes are observable at all, and the literature on environmental economics suggests that such enterprises face higher cost of capital constraints to adopting energy efficiency technologies. Despite this, however, as mentioned, price effects stemming from the proposed regulation are expected to be very small, if any.

In summary, no small businesses are expected to be directly affected by this regulation. Local small businesses may be indirectly impacted, but WST cessation will reduce average annual industry revenue in the county by about 2% (Section 4), with a fraction

[13] "Current" in this context refers to December 2023

[14]AAA Average California Gas Price, December 2023

of this being diverted from small business coffers. Statewide, small businesses can be expected to incur aggregate costs well below estimated Gross Domestic Product (GDP) percentage impacts because they are largely outside the supply chain of the regulated sector (Oil and Gas extraction). Impacts on small business energy costs will be significantly mitigated by imported energy, as discussed elsewhere. Apart from environmental and health effects discussed elsewhere, no benefits for small business are envisioned.

2.6. Competitive Advantage/Disadvantages for California Businesses

Because WST cessation will increase costs and reduce productivity for operators using this technology, their competitive position will be adversely impacted, at least in the short-term. Compared to more WST-reliant firms, the relative advantage will thus accrue to both in-state (non-WST) competitors and out-of-state producers regardless of their technology regimes. In the context of steady-state in-state, national, and global Oil and Gas markets, the regulation could increase supply by in-state, non-WST firms, as well as imports to California. These responses will depend on price signals arising from any supply gap resulting from declining WST-facilitated production. Since Oil and Gas is a commodity category with a high degree of product homogeneity (fuels from different sources are close substitutes), and the expected gap is small relative to external markets, price impacts are projected to be very small (i.e. less than half a cent per gallon of gasoline if applied to current gas prices), if any.

Beyond the sector itself, we know from experience of the 1970's energy crisis that the pervasive nature of fossil fuel energy services makes the whole economy vulnerable to Oil and Gas price escalation. California has improved its resilience in this context, reducing the risk of Oil and Gas price pass-through with a combination of determined investments in energy efficiency and renewable energy supply alternatives. Current events remind us that global energy markets can be quite unpredictable and volatile, but as explained elsewhere in this SRIA, price effects of this particular regulation are expected to be very small, if any due to reduced demand for fossil fuels and substitution from other markets.

3. BENEFITS TO CALIFORNIA BUSINESSES AND CONSUMERS

In this section we assess the direct benefits of the proposed WST permitting phase out and quantify them where possible. While the previous section addressed costs associated with foregone Oil and Gas revenue, eliminating WST would also reduce firm expenditures within the sector. These costs not incurred are quantified here as direct benefits.

Other potential benefits are discussed but not quantified because insufficient data is available to quantify the link between reduced production as a result of WST and reduced emissions which are necessary to see health and environmental benefits. Additional potential benefits include limiting exposure to potential hazards attributable to WST such as chemical changes in the soil, water, or air (CARB, 2020; Shonkoff et al 2015). In addition, there is some evidence from other states that the elimination of WST could decrease seismic activity risk (Norris et al 2015). However, seismic activity has not been detected by the U.S. Geological Survey (USGS) as a result of WST activities in California.

Other hazards are not directly linked to WST itself but rather to the expanded Oil and Gas development enabled by WST. These indirect hazards encompass any damages that scale with the volume of Oil and Gas production including emissions that influence local air quality. Based on available evidence, indirect damages caused by the Oil and Gas production enabled by WST comprise most of the risk associated with the technology application in California (Shonkoff et al 2015 pg. 375). Well stimulation procedures themselves contribute a limited amount of the total risk ultimately associated with the practice. While insufficient data are available to fully quantify most of these benefits, they are discussed qualitatively at the end of this section.

3.1. WST Expenses Not Incurred

The costs of WST applications not incurred under the proposed regulation were estimated using information gathered by CalGEM from Oil and Gas operators in the lead-up to SB 4 regulations.[15] Data were combined to predict annual, future expenditures related specifically to WST operational costs that would not be incurred

[15] SB 4 regulations defined a new suite of reporting requirements for in-state Oil and Gas firms; these requirements focused especially on the application of various forms of WST.

under the proposed regulation (CalGEM, 2013; Williams & Genest, 2018). Non-WST operational cost estimates were derived through a synthesis of these aforementioned production forecasts with Oil and Gas firm expense reporting (Department, 2021d; Department, 2021e). These steps facilitated estimation of both the upfront operational costs of WST and all other (non-WST) operational costs that Oil and Gas firms would have incurred amidst this foregone WST-facilitated production. Table 4 shows the expenses not incurred separately by category and in total. These avoided expenditures are considered direct benefits of the proposed regulation because they are eliminated in direct response to the WST phase out.

Table 4: Direct Benefits[16] (Permit Phase-Out Scenario)

Year	Upfront WST Expenses not incurred ($)	Operational Expenses not incurred ($)	Total Expenses not incurred ($)
Year 1	2,986,981	17,309,164	20,296,145
Year 2	8,395,824	48,449,988	56,845,812
Year 3	13,008,328	74,756,750	87,765,078
Year 4	16,975,935	97,156,774	114,132,709
Year 5	20,620,924	117,535,715	138,156,639
Year 6	24,132,455	136,992,685	161,125,140
Year 7	27,555,005	155,790,989	183,345,994
Year 8	30,907,890	174,047,958	204,955,848
Year 9	34,224,624	191,958,671	226,183,295
Year 10	37,520,170	209,611,459	247,131,629

These benefits in the form of avoided costs represent the total of quantifiable benefits considered here. However, it should be emphasized that they are not comprehensive of all likely benefits associated with the proposed WST permitting phase out. For example, health benefits associated with limiting community exposure to environmental hazards such as water and air pollution are not quantified. Due to limitations in evidence and data, and uncertainty around the locations of future wells, quantifying these benefits is beyond the scope of this SRIA. Benefits quantified here thus represent a portion of total benefits. Additional potential benefits not quantified are discussed further in Section 3.3.

[16] See Appendix 4 for methodological details on how estimates were derived.

3.2. Assumptions and Uncertainty

Estimates of expenses not incurred rely on Oil and Gas production forecasts which have several key sources of uncertainty that were discussed in detail above in the context of costs. These same assumptions and uncertainties apply here – that, broadly speaking, historical data on Oil and Gas production, pricing, and other sector details are relevant in predicting how these will relate in the future. See Section 2.3 for additional details.

Operational costs also rely on information from SEC 10K reporting of existing Oil and Gas operators and the analysis used WST cost information that CalGEM gathered from existing Oil and Gas operators when preparing SB 4 regulations. Estimates of costs not incurred therefore rely on these numbers and we assume they are accurate and representative of the sector as a whole.

In addition, CalGEM gathered WST costs when SB 4 regulations were prepared in 2013. Thus, even adjusting for inflation, WST cost estimates miss the specific changes of WST costs since 2013. Still, this is the best possible estimate available for computing WST costs.

Finally, the analysis extrapolated WST and non-WST cost rates (i.e., cost per BOE) of some major Oil and Gas producers to all Oil and Gas producers. Thus, the estimated costs of existing Oil and Gas producers in California would deviate from their actual Oil and Gas costs to the extent that production cost rates among reporting Oil and Gas operators differ from the remainder Oil and Gas operators.

For full details on the data and estimation procedures see Appendix 4.

3.3. Unquantified Benefits

3.3.1. Public Health Benefits from Reduced Pollution Exposure

A comprehensive accounting of potential public health impacts associated with the proposed WST phase out is beyond the scope of this economic analysis. In this section we discuss the factors that would influence the magnitude of these benefits.

Well stimulation could potentially generate public health hazards through the stimulation process itself or through the additional Oil and Gas production induced. Based on available evidence, general hazards caused by the additional induced Oil and Gas production that is facilitated by WST (and not well stimulation itself) comprise most of the public health risk associated with WST application in California (Shonkoff et al 2015 pg. 375).

To better understand the public health risks of Oil and Gas production in California, and to help inform CalGEM's Public Health rulemaking process, a scientific advisory panel was assembled in October 2020 (Shonkoff et al 2021). The panel reviewed available evidence and concluded "with a high level of certainty" that:

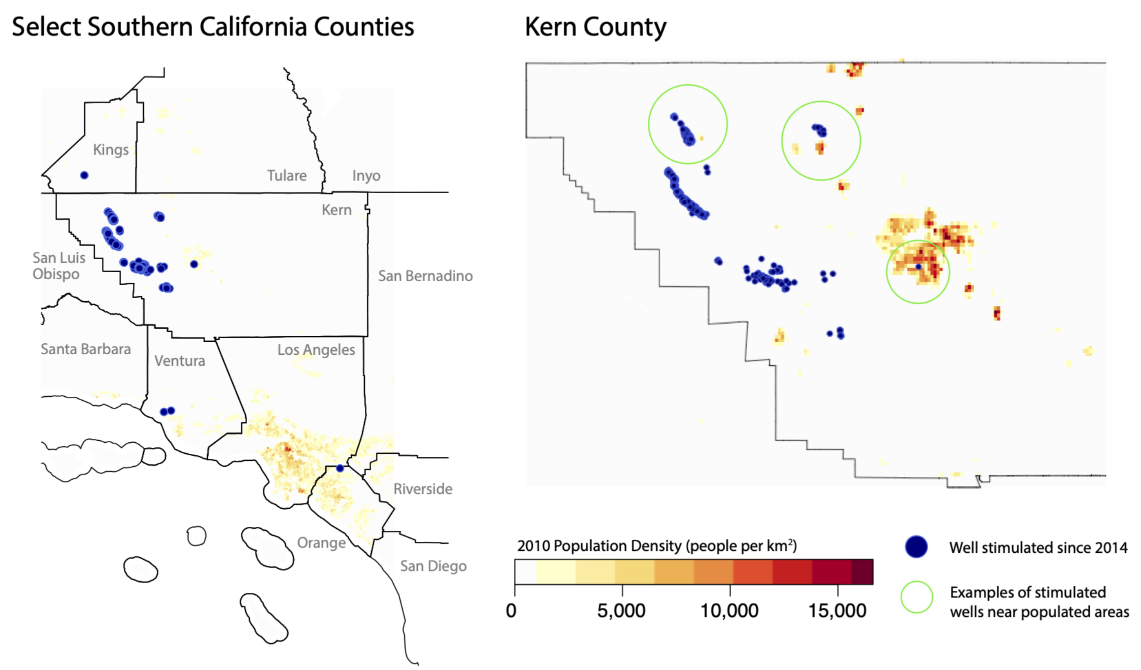
- Concentrations of health-damaging air pollutants are more concentrated near Oil and Gas production sites (Shonkoff et al 2021, pg. 11)
- There is a causal relationship between close geographic proximity to Oil and Gas development and adverse respiratory and perinatal outcomes (Shonkoff et al 2021, pg. 4)
- These conclusions apply to California Oil and Gas production methods (Shonkoff et al 2021, pg. 2)

These findings were based on a review of available studies examining health impacts associated with both conventional and unconventional Oil and Gas production and as part of larger ongoing efforts to comprehensively assess public health benefits associated with limiting proximity of sensitive receptors to Oil and Gas production in California. The assessment does not pertain specifically to WST activities but is relevant to the WST permitting phase out policy because the permitting phase out is estimated to reduce total Oil and Gas production levels.

The magnitude of public health benefits associated with the proposed WST permitting phase out would largely depend on the size of the population in proximity to wells that would have been stimulated absent the permit phase out. Most, but not all, stimulated wells in California are located at remote sites away from populated areas and are located in the western part of Kern County (see Figure 4). Thus, impacts of the regulation are likely to be limited to that area of Kern County that is proximal to these wells.

Due to the limited geographical extent of well stimulation practices in California, it is possible to identify the general location of communities most likely to experience public health benefits from the proposed regulation as those surrounding the Belridge North, Belridge South, and Lost Hills fields. These wells are concentrated in the area because of geologically favorable conditions for WST (Shonkoff et al 2015). In light of these considerations, populations living in western Kern County are most likely to accrue the majority of the benefits from the proposed regulation. These benefits will accrue slowly, as production decreases due to the inability of wells to be stimulated.

Figure 4: Population Density near Wells Receiving WST



Note: Map of wells stimulated since 2014 overlaid with population density – for select Southern California counties (left) and Kern County (right). Most WST wells are located in Kern County, some of which are proximate to areas with population densities in excess of 5,000 individuals per km²

3.3.2 Avoided Worker Injuries

Employment in the Oil and Gas extraction sector is associated with a number of risks to workers including explosions and fires, chemical exposures, falls, and vehicle accidents, among others (OSHA, 2021). WST practices represent a subset of the overall risks and include hazards related to working with high pressure fluids and exposure to chemicals. The proposed WST phase out would both eliminate risk from WST-specific occupational hazards as well as reduce total worker exposure to hazards more generally associated with Oil and Gas production (due to the associated decline in production). However, insufficient data are available to quantify avoided occupational hazards.

National data for Oil and Gas extraction activities from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) Current Statistics (BLS, 2020) indicate injury rates for all workers in Oil and Gas Extraction (NAICS code 211000) were 19.3 fatal occupational injuries per 100,000 Full-Time Equivalent workers in 2019. However, these risks are not specific to the well stimulation process itself, but to Oil and Gas production more generally. While activities associated with WST like working with stimulation chemicals are known to pose a hazard to workers, OSHA injury reports do not include sufficient information to assess whether a given injury was associated with WST activities or, more precisely, whether a specific injury would have been prevented had WST practices not been used.[17] Moreover, even if this information were reported, there are likely not enough workers participating in WST activities to generate stable statistics on injury rates with these practices.

3.3.3. Water Inputs in WST

In 2019, WST in California directly used 643,000 barrels (27 million gallons) of water, about 95% of which was suitable for human consumption or agricultural use (Department 2021a). The majority of water use in WST-enabled Oil and Gas recovery, though, occurs in the course of production outside of WST itself. However, previous analyses have indicated that much depends on the particular portfolio of secondary production techniques, and that water use outside of WST can range from 2-16 times the direct WST water inputs (Shonkoff 2015). Using 2019 production as a baseline, this implies potential, cumulative water savings of 81-459 million gallons annually.

3.3.4. Effects on Water and Soil Quality

Analyses of groundwater and soil adjacent to WST- enabled Oil and Gas wells have been carried out by a variety of research bodies including the California Water Board (CA Water Board 2018) and the USGS (Gillespie et al 2019). These assessments suggest that the fluid injections associated with WST and the disposal of produced water may both increase the salinity of nearby waters and soils as well as increase the presence of contaminants (e.g., arsenic, boron, radionuclides) (Gillespie et al 2019; CA Water Board 2018).

A relative scarcity of data, including longitudinal assessments to gauge any effects on municipal water supplies, inhibits the quantification of these impacts on economic, environmental, and human health. Nevertheless, concrete litigation has manifested on this basis; for example, agricultural producers have pursued and successfully obtained

[17] This is not a straightforward assessment. For example, imagine a hypothetical scenario where a worker was injured by a truck at a well that was recently stimulated. To determine whether the injury was attributable to stimulation activities an assessment would need to be made as to whether that truck would have been utilized in a scenario where that well had not been stimulated.

compensation from Oil and Gas firms on the grounds of salinity-induced damage to their soils and crops (Watson 2021).

3.3.5. Equity Concerns and Psychosocial Harm

Research indicates that psychosocial harms and other negative externalities are associated with in-state Oil and Gas operations, including those facilitated by WST. Further, these negative externalities tend to fall disproportionately on rural, low-income, non-White communities – Latinx residents in particular (NRDC 2014; Ferrar 2014). The benefits to local communities and environmental resources discussed elsewhere in this assessment would thus more intensely accrue to these groups in the context of a permitting phase out.

3.3.6. Seismic Activity

WST has been documented as inducing seismic activity in the United States and elsewhere (Skoumal et al 2018, Schultz and Wang 2020, Wang 2020). However, studies suggest that the intensity of this activity may be mild relative to California's typical seismic context (Jackson et al 2014). More specifically, the vast majority of seismic activity that has been connected to WST has been of a magnitude below the threshold recognized as posing a risk to humans or structures. The relatively rare instances in which WST is suspected as having induced seismic activity beyond that threshold (i.e. causing bodily harm and damaging property) are associated with fluid injections into fault-adjacent "deep strata" – rock layers that extend significantly further into the earth compared to the more "shallow" wells typical of WST operations in California (Ellsworth 2013). Moreover, current WST regulations require seismic monitoring and across all years with available data (2016-2020) there is no evidence of any seismic activity associated with WST in California.

3.3.7 Wildlife Habitat

Assigning a dollar value to wildlife stewardship is complex, and methodologically problematic. Ecological researchers have nevertheless found that a number of endangered species in California are likely to face increased habitat encroachment as a result of Oil and Gas development in the state: WST in particular may lead to relatively intensified habitat fragmentation as compared to non-WST extraction operations (Robbins 2013).

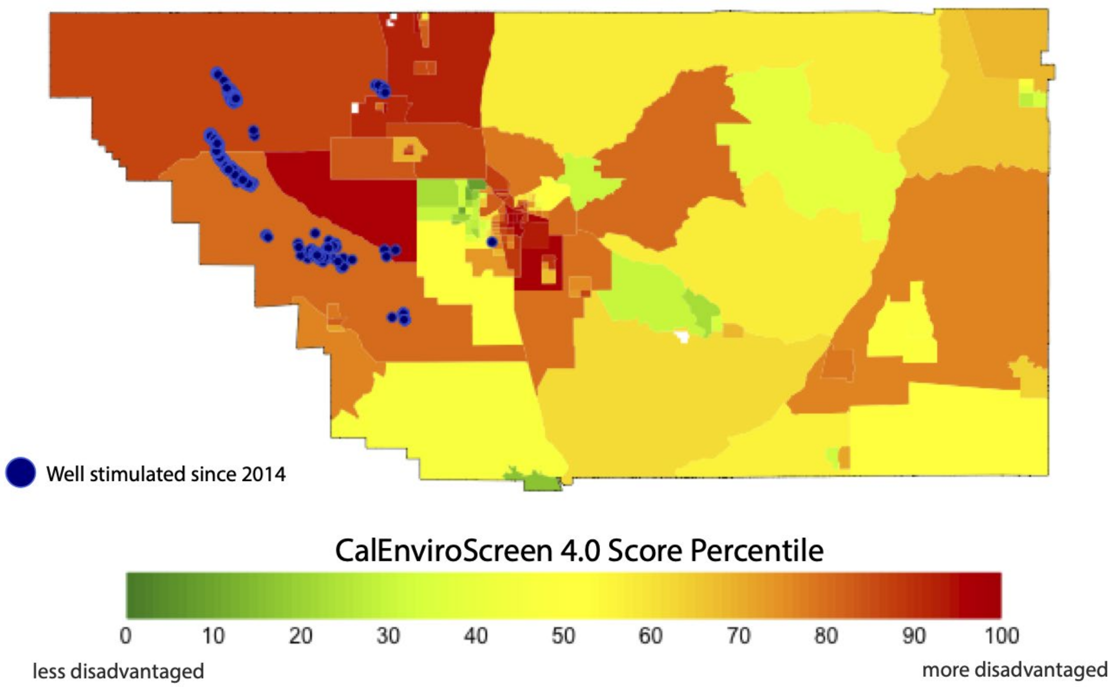
3.3.8. Carbon Intensity & Greenhouse Gas Emissions

The total greenhouse gas emissions associated with extracting and refining a barrel of crude oil depend on a variety of factors, including utilized operational techniques and natural differences between hydrocarbon deposits. Oil with higher "carbon intensity" releases larger quantities of greenhouse gas emissions to produce a given amount of refined fuel. These conditions may change in the context of a WST permitting ban. On the operational side, evaluations of California's Oil and Gas sector have found that the greenhouse gas emissions associated with WST well operations are on average lower than those associated with alternative production techniques (e.g., steam-flooding) (CCST & LBNL 2015a). In this sense, a shift away from WST could put upward pressure on greenhouse gas emissions. Conversely, WST is practiced in oil fields that, relative to the statewide average, have high carbon intensity crude; a geographic shift of Oil and Gas operations away from these fields could put downward pressure on these emissions. While a relative shift towards fuel imports would reduce greenhouse gas emissions released in California, the ultimate emissions impact of such a change would depend on the carbon intensity of those out-of-state deposits (CARB 2021). Further, even if in the short term an inflexible demand for fossil fuels is met by increased hydrocarbon extraction and greenhouse gas emissions occurring partially outside of California (and thus beyond the direct regulatory control of California law), that in-state demand may decrease over time, and hydrocarbons not extracted in California due to a phase out of WST activities will remain underground in California rather than being converted to greenhouse gas emissions affecting the global climate.

3.4. Distributional Impacts of Potential Benefits

The impacts of the proposed WST phase out will not be evenly distributed across the population. People living nearby stimulated wells would experience the most benefits from reduction in WST-facilitated production because proximity to wells comes with the highest likelihood of experiencing impacts. Most of these residents tend to come from disadvantaged communities. To assess the vulnerability of populations living near stimulated wells we examined CalEnviroScreen 4.0 scores (OEHHA 2021) in Kern County near wells that have been stimulated in the past. CalEnviroScreen is a tool developed by the California Office of Environmental Health Hazard Assessment (OEHHA) for the purpose of identifying California communities that are disproportionately burdened by multiple sources of pollution and other factors. The CalEnviroScreen score provides a measure of vulnerability and can be used to identify disadvantaged communities. Here we rely on the percentile of CalEnviroScreen score (higher scores correspond to greater disadvantage) and map results in western Kern County where most well stimulation takes place (Figure 5).

Figure 5: Relative Advantage of Populations Near Wells Receiving WST



Most wells that have been stimulated since 2014 are located in census tracts designated as disadvantaged communities. On average, census tracts within Kern County receive a CalEnviroScreen Score Percentile of 66 suggesting they are more disadvantaged than 66% of census tracts statewide. Within Kern County, census tracts where stimulated wells are located have an average CalEnviroScreen Score percentile of 79 while census tracts in Kern County without stimulated wells have an average score percentile of 65. In other words, census tracts with WST activity are substantially more vulnerable to environmental hazards than census tracts without WST activity both within Kern County and statewide.

The census tracts in Kern County with stimulated wells are considered more disadvantaged than census tracts in Kern County without stimulated wells in part because they have higher rates of poverty (census tracts with WST are in the 78th percentile for poverty; census tracts without WST are in the 42nd) and higher rates of water contamination (census tracts with WST have a water contamination rate in the 88th percentile; census tracts without WST are in the 75th). With respect to Baseline air quality, census tracts with a history of WST have slightly lower Baseline PM2.5 and ozone levels than census tracts without WST (13.4 ug/m3 vs 12.7 ug/m3 PM2.5 and 90.5 vs 79.9 ppm ozone). This is likely because the census tracts with a history of WST are more rural and have fewer other sources of pollution contributing to poor air quality (e.g., transportation emissions). In sum, the impacted populations are likely to be disproportionately vulnerable according to the state's CalEnviroScreen Tool.

Given this existing vulnerability and the geographic focus of WST, benefits of the regulation are most likely to accrue to those disadvantaged populations living in the areas surrounding the Kern County fields that are most likely to be stimulated.

4. MACROECONOMIC IMPACTS

4.1. Methodology

The economy-wide impacts of the proposed WST phase out are evaluated using the Berkeley Economic Advising and Research (BEAR) forecasting model. The BEAR model is a dynamic computable general equilibrium (CGE) model of the California economy (see Appendix 2 for a technical summary). It explicitly represents demand, supply, and resource allocation across the state, estimating economic outcomes over the period 2024-2032. For this SRIA, the BEAR model was aggregated to 60 economic activities, with detailed representation of the sectors most likely affected by the WST rule.

4.2. Regulatory Baseline

The current version of the BEAR model is calibrated using 2020 IMPLAN data for the California economy (see Appendices 1 and 2). Both the Baseline and PRS use the Department of Finance conforming forecast from May 2022 including official assumptions on GDP growth projections for the State and population forecasts. In addition to DOF-supported macroeconomic calibration, the Baseline scenario needed to reflect microeconomic realities of the state's Oil and Gas sector. To develop this component, the Department and its consultants reviewed the historical evolution of California's Oil and Gas production, including the contribution of well stimulation to Oil and Gas production. In doing so, the SRIA relies on internal data records of well stimulation disclosures and Oil and Gas production from CalGEM going back to 1977.

This analysis is based on 2022 baseline data. A preliminary review of the 2023 data indicates that new baseline data would not change the analysis significantly.

The Baseline also accounts for the performance of California's Oil and Gas industry with respect to employment, wages, business size, and operating location over time, including the proportion attributable to production facilitated by WST. Accordingly, the Department and its experts gathered industry data from the Employment Development Department to develop this historical assessment. For more details on these sector imputations, see Appendix 4 below.

As described in the benefits sections of this report, the SRIA team also utilized detailed demographic and socioeconomic characteristics of localities close to oil operations to evaluate distributional impacts of public health benefits associated with the proposed WST phase out. This work relied on the state's CalEnviroScreen 4.0 database, which tracks a diverse array of demographic and economic data at the census tract level.

To support this assessment, the Department prepared detailed 2021-2039 Baseline projections on Oil and Gas production. The Oil and Gas production forecast relied on historical CalGEM data; the 2021 Annual Energy Outlook of the EIA, using historical relations between national and state production; research literature; and inputs from subject matter and industry experts. The Oil and Gas employment and business establishments projections relied mainly on DOF's Economic Forecast. Finally, the SRIA relied on alternative public data and research sources where further business establishment and employment information was needed.[18]

4.3. Scenarios

The macroeconomic impact results are based on the expected changes in costs attributable to the regulatory implementation of the WST permitting phase out. The main scenario, "Proposed" (PRS), represents the expected impact on the overall California economy associated with this regulation's implementation as it is currently worded, and takes account of both the costs and benefits of the proposed WST rule.

4.4. Inputs to the Assessment

In addition to the BEAR model's detailed database on the Baseline structure of the California economy, the macroeconomic assessment is calibrated to incremental, sector specific WST costs and benefits described above. Costs of lost Oil and Gas firm

[18] See discussion in Section 3.3 regarding occupational safety.

profits are captured through changes in oil production which enter directly in the BEAR model.

Note that these costs and benefits are entered into the BEAR model as direct (not net) costs and benefits and with indirect and induced costs and benefits derived within the model as they would pass through markets and institutional transfers across the state economy. Both forms of cost and benefit impacts are captured by the BEAR model and then aggregated into net economic impacts, annually over the period 2024-2032.

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

4.5. Macroeconomic Estimates

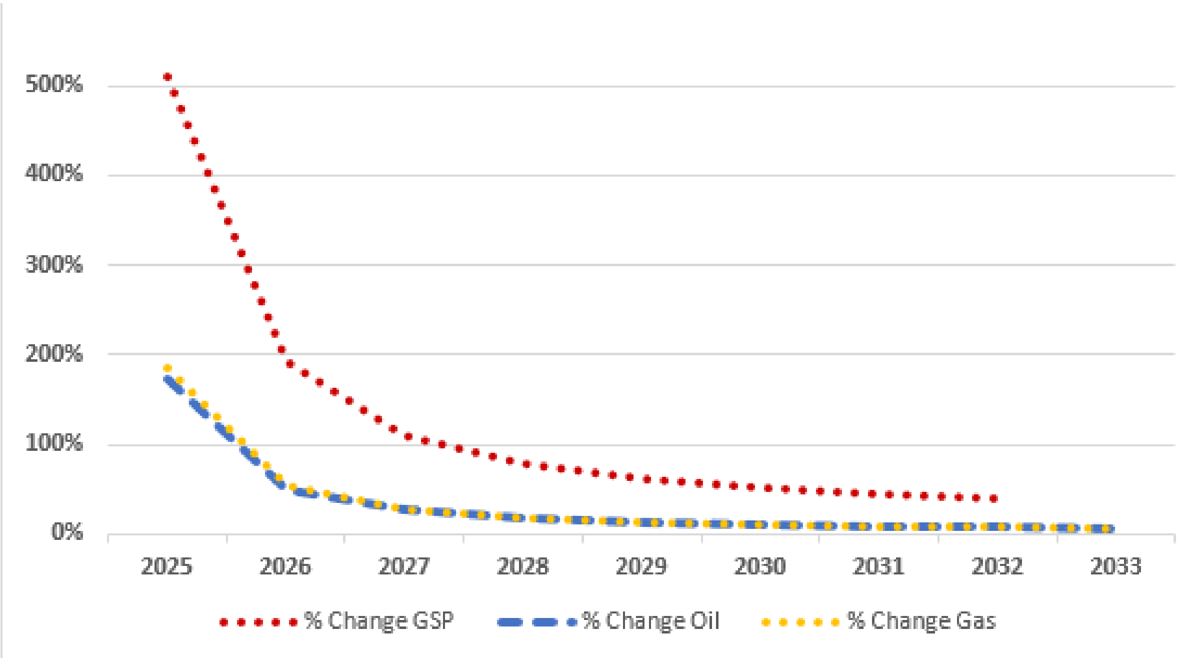
Table 5: Economy-Wide Impacts of WST Regulations

$M Impact	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	-19	-116	-339	-712	-1,268	-2,046	-3,093	-4,462	-6,218	-2,030
Employment (FTE)	-54	-104	-88	-57	-62	-142	-334	-676	-1,208	-303
Real Output	-57	-248	-617	-1,206	-2,073	-3,287	-4,924	-7,075	-9,847	-3,259
Investment	4	-24	-121	-288	-529	-851	-1,265	-1,781	-2,412	-807
Percent Impact	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	Average
Gross State Product ($M)	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.04%	-0.05%	-0.07%	-0.09%	-0.04%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real Output	0.00%	0.00%	-0.01%	-0.02%	-0.03%	-0.04%	-0.06%	-0.08%	-0.10%	-0.04%
Investment	0.00%	0.00%	-0.02%	-0.04%	-0.06%	-0.10%	-0.14%	-0.19%	-0.25%	-0.10%

Note: All results are annual average differences from Baseline over Years 1 through 9. All figures in 2020 $ millions or Full-time Equivalent (FTE) employment headcounts.

Comparing the economy-wide impacts presented in Table 5 to the changes in production predicted in Table 2 in Figure 6, we can see that although there is a significantly larger impact on GSP in the first few years the change in impact slows by the end of the decade and is similar to the graph of changes in time for oil and gas production.

Figure 6: Percentage Change in GSP Relative to Percentage Change of Oil and Gas



4.5.1. Overall Economy Response

A summary of aggregate macroeconomic impacts of the regulation is given in Table 5. Three salient features are apparent. First, the regulation is significant to Baseline or "Business as Usual" economic activity in the state's own Oil and Gas sector, and this translates into real net losses for established business in and closely allied to WST activities in the sector. Second, the WST regulation will reduce average annual real GSP relative to the Baseline reference by about $2 billion per year over the period 2024-2032. As will be emphasized throughout this assessment, this number is completely overwhelmed by Baseline aggregate growth, meaning the result is negative only relative to no WST policy.

4.5.2. Creation or Elimination of Jobs within California

The aggregate job results follow the slower growth trend in the sector, yielding an average of about 300 fewer new jobs across all sectors of the California economy, as represented in the "Employment FTE" rows of Table 5. Oil and Gas is among the most capital-intensive sectors in the California economy. When a policy represses investment in such a sector, the impact to job creation is much lower on a percentage basis than other sectors. Data from the Bureau of Economic Analysis and Bureau of Labor Statistics suggest industry sectors including “retail”, “private services”, and “construction” are significantly more labor-intensive than the oil and gas sector, so jobs not created from repressed investment in those sectors would be higher on a percentage basis than in the oil and gas sector. Although some of the jobs that would have been created are relatively highly compensated, at the aggregate level these changes are less than a hundredth of one percent for all sectors, and do not reverse Baseline job growth in this industry or across California.

The 300 new jobs annually over ten years that will not be created if the WST prohibition is implemented includes jobs not created in the oil and gas industry as well as across sectors. It is important to remember that jobs associated with WST is not just limited to the jobs needed to perform the stimulation itself, but because WST ultimately increases oil and gas production from wells where it is used, it also includes jobs associated with increased oil and gas production. Further, the 300 new jobs not created annually includes not just new jobs in the oil and gas sector, but in other sectors as well. The model relied on suggests that the majority of jobs that will not be created occur in impacted non-oil-and-gas industry sectors, including supply chain partners and sectors impacted by worker spending. This jobs model did not account, however, for the potential effect of decreasing in-state demand for oil and gasoline on jobs in the sector regardless.

4.5.3. Creation of New Businesses or the Elimination of Existing Businesses within California

The implications of the proposed regulation for the state business environment are intuitive, and it is reasonable to expect cost-induced contraction within the regulated sector and demand/productivity driven expansion in services and other manufacturing. Unfortunately, we lack the detailed data needed to predict enterprise level adjustments, i.e., specific firm entry or exit. While cessation of WST reduces the technology options for the industry, many firms are viable without having adopted it. Current WST operators may see narrower margins, but not be forced to give up their work in the state or even any individual operations. Only time will tell how this adjustment plays out at the firm level, where the impact of the regulatory change will depend upon many sources of uncertainty.

4.5.4. Competitive Advantages or Disadvantages for Businesses Currently Doing Business within California

To the extent that the regulation increases costs for WST practitioners, it will undermine their individual competitiveness against non-WST operators and out-of-state competitors with or without WST technology options. Again, we do not possess sufficiently detailed enterprise-level data to predict these competitive adjustments at the microeconomic level. However, our analysis reveals that California's economy as a whole will not suffer significant Oil and Gas supply constraints or attendant price inflation. Our economic forecasting model accurately reflects the fact that California imports a significant majority of its Oil and Gas, that imports are very close substitutes for its own production, and global supply of oil will not be disrupted by the proposed regulation. Importantly, the model does not explicitly account for the substantial reduction in transportation fuel demand associated with the implementation of CARB's scoping plan—reduction that would occur with or without the proposed WST regulation. Thus, the price and inflationary pressures presented in this analysis should be interpreted as conservative estimates.

These findings can be seen in Table 6 and Table 7 below, which show supply, demand, and related estimates for the Oil and Gas sector. Several features deserve closer examination. As expected, the regulation increases cost and reduces productivity for some operators, reducing in-state output and investment in the sector, but this decline only averages 2% in each year (not compounded) of the forecast period. Even without induced innovation (not modeled here), the sector appears to be quite resilient.

Table 6: Trend Adjustments in California Oil and Gas ($M)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
CA Supply	-11	-72	-212	-437	-755	-1,183	-1,736	-2,434	-3,303	-629
CA Demand	-17	-68	-157	-290	-475	-723	-1,047	-1,462	-1,986	-397
Imports	-6	4	55	147	280	460	689	972	1,317	233
Exports	1	-6	-32	-75	-136	-216	-317	-439	-585	-111
Investment	-3	-21	-63	-130	-225	-353	-517	-726	-985	-188

Note: Difference from Baseline scenario in year indicated. All figures in 2020 $ millions

Table 7: Trend Adjustments in California Oil and Gas (percentage difference from Baseline)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Averag e
CA Supply	0%	0%	-1%	-2%	-3%	-4%	-6%	-8%	-10%	-3%
CA Demand	0%	0%	-1%	-1%	-2%	-3%	-4%	-5%	-6%	-2%
Imports	0%	0%	0%	1%	3%	5%	7%	9%	12%	3%
Exports	0%	0%	-2%	-3%	-6%	-9%	-12%	-16%	-19%	-5%

4.5.5. Price Impacts

As Table 7 indicates, imports and declining demand compensate for lower in-state production, and the BEAR model estimates that prices could conceivably rise to achieve this substitution, but any price impacts would be very small, if any (e.g. less than half a cent per gallon of gasoline if applied to current gas prices). With respect to Oil and Gas, it must be recalled that California is a large consumer, but a small supplier in global markets. Taken together, these two facts mean that, at the margin, changes in state output can easily be offset by domestic and international energy trade. Economically speaking, the "trade effect" of competing out-of-state oil supplies and dominant imports (80% of CA demand) is modest, and elastic enough to limit price inflation. In terms of pass-through impact on other economic activities and institutions, the effects will be even smaller. Nationally, fuel cost is equivalent to 5% of GDP. Thus the "inflationary" impact of the regulation, in aggregate, could average 0.1%, a number that is dwarfed by more systemic sources of fossil fuel price volatility. Even if these price effects were discernible, their magnitude is such that they would be very unlikely to trigger behavioral changes. Much more decisive factors, such as decarbonization trends and macro energy market trends, are likely to be decisive for individual energy use and technology adoption decisions. Additionally, it should be noted that the BEAR model does not include field-specific price substitution when it estimates an increase in price. For example, oil from the Lost Hills field, one of the few areas where WSTs take place, is typically more expensive than other fields in California and imported oil. The BEAR model also does not account for the higher carbon intensity of Lost Hills and South Belridge fields which result in higher compliance costs under California Low Carbon Fuel Standard. The most likely substitutions have lower carbon intensity scores even when accounting for life cycle emissions from transportation and flaring[19].

Finally, any impact to prices associated with reduced supply from WST-enabled production is likely to be neutralized by the increased deployment of electric vehicles necessary to meet the demand induced by the requirement that all new cars and light trucks sold in California by 2035 be zero-emission vehicles. Consistent with Governor Newsom's Executive Order N-79-20, CARB estimates that plug-in hybrid electric vehicles and zero-emission vehicles will increase from 35% of new vehicles to 100% of new vehicles by 2035[20]. This dramatic expansion of clean vehicles will substantially reduce

[19] California Air Resources Board Calculation of 2020 Crude Average Carbon Intensity Value: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/crude-oil/2020_crude_average_ci_value_final.pdf

[20] California Moves to accelerate to 100% new zero-emission vehicle sales by 2035: https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035

demand beyond the reduction contemplated in this analysis, for oil overshadowing the supply reduction associated with this regulation.

4.5.6. Increase or Decrease of Investment in California

Although the macroeconomic impact on state investment is negligible, WST restrictions will have more direct but complex impacts on the regulated sector. The investment climate will be impacted by the regulation in different directions, with three primary factors to consider. First, lower productivity for some wells will discourage investment by operators in conventional production methods. Second, options for more innovative investment may be taken up by such firms, competitors, or new entrants (more on this in the next section). Finally, lower productivity will slightly diminish export competitiveness.

4.5.7. Incentives for Innovation in Products, Materials, or Processes

Although techniques and processes in the fossil fuel industry are well-established, having been developed over the sector's extensive history, innovation continues there, particularly in the digitization of exploration and production technologies. While these represent different approaches to increasing exploitable reserves and process efficiency/productivity, they all lead to the same bottom line for the sector as a whole. Predicting innovation is rarely successful for economic forecasters, and in this sector data to support that is very sparse and proprietary. It suffices for the present to observe that WST cessation does not change the state's resource base in any way, opening opportunities for innovators to find new, more environmentally friendly pathways to responsibly and sustainably harvest and benefit from California energy resources.

4.6. Benefits to California Businesses and Consumers

4.6.1. Operators

Oil and Gas operators within the state will be better or worse off, in terms of direct impacts, to the extent that they are reliant or not on WST. The first category will incur the direct costs estimated by the Department and presented as data for this SRIA. This is expected to repress investment and employment at least temporarily, with a potential rebound from investment in other productivity-enhancing technologies. Operators who simply cease production will cut their short-term costs and may move to energy reserves that do not require WST. Those remaining in operation may find investments that yield innovation and even greater efficiency.

that could responsibly model these microeconomic changes, and we have therefore made conservative assumptions that they will incur adjustment costs without discoveries of new technologies.

4.6.2. Other California Private Enterprises

For the purposes of the SRIA, other California private enterprises fall into two groups. The first are those allied with WST operators by "economic proximity", either physically close and sharing local economic activity or in some supply chain relationship. Nonetheless, they would experience indirect or induced costs from WST adversity. Results like this could be teased out with very detailed multiplier models, but they are dwarfed in the statewide analysis and in any case such firms are few in number and mostly diversified between WST and non-WST operators.

5. FISCAL IMPACTS

5.1. State and Federal Revenues

As expected, the relative reductions of GSP/GDP would be accompanied by lower revenue from many income-based fiscal sources. These effects are summarized in the following table, predicable in direction but very negligible in comparison to Baseline fiscal resources as well as small relative to the net economic costs and benefits of the policy. It should be noted that the BEAR model aggregates state and local government revenue streams, and because oil sector production activities are spatially concentrated, there will be disproportionate impacts in some localities. This issue is discussed further in the next sub-section, but for income-based taxes it is reasonable to assume that the regulation will impact State and Federal revenues by less than the maximum GDP change over the next decade (see Table 5).

Table 8: Estimated State and Federal Revenue Reductions of the PRS Associated with Income-Based Taxes ($millions)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
State	1	0	-7	-20	-37	-59	-86	-120	-148	-53
Federal	1	0	-4	-10	-18	-29	-41	-53	-79	-26

As discussed in sections 2.3 above, the PRS will have no impact on the revenues of CalGEM as it pertains to the oil and gas assessment, because the assessment will always be adjusted to meet budgetary needs irrespective of WST permitting. Idle well fees will be added to a fund used to remediate orphan wells, but the PRS does not anticipate any change in the number and amount of idle wells fees as a result of the rule. With respect to more targeted fiscal policies like gasoline and other fuel tax revenue, this analysis suggests that any impacts attributable to the proposed WST permitting phase out are negligible. Certainly, upstream regulatory effects can trickle down to the retail level – but a variety of factors inhibit that process here.

Section 4.5.4 "Competitive Advantages or Disadvantages" above illustrates the expected changes in demand for Oil and Gas relative to the regulatory Baseline, as well as possible price adjustments. On an average annual basis, the relative decline of in-state production and fuel demand, as well as the relative increase in fuel prices, could increase over the Baseline. Much of this outcome has to do with relatively modest estimates of future in-state Oil and Gas production derived from wells that would have been stimulated in the future, absent the proposed regulation. Even modest decreases in California Oil and Gas production, however, will be offset by the fuel imports they encourage and the substantial anticipated reduction in demand associated with new Zero Emission Vehicles and Plug-in Hybrid Electric Vehicles.

Californians' fuel demand is unlikely to be significantly affected by the trend price effects discussed in Section 4, averaging less than 0.1% of average household income and likely less than half a cent per gallon of gasoline if applied to current gas prices, if any. Historically, consumer demand for transport fuels has also been quite own-price inelastic. Accordingly, state revenue impacts passing from this regulation through the fuel system are estimated to be negligible. Again, CARB anticipates a 94% reduction in demand within the next 23 years, much of which will take place within this analysis period, but is not explicitly accounted for.

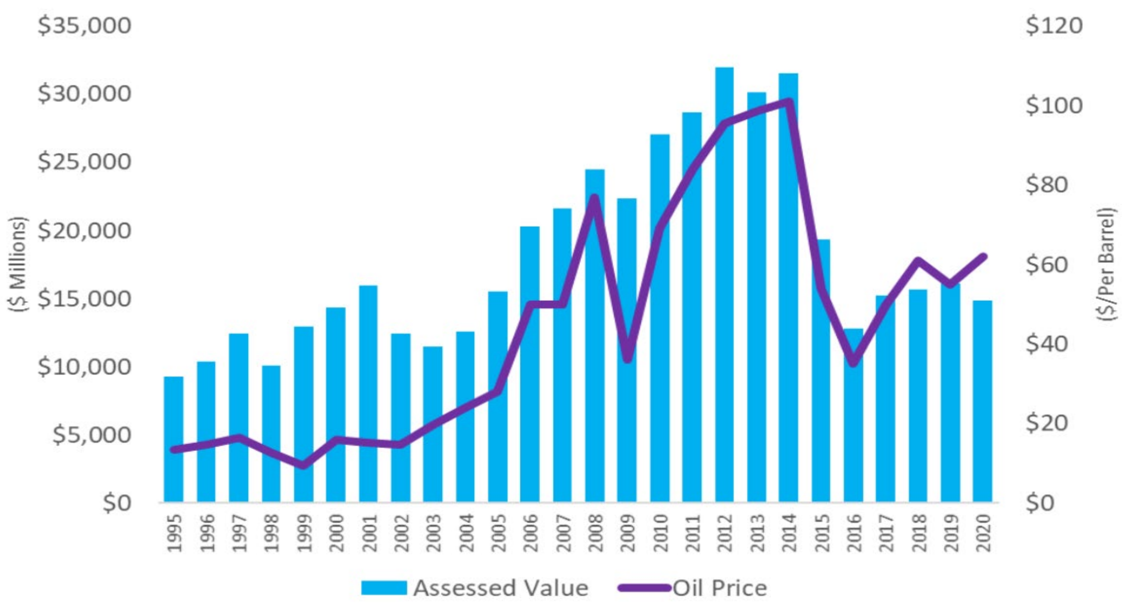
5.2. Local Government

Kern County is home to the majority of California's Oil and Gas wells incorporating WST in their production. There will be disproportionate impacts in Kern County because all of the WST permits since 2015 have been for WST activity there, making it the only county likely to experience WST in the immediate future without the regulation and, thus, the only county likely to experience production impacts from the regulation.

According to a recent report by the Kern County Assessor's Office, Kern County receives a significant portion of its annual budget from income taxes paid by oil and gas corporations and their employees, revenues from sales taxes for oil and gas purchases, and related market activity, and is expected to decline at roughly the same rate as production declines. Because production after 10 years without WST permits would be 96% of baseline for oil and 96.1% of baseline for gas unless new technologies are developed, it is anticipated that these Kern County revenues associated with production would also decrease to 96% of baseline over the same time period.

In FY 2018-19 property taxes from Oil and Gas facilities represented some $197 million, 7.4% of all county tax revenue (Natelson Dale Group 2020) and the industry is an important contributor to local infrastructure, including schools, public safety, streets and roads, and parks. Regulations pertaining to the valuation of Oil and Gas properties allow for taxable amounts to be reassessed over time in response to "changes in the expectation of future production capabilities" (CCR 18 § 468). Thus, Kern County's tax revenues are influenced by changes in both the valuation of existing Oil and Gas operations, as well as the establishment and valuations of new operations in the future.

Figure 7: Kern County Oil and Gas Assessed Property Values, 1995-2020



A WST permitting phase out would mean that new Oil and Gas wells would not be drilled if their production was considered economically feasible only in the context of WST use. Similarly, the assessed value of a particular well is likely to decline if operators can demonstrate that future reserve estimates were predicated on future WST applications. WST's regional concentration in Kern County implies that, all else equal, a permitting phase out should diminish property tax revenues derived from in-county Oil and Gas operations.

The ultimate reduction in Oil and Gas property tax revenue depends on an array of factors. Certainly, the production and taxable valuation of existing wells whose planned production does not include WST would not be substantively affected by a permitting phase out. Moreover, looking at past well property valuations, it is clear that the global price of oil is a much more important determinant of the tax base than the fraction of WST production in the county (Figure 7). As for existing wells whose planned production did include future WST application, any drop in their valuation will depend on site-specific geologic factors. Specifically, some extraction may not occur without WST, as other Oil and Gas deposits may instead become relatively less accessible or less economical to extract. Therefore, the magnitude of short-term impacts on Kern County tax revenues brought about by a WST permitting phase-out is difficult to estimate.

In the medium- to long-term, the ultimate effect of a WST permitting phase out on Kern County Oil and Gas tax revenues is even more difficult to gauge, owing to the unpredictability of advances in extraction technology and other drivers of local property values. On the one hand, a curtailment of production options (e.g., WST) should make certain Oil and Gas deposits less economically valuable, holding constant the technological capacities of Oil and Gas operators.

In the short- and medium-term, however, there is little doubt that the regulation will lower some well revenue and attendant property value. Still, even under the most pessimistic possible assumptions (i.e., the county assesses WST property at zero), this would write down less than 10% of existing production assets in the county, meaning a decline of .10*7.4% or less than 1% of total county tax revenue by the Natelson Dale Group's 2020 estimate. Moreover, no part of the regulations affecting local government constitute a "reimbursable mandate" as understood in California, meaning this burden would not be offset by state fiscal resources.

Overall, it can be anticipated that a WST permitting phase out will – at least in the short-term – reduce Kern County tax revenues derived from Oil and Gas sector property and other local transaction related taxes. The magnitude of such a decline, though, would be unlikely to exceed 1% of current county revenue and depends on cumulative, well-specific geological conditions, and alternative, competing land use decisions. Additionally, the medium- and long-term picture is made increasingly unclear on account of the uncertainties of technological innovation that will be incentivized by a WST phase out. These could substantially or more than offset the currently anticipated well declines in well yields. Moreover, rising oil prices due to broader macroeconomic circumstances could easily offset this component of both industry revenue and property tax valuation, just as it did in the prior decade (Figure 7).

5.3. State Government Finances

Department staff have been enforcing regulations specific to WST since 2014, the year they first became effective on an emergency basis. In that 2014-2015 fiscal year, the Department received approval for 60 permanent positions, 5 limited-term positions, and a baseline appropriation of $13,007,000, with $9,285,000 ongoing from the Oil, Gas, and Geothermal Administrative Fund. These funds were intended to provide resources to directly enforce new WST requirements related to permit issuance, including technical and environmental review. The limited term positions and one-time expenditures have been completed, leaving 60 permanent positions in ongoing appropriations. The total operational expense for all 60 of the originally authorized positions is approximately $10.8 million as of fiscal year 2021-2022.

One year after full implementation of the proposed WST regulations, it is anticipated that the Department will only need 4 positions for continuing tasks related to WST. These tasks include legal consultation, the WST Annual Report, well maintenance review, data management and disclosure, compliance review (e.g., well integrity, and geologic and hydraulic isolation of Oil and Gas formations) and enforcement for wells stimulated before the permitting phase out. The 56 positions which will no longer be needed have equivalent average operating expenses of $9.7 million to $10.4 million depending on which positions are ultimately retained. In response to this anticipated decline, the Department has a range of options from phasing out positions to redirecting staff positions to other ongoing and emerging programs.

5.4. Other State Agencies

State public health and medical resources may experience reduced demand for the services/resources, particularly in service to Disadvantaged Communities with higher pollution burdens and greater economic vulnerability. We have attempted to assess these populations with our CalEnviroScreen spatial analysis (discussed elsewhere in this SRIA).

5.4.1. California Air Resources Board (CARB)

CARB staff have been supporting and implementing hydraulic fracturing and well stimulation requirements as set forth in SB 4 since 2014. CARB was approved for 6 permanent positions and $300,000 in contract funds for a total of $1,304,000 ongoing from the Oil, Gas, and Geothermal Administrative Fund. CARB responsibilities under the statute are to develop and continually implement formal agreements with CalGEM and local air districts, develop and enforce regulations to control air pollutants from oil and gas wells stimulated using hydraulic fracturing or other techniques, performing technical work on air quality modeling and risk assessments to support the regulation, and overseeing an emissions testing program on stimulated wells.

CARB will continue to need the 6 positions for one full year after full implementation of the proposed well stimulation regulations. After that, it is anticipated that CARB will continue to need 2 positions for tasks related to WST. These tasks include legal consultation and ongoing analysis and communication of air monitoring data collected under SB 4. Once the collection of air monitoring data is no longer needed, the total reduction in needed fiscal resources will be equal to the $1,304,000 ongoing from the Oil, Gas, and Geothermal Administrative Fund, but the timing of this reduction is unclear as staffing needs post-regulation are still being determined.

5.4.2. State Water Resources Control Board

SB 4 required the State Water Resources Control Board (State Water Board) to establish and implement a comprehensive groundwater monitoring and oversight program for oil and gas field activities, including well stimulation. To implement the program, the State Water Board was approved for $6.2 million for 14 new positions at $2.0 million and $4.2 million for contracts for fiscal year 2014-15, then $9.4 million for 14 positions at $2.0 million and $7.4 million for contracts for fiscal year 2015-16 and ongoing. Funding is provided through CalGEM's Oil, Gas, and Geothermal Administrative Fund.

After two to three years of full implementation of CalGEM's proposed well stimulation phase out regulation, the State Water Board anticipates that only 9 positions will be necessary to conduct the on-going program work related to the provisions of Senate Bill 4. This work includes implementation and oversight of the Oil and Gas Regional Monitoring Program administered by the USGS, review of operator submitted groundwater monitoring reports from previously approved monitoring plans in areas of well stimulation, development of the "Annual Performance Report: Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation", management of data in the State Water Board's GeoTracker system, and legal consultation. The five positions that will no longer be needed have an equivalent average operating expense of approximately $1.1 million. It is anticipated that these positions will be re-directed to other on-going and emerging programs.

5.4.3. Office of Environmental Health Hazard Assessment

The Office of Environmental Health Hazard Assessment (OEHHA) also was tasked with WST related activities in SB 4, specifically, cooperation with the California Natural

Resources Agency in the development of a health and risk assessment for WST. This report was completed by the California Council of Science and Technology in July 2015. As such, OEHHA should not experience any costs or savings as a result of this rulemaking.

6. ECONOMIC IMPACTS OF THE REGULATORY ALTERNATIVES

In addition to the Baseline and the Proposed Regulatory Scenario (PRS), DOF's guidelines require agencies to evaluate two feasible alternatives to the PRS. This implies that each SRIA will include four scenarios (not including any additional sensitivity analyses that might be considered). One of the two alternatives should include regulatory actions that could be interpreted as less stringent or with lower direct cost. This is meant to represent a "second best" option in terms of providing lesser benefits to the proposed regulation. The second alternative should be considered more stringent, with higher direct costs and perhaps higher direct benefits. To the extent possible, the baseline and alternatives should be analyzed with the same quantitative rigor as the proposed regulation.

6.1. Less Stringent Regulatory Alternative

For the present regulation, we consider a less stringent alternative to be a five-year extension of the deadline for ending WST permits. This would have three direct impacts, two of which would simply defer direct costs and benefits by five years. The third impact would be to offer the industry more time to make productivity compensating investments before losing the yield benefits of WST. Measuring effects of the first two factors is straightforward as the real direct costs and benefits remain the same for each scenario, but we have neither the data nor a convincing behavioral model to estimate innovation pathways.

In the absence of a more sophisticated prediction model, however, some guidance on the likely industry technological response can be gleaned from our aforementioned survey of California Oil and Gas firms. Specifically, respondents were asked whether they anticipated the WST permitting phase out would "stimulate a shift to specific technological alternatives [to WST]," such as steam flooding. On this point, firms with a history of WST use answered overwhelmingly in the negative.

6.2. More Stringent Regulatory Alternative

To examine a more stringent alternative, we look to the policy debate on hydraulic fracturing and examine the consequences of a complete and immediate moratorium on WST in California that would end both permitting and WST activity immediately. Again, the main direct effects would be a temporal shift in the real costs and benefits, advancing environmental gains to the nearer term and forsaking WST yield benefits right away.

6.3. Macroeconomic Impacts

The regulatory alternatives are compared with the proposed WST regulation in Table 9 below, showing the annual macroeconomic impacts over the evaluation period 2024-32.[21] At the outset, it must be emphasized that, because the Baseline California economy is growing over this period, all scenarios would see rising macroeconomic aggregates over time and this table only shows small incremental (but not directional) changes in that growth trajectory.

Table 9: Macroeconomic Impacts of the Proposed and Alternative Regulations

WST Proposed Regulation

$M Impact	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	-19	-116	-339	-712	-1,268	-2,046	-3,093	-4,462	-6,218	-2,030
Employment (FTE)	-54	-104	-88	-57	-62	-142	-334	-676	-1,208	-303
Real Output	-57	-248	-617	-1,206	-2,073	-3,287	-4,924	-7,075	-9,847	-3,259
Investment	4	-24	-121	-288	-529	-851	-1,265	-1,781	-2,412	-807
Percent Impact	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	Average
Gross State Product ($M)	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.04%	-0.05%	-0.07%	-0.09%	-0.04%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real Output	0.00%	0.00%	-0.01%	-0.02%	-0.03%	-0.04%	-0.06%	-0.08%	-0.10%	-0.04%

[21] This period was extended from 2024-2031 to accommodate the more restrictive alternative, going into force immediately.

Investment	0.00%	0.00%	-0.02%	-0.04%	-0.06%	-0.10%	-0.14%	-0.19%	-0.25%	-0.10%

The results in the next two tables highlight some advantages of the PRS from a statewide economy perspective, but do not reflect others. Aggregate average changes across key economic metrics are displayed over the period of Years 1 through 9, as in the last column of the previous table. Absolute magnitudes of the output-based aggregates are consistent with the stringency of each regulation, but we see different adjustment pathways. Relative to the PRS (first scenario, "S1"), delays in implementation (second scenario, "S2") reduce costs to industry by deferring WST retirement until five years later, but those cost are just deferred to a later timeframe. Gross state income and employment are again lower than Baseline trends, but still growing in absolute terms. Across all the macroeconomic aggregates, the PRS impact is very negligible (generally less than one-hundredth of one percent. Although the economic costs of the less stringent policy seem lower, it must be emphasized that it would delay the environmental, public health, and other mitigation expected from WST cessation, and would similarly delay the value of the benefits that would accrue to disadvantaged communities. The value of the public health and environmental harm caused by these of these delays could certainly exceed the difference between the PRS and Less Stringent alternative.

The more stringent alternative policy goes into effect earlier, and its cumulative impact is significantly more adverse a decade from now, with average annual real GDP reductions of $2.7B and 50% higher number of jobs not created. Again, the environmental and health benefits of accelerated WST retirement could be significant here, but the PRS was chosen to accommodate sectoral adjustment needs, while meeting stated objectives for environmental quality. Additionally, this jobs model does not account for the potential effect of decreasing in-state demand for oil and gasoline on jobs in the sector regardless.

Table 10: Less Stringent Alternative

$M Impact	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	0	0	0	0	0	-40	-209	-571	-1,162	-220
Employment (FTE)	0	0	0	0	0	-33	-59	-50	-62	-23
Real Output	0	0	0	0	0	-88	-394	-992	-1,947	-380
Investment	0	0	0	0	0	-7	-67	-213	-448	-82
Percent Impact	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Average**
Gross State Product ($M)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	0.00%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Real Output	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	0.00%
Investment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.02%	-0.05%	-0.01%

Table 11: More Stringent Alternative

$M Impact	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Average
Gross State Product ($M)	-16	-101	-303	-643	-1,152	-1,865	-2,827	-4,086	-5,703	-7,742	-2,714
Employment (FTE)	-59	-116	-101	-66	-61	-124	-292	-600	-1,087	-1,795	-471
Real Output	-52	-227	-562	-1,097	-1,885	-2,989	-4,482	-6,446	-8,981	-12,193	-4,318
Investment	-16	-104	-259	-485	-788	-1,179	-1,667	-2,265	-2,987	-9,745	-2,164
Percent Impact	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Average**
Gross State Product ($M)	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.03%	-0.05%	-0.07%	-0.09%	-0.12%	-0.04%
Employment (FTE)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.00%
Real Output	0.00%	0.00%	-0.01%	-0.01%	-0.02%	-0.04%	-0.05%	-0.07%	-0.10%	-0.12%	-0.04%
Investment	0.00%	0.00%	-0.01%	-0.03%	-0.06%	-0.10%	-0.14%	-0.18%	-0.24%	-0.30%	-0.12%

Note: Differences from Baseline scenario. All figures in 2020 $ millions or percentage unless otherwise noted.

First, it should be noted that, after adjusting for timing, the results are closely comparable between alternatives for a simple reason: since the non-ban of WST was not considered as an alternative, timeframe of the permitting phase out was the only “degree of freedom” in evaluating these hypothetical regulatory alternatives. Looking at more detailed relative performance, absolute magnitudes of the aggregates are fully consistent with the stringency of the regulation: new costs increase positively with the stricture of the scenario. The less stringent alternative (“S2”) has lower output adjustment cost over the period considered (not necessarily over a longer period).

Conversely, more immediate implementation (“S3”) would have higher accumulated real GDP and job impacts by 2032. Different stakeholders are also affected differently. While delays (second scenario, “S2”) reduce costs to industry, earlier implementation (first and third scenario, “S1” and “S3”) would compound any environmental and health benefits more strongly over time (not measured here). Because the latter are not estimated in this assessment, the social costs of deferred implementation are likely to be much lower or even negative (net beneficial).

On an annual average basis, the PRS (“S1”) seems to balance these countervailing forces.

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APPENDIX 1
DEPARTMENT OF FINANCE COMPLIANT BASELINE CALIBRATION

A1.1. Introduction

The following document provides background information on the Baseline scenario calibration for the Berkeley Energy and Resources (BEAR) Model, conforming its macroeconomic projections to the May, 2022 projections available from the California Department of Finance (DOF).[22, 23, 24] As a condition for implementation in Standardized Regulatory Impact Assessment (SRIA) analysis, economywide models must provide accurate reference baselines for comparison to their own SRIA regulatory scenarios as well as other state economic assessment.[25]

A1.2. Macroeconomic Baseline Forecasts

There are three fundamental macroeconomic series of importance for Baseline calibration: Population, Employment, and Personal Income. The following three figures compare forecasts for these series between DOF and BEAR. As it happens, population is exogenous (input) to the BEAR model, though these two series are identical. In the case of Personal Income, DOF forecasts only extend to 2025, but BEAR tracks these very closely through the calibration mechanism described in Section 9 below.

[22] California Code of Regulations, title 1, section 2003(b)

[23] https://www.dof.ca.gov/forecasting/demographics/projections/

[24] https://www.dof.ca.gov/Forecasting/Economics/

[25] We would like to express our thanks to the DOF Chief Economist and her staff for their cooperation and data sharing to support this calibration exercise. Any errors implementing these inputs are solely the responsibility of the authors.

Figure A1.1

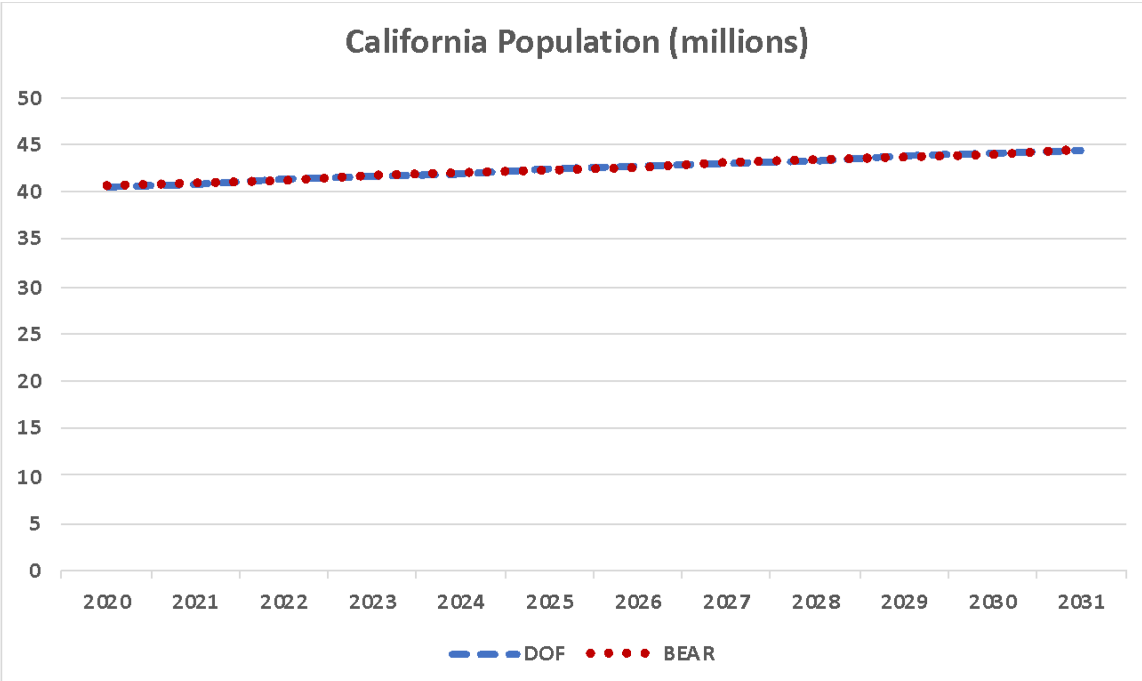
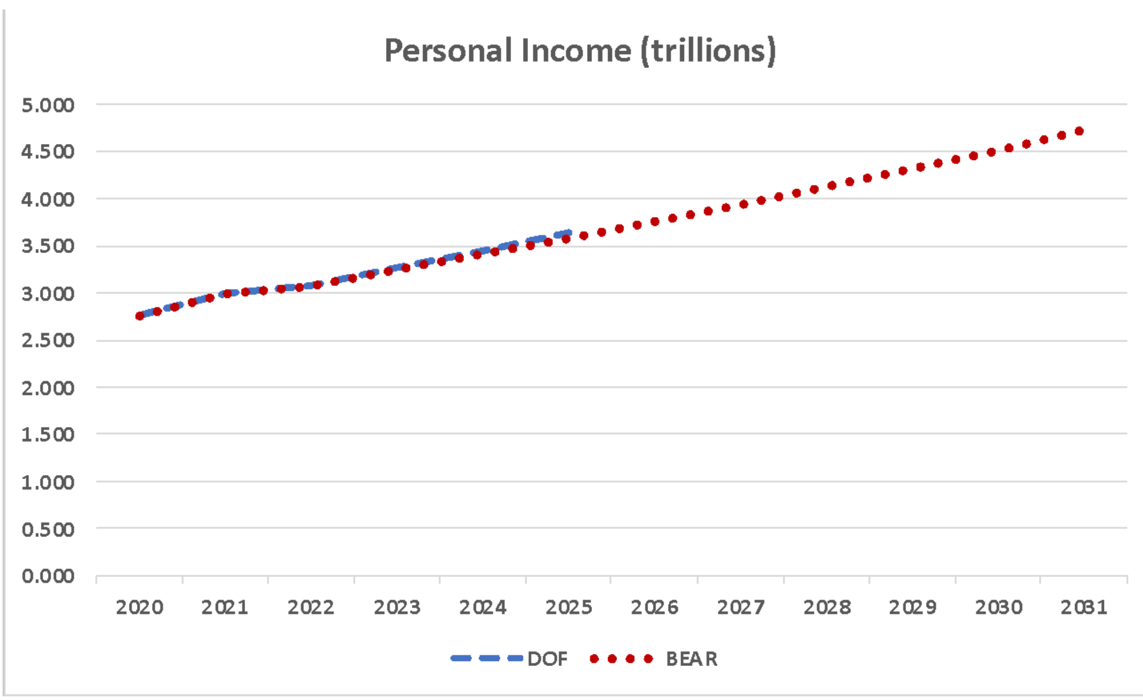


Figure A1.2



Beyond 2019, BEAR's aggregate Personal Income growth is calibrated to an average (2013-2019) of 4.5%. Finally, DOF and BEAR projections of Total Wages and Salaries and Employment are compared in Figures 7.3 and 7.4.

Figure A1.3

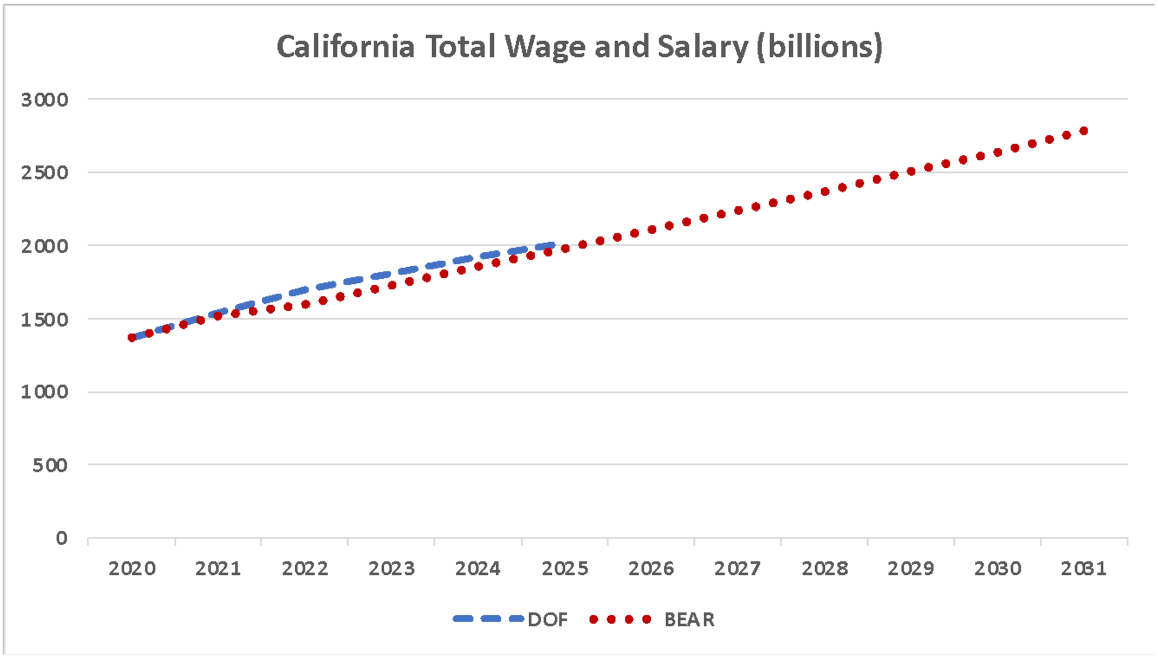
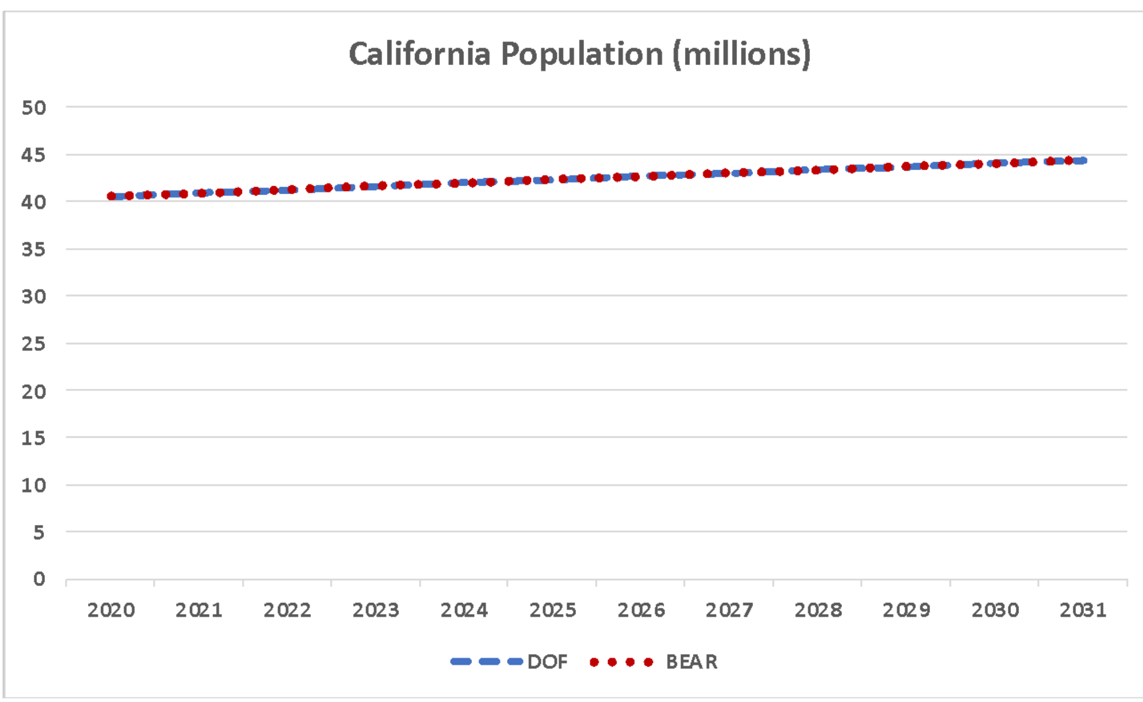


Figure A1.4



A1.3. Sectoral Baseline Forecasts

The following figures summarize the results of the BEAR Baseline calibration for a 12-sector aggregation compatible with published DOF forecasts. The latter projections (blue dashed series) are for the years 2020-2024 only, while BEAR extrapolates these annually to 2031.

Figure A1.5

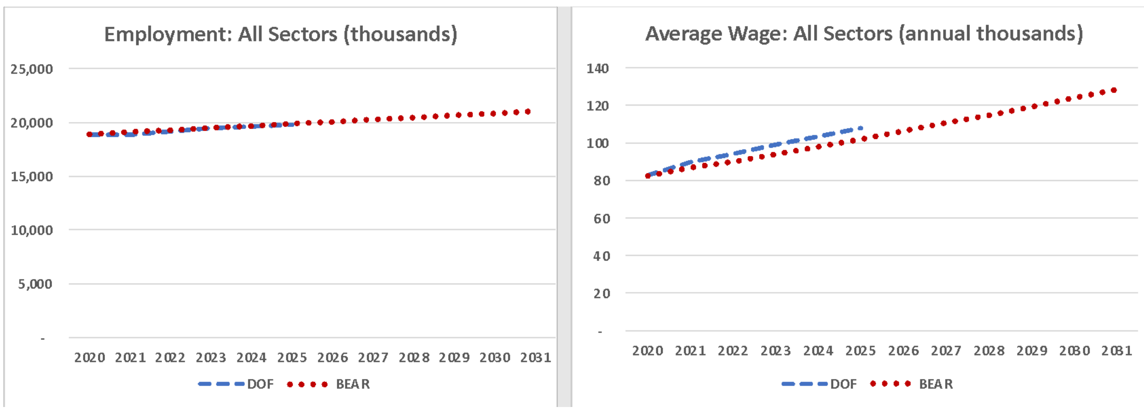


Figure A1.6

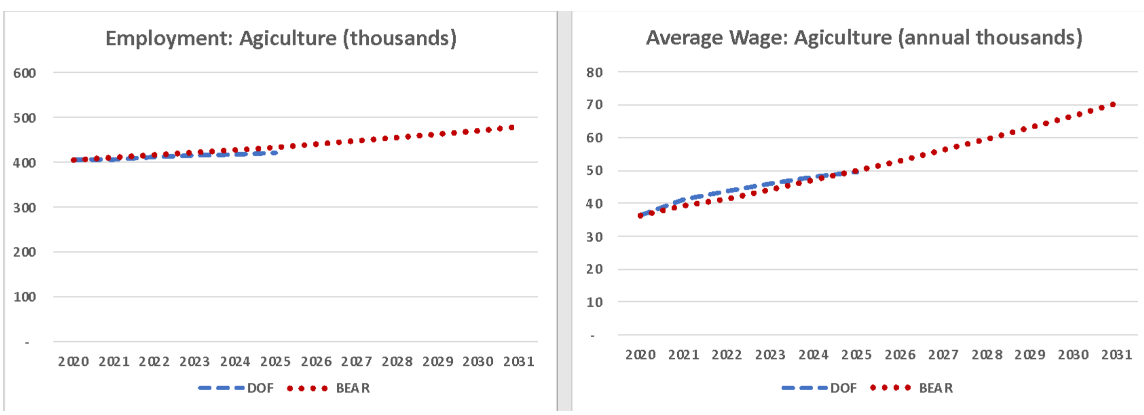


Figure A1.7

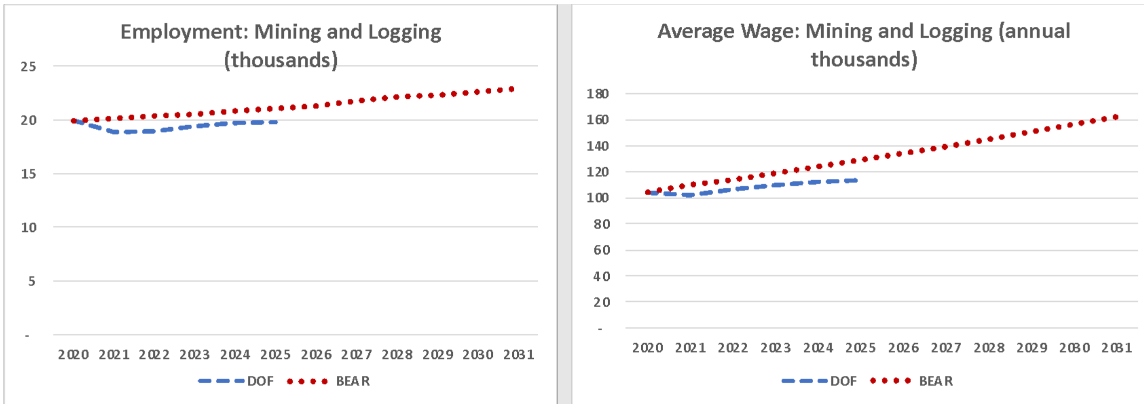


Figure A1.8

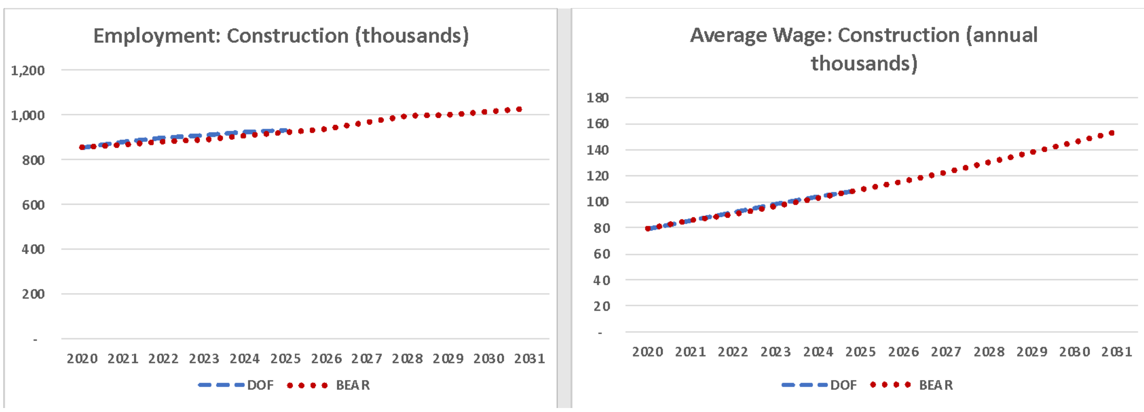


Figure A1.9

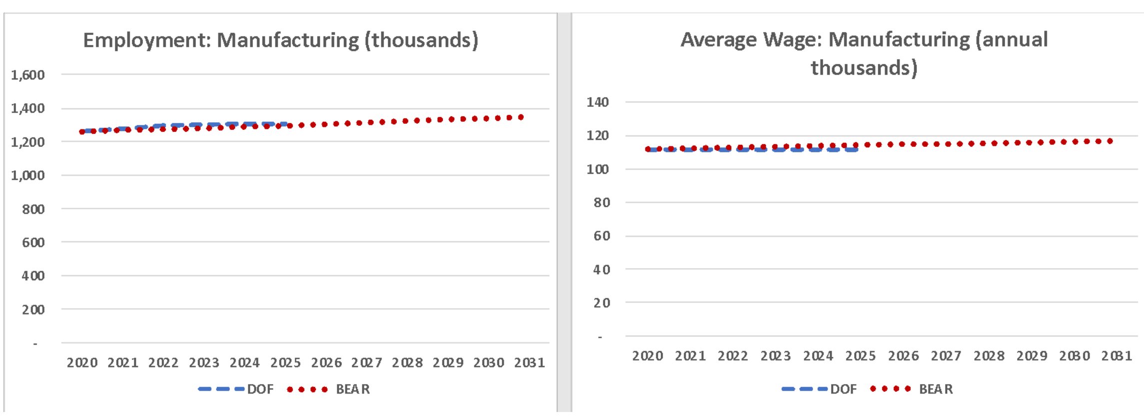


Figure A1.10

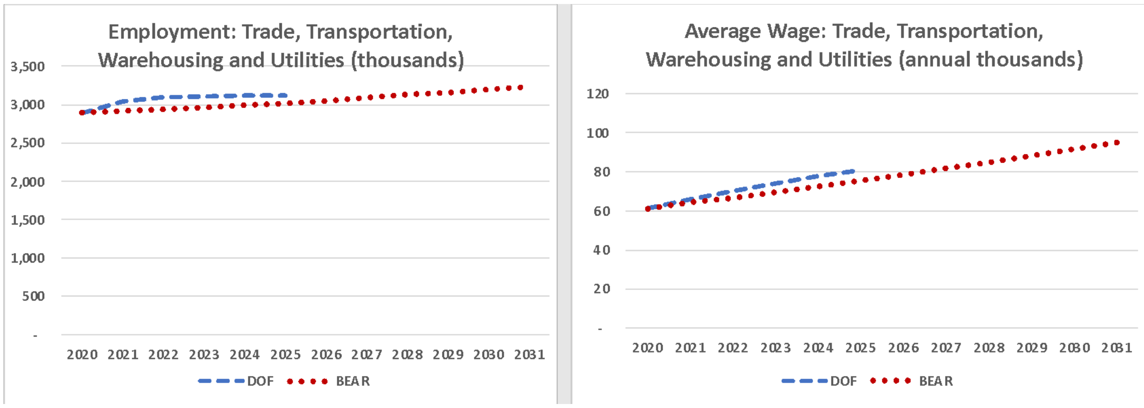


Figure A1.11

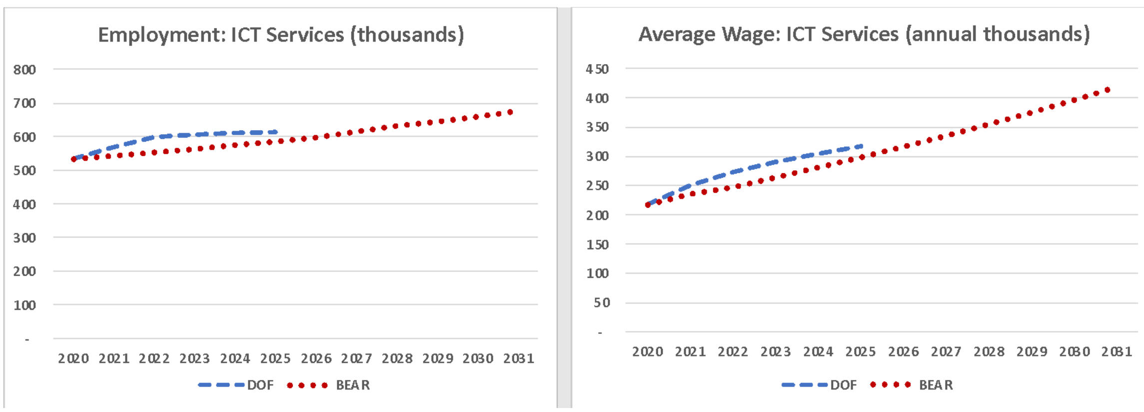


Figure A1.12

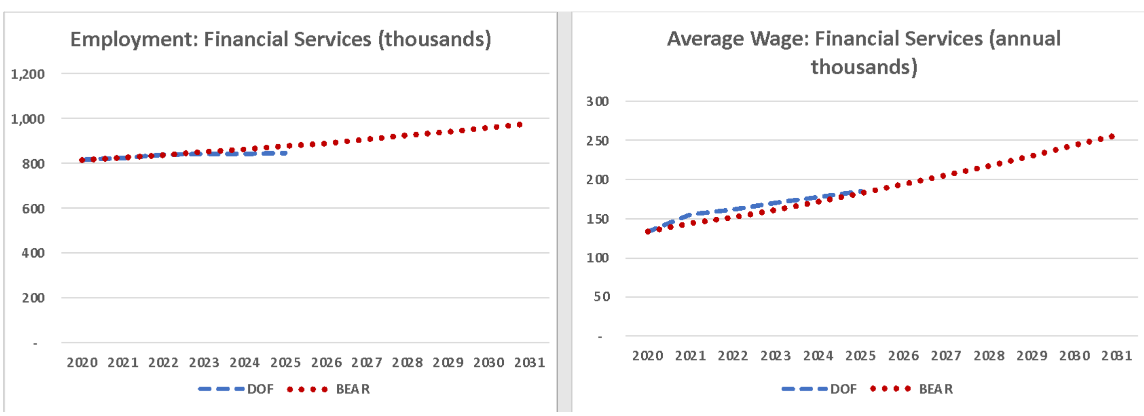


Figure A1.13

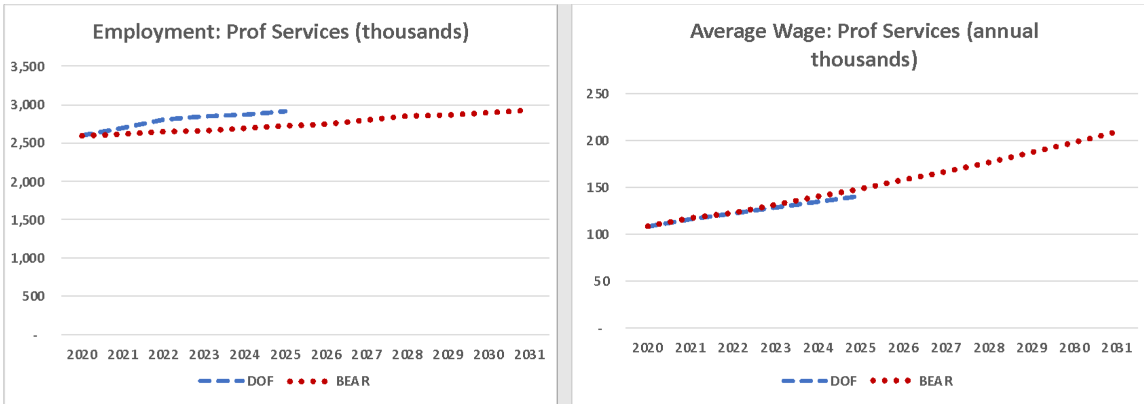


Figure A1.14

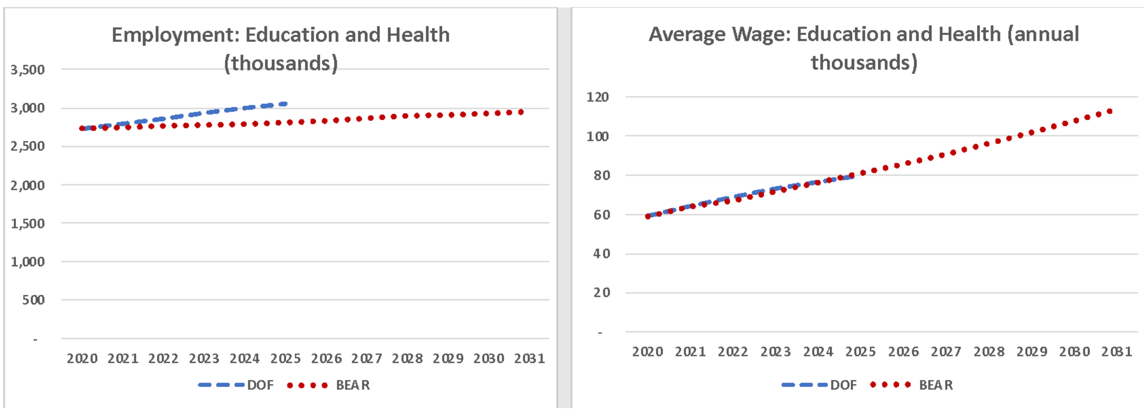


Figure A1.15

Figure A1.16

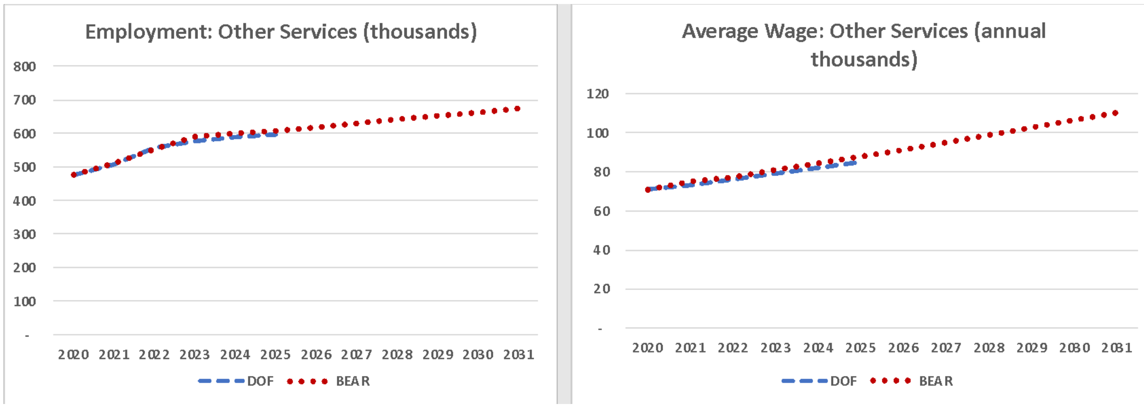
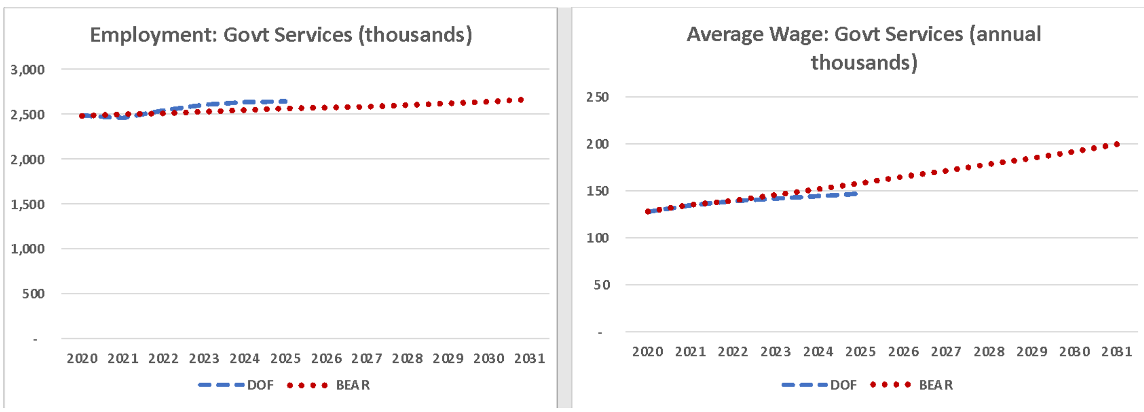


Figure A1.17



A1.4. Baseline Calibration of the BEAR Model

The BEAR model is calibrated to state real Personal Income growth rates, obtained from DOF. Using exogenous rates of implied growth in total factor productivity (TFP), the model computes supply, demand, and trade patterns compatible with domestic and state market equilibrium conditions. Equilibrium is achieved by adjustments in the relative prices of domestic resources and commodities, while international equilibrium is achieved by adjusting trade patterns and real exchange rates to satisfy fixed real balance of payments constraints.

The calibration procedure highlights the two salient adjustment mechanisms in the model (as well as the real economies), prices in California, U.S. domestic and international markets. General equilibrium price adjustments are generally well understood by professional economists but the degree of segmentation between state, national, and global markets depends on many factors.

Because CGE like this do not capture the aggregate price level or other nominal quantities, there are no pure inflationary or monetary effects in the sense of traditional macroeconomics or finance. Since there is no money metric in the model, all prices are relative prices. If there were financial assets in the model, one could define a nominal inflation and interest rates as the relative prices of financial assets (money, bonds, etc.). Without them, prices only reflect real purchasing power, i.e., the relative price of goods and services in terms of each other.

APPENDIX 2
TECHNICAL SUMMARY OF THE BEAR MODEL

The Berkeley Energy and Resources (BEAR) model is in reality a constellation of research tools designed to elucidate linkages across the California economy. The schematics in Figures A2.1. and A2.2 describe the four generic components of the modeling facility and their interactions. This section provides a brief summary of the formal structure of the BEAR model.[26] For the purposes of this report, the 2013 California Social Accounting Matrix (SAM), was aggregated along certain dimensions. The current version of the model includes 195 activity sectors, 22 occupations, and ten households aggregated from the original California SAM. The equations of the model are completely documented elsewhere (Roland-Holst, 2015), and for the present we only review its salient structural components.

A2.1. Structure of the CGE Model

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices, the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is precisely specified, equilibrium always exists, and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economywide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other

[26] See Roland-Holst (2015) for a complete model description.

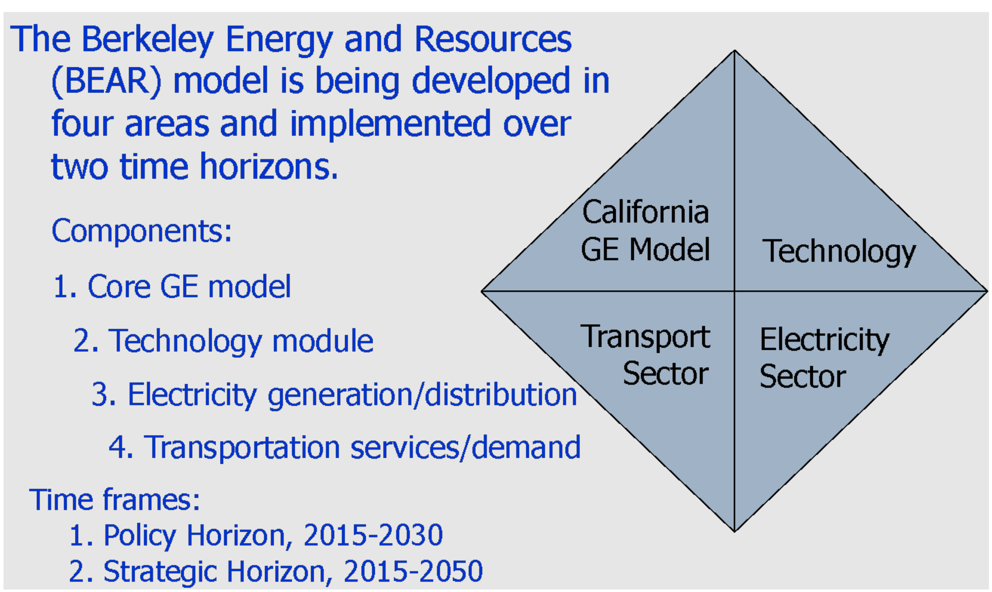
domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes are not only substantial but may in some cases even outweigh direct effects. Only a model that consistently specifies economywide interactions can fully assess the implications of economic policies or business strategies. In a multi-country model like the one used in this study, indirect effects include the trade linkages between countries and regions which themselves can have policy implications.

The model we use for this work has been constructed according to generally accepted specification standards, implemented in the GAMS programming language, and calibrated to the new California SAM estimated for the year 2012. The result is a single economy model calibrated over the thirty-five-year interval time-path from 2015 to 2050. Using the very detailed accounts of the California SAM, we include the following in the present model:

A2.2. Production

All sectors are assumed to operate under constant returns to scale and cost optimization. Production technology is modeled by a nesting of constant-elasticity-of-substitution (CES) function.

Figure A2.1: Component Structure of the Modeling Facility



In each period, the supply of primary factors — capital, land, and labor — is usually predetermined.[27] The model includes adjustment rigidities. An important feature is the distinction between old and new capital goods. In addition, capital is assumed to be partially mobile, reflecting differences in the marketability of capital goods across sectors.[28] Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply conditions in all markets.

A2.3. Consumption and Closure Rule

All income generated by economic activity is assumed to be distributed to consumers. Each representative consumer allocates optimally his/her disposable income among the different commodities and saving. The consumption/saving decision is completely static: saving is treated as a "good" and its amount is determined simultaneously with the demand for the other commodities, the price of saving being set arbitrarily equal to the average price of consumer goods.

The government collects income taxes, indirect taxes on intermediate inputs, outputs and consumer expenditures. The default closure of the model assumes that the government deficit/saving is exogenously specified.[29] The indirect tax schedule will shift to accommodate any changes in the balance between government revenues and government expenditures.

The current account surplus (deficit) is fixed in nominal terms. The counterpart of this imbalance is a net outflow (inflow) of capital, which is subtracted (added to) the domestic flow of saving. In each period, the model equates gross investment to net saving (equal to the sum of saving by households, the net budget position of the government and foreign capital inflows). This particular closure rule implies that investment is driven by saving.

[27] Capital supply is to some extent influenced by the current period's level of investment.

[28] For simplicity, it is assumed that old capital goods supplied in second-hand markets and new capital goods are homogeneous. This formulation makes it possible to introduce downward rigidities in the adjustment of capital without increasing excessively the number of equilibrium prices to be determined by the model.

[29] In the reference simulation, the real government fiscal balance converges (linearly) towards 0 by the final period of the simulation.

A2.4. Trade

Goods are assumed to be differentiated by region of origin. In other words, goods classified in the same sector are different according to whether they are produced domestically or imported. This assumption is frequently known as the *Armington* assumption. The degree of substitutability, as well as the import penetration shares are allowed to vary across commodities. The model assumes a single Armington agent. This strong assumption implies that the propensity to import and the degree of substitutability between domestic and imported goods is uniform across economic agents. This assumption reduces tremendously the dimensionality of the model. In many cases this assumption is imposed by the data. A symmetric assumption is made on the export side where domestic producers are assumed to differentiate the domestic market and the export market. This is modeled using a *Constant-Elasticity-of-Transformation* (CET) function.

A2.5. Dynamic Features and Calibration

The current version of the model has a simple recursive dynamic structure as agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities. Dynamics in the model originate in three sources: i) accumulation of productive capital and labor growth; ii) shifts in production technology; and iii) the putty/semi-putty specification of technology.

A2.6. Capital Accumulation

In the aggregate, the basic capital accumulation function equates the current capital stock to the depreciated stock inherited from the previous period plus gross investment. However, at the sectoral level, the specific accumulation functions may differ because the demand for (old and new) capital can be less than the depreciated stock of old capital. In this case, the sector contracts over time by releasing old capital goods. Consequently, in each period, the new capital vintage available to expanding industries is equal to the sum of disinvested capital in contracting industries plus total saving generated by the economy, consistent with the closure rule of the model.

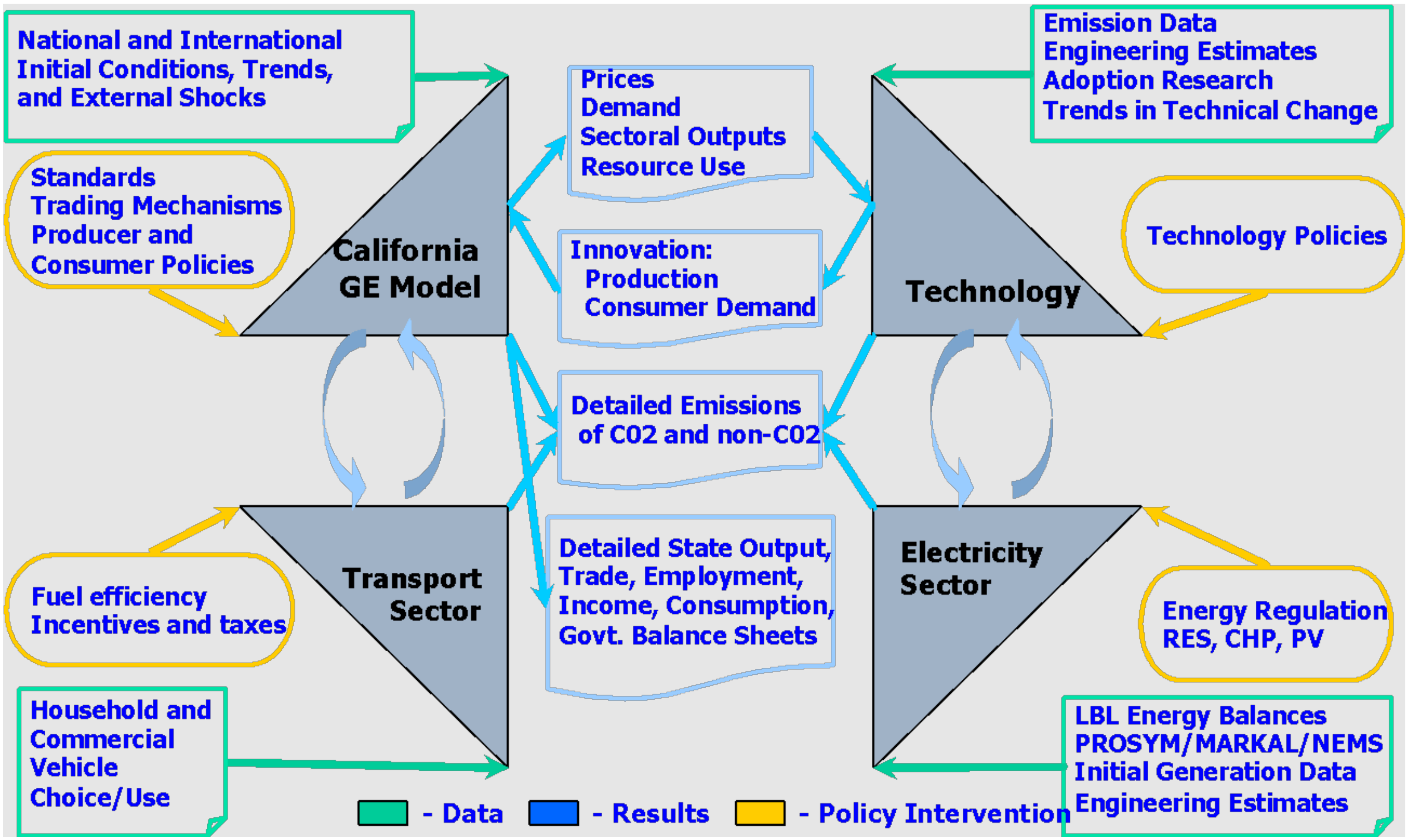
A2.7. The Putty/Semi-Putty Specification

The substitution possibilities among production factors are assumed to be higher with the new than the old capital vintages — technology has a putty/semi-putty specification. Hence, when a shock to relative prices occurs (e.g., the imposition of an emissions fee), the demands for production factors adjust gradually to the long-run optimum because the substitution effects are delayed over time. The adjustment path depends on the values of the short-run elasticities of substitution and the replacement rate of capital. As the latter determines the pace at which new vintages are installed, the larger is the volume of new investment, the greater the possibility to achieve the long-run total amount of substitution among production factors.

A2.8. Profits, Adjustment Costs, and Expectations

Firms output and investment decisions are modeled in accordance with the innovative approach of Goulder and co-authors (see e.g., Goulder et al: 2009 for technical details). In particular, we allow for the possibility that firms reap windfall profits from events such as free permit distribution. Absent more detailed information on ownership patterns, we assume that these profits accrue to U.S. and foreign residents in proportion to equity shares of publicly-traded US corporations (16% in 2009, Swartz and Tillman:2010). Between California and other US residents, the shares are assumed to be proportional to GSP in GDP (11% in 2009).

Figure A2.2: Schematic Linkage between Model Components



A2.9. Dynamic Calibration

The model is calibrated on exogenous growth rates of population, labor force, and GDP. In the so-called Baseline scenario, the dynamics are calibrated in each region by imposing the assumption of a balanced growth path. This implies that the ratio between labor and capital (in efficiency units) is held constant over time.[30] When alternative scenarios around the Baseline are simulated, the technical efficiency parameter is held constant, and the growth of capital is endogenously determined by the saving/investment relation.

Table A2.1: California SAM for 2013 – Structural Characteristics

1. 195 commodities (includes trade and transport margins)
2. 24 factors of production
3. 22 labor categories
4. Capital
5. Land
6. 10 Household types, defined by income tax bracket
7. Enterprises
8. Federal Government (7 fiscal accounts)
9. State Government (27 fiscal accounts)
10. Local Government (11 fiscal accounts)
11. Consolidated capital account
12. External Trade Account

Table A2.2: Aggregate Accounts for the SRIA Assessment

The 50 Production Sectors and Commodity Groups represent the aggregation of the 195 original sectors that will be used for the current assessment.

Sectoring Scheme for the BEAR Model

The following sectors are aggregated from a new, 199 sector California SAM.

	Label	Description
1	A01Agric	Agriculture
2	A02Cattle	Cattle and Feedlots

[30] This involves computing in each period a measure of Harrod-neutral technical progress in the capital-labor bundle as a residual. This is a standard calibration procedure in dynamic CGE modeling.

	Label	Description
3	A03Dairy	Dairy Cattle and Milk Production
4	A04Forest	Forestry, Fishery, Mining, Quarrying
5	A05OilGas	Oil and Gas Extraction
6	A06OthPrim	Other Primary Products
7	A07DistElec	Generation and Distribution of Electricity
8	A08DistGas	Natural Gas Distribution
9	A09DistOth	Water, Sewage, Steam
10	A10ConRes	Residential Construction
11	A11ConNRes	Non-Residential Construction
12	A12Constr	Construction
13	A13FoodPrc	Food Processing
14	A14TxtAprl	Textiles and Apparel
15	A15WoodPlp	Wood, Pulp, and Paper
16	A16PapPrnt	Printing and Publishing
17	A17OilRef	Oil Refining
18	A18Chemicl	Chemicals
19	A19Pharma	Pharmaceutical Manufacturing
20	A20Cement	Cement
21	A21Metal	Metal Manufacture and Fabrication
22	A22Aluminm	Aluminum
23	A23Machnry	General Machinery
24	A24AirCon	Air Conditioning and Refrigeration
25	A25SemiCon	Semi-conductor and Other Computer Manufacturing
26	A26ElecApp	Electrical Appliances
27	A27Autos	Automobiles and Light Trucks
28	A28OthVeh	Vehicle Manufacturing
29	A29AeroMfg	Aeroplane and Aerospace Manufacturing
30	A30OthInd	Other Industry
31	A31WhlTrad	Wholesale Trade
32	A32RetVeh	Retail Vehicle Sales and Service
33	A33AirTrns	Air Transport Services
34	A34GndTrns	Ground Transport Services
35	A35WatTrns	Water Transport Services
36	A36TrkTrns	Truck Transport Services

	Label	Description
37	A37PubTrns	Public Transport Services
38	A38RetAppl	Retail Electronics
39	A39RetGen	Retail General Merchandise
40	A40InfCom	Information and Communication Services
41	A41FinServ	Financial Services
42	A42OthProf	Other Professional Services
43	A43BusServ	Business Services
44	A44WstServ	Waste Services
45	A45LandFill	Landfill Services
46	A46Educatn	Educational Services
47	A47Medicin	Medical Services
48	A48Recratn	Recreation Services
49	A49HotRest	Hotel and Restaurant Services
50	A50OthPrSv	Other Private Services

These data enable us to trace the effects of responses to climate change and other policies at unprecedented levels of detail, tracing linkages across the economy and clearly indicating the indirect benefits and tradeoffs that might result from comprehensive policies, pollution taxes or trading systems. As we shall see in the results section, the effects of climate policy can be quite complex. In particular, cumulative indirect effects often outweigh direct consequences, and affected groups are often far from the policy target group. For these reasons, it is essential for policy makers to anticipate linkage effects like those revealed in a general equilibrium model and dataset like the ones used here.

It should be noted that the SAM used with BEAR departs in a few substantive respects from the original 2012 California SAM. The two main differences have to do with the structure of production, as reflected in the input-output accounts, and with consumption good aggregation. To specify production technology in the BEAR model, we rely on both activity and commodity accounting, while the original SAM has consolidated activity accounts. We chose to maintain separate activity and commodity accounts to maintain transparency in the technology of emissions and patterns of tax incidence. The difference is non-trivial and considerable additional effort was needed to reconcile use and make tables separately. This also facilitated the second SAM extension, however, where we maintained final demand at the full 119 commodity level of aggregation, rather than adopting six aggregate commodities like the original SAM.

A2.10. Emissions Data

Emissions data were obtained from California's own detailed emissions inventory. In most of the primary pollution databases like this, measured emissions are directly associated with the volume of output. This has several consequences. First, from a behavioral perspective, the only way to reduce emissions, with a given technology, is to reduce output. This obviously biases results by exaggerating the abatement-growth tradeoff and sends a misleading and unwelcome message to policy makers.

More intrinsically, output-based pollution modeling imperfectly captures the observed pattern of abatement behavior. Generally, firms respond to abatement incentives and penalties in much more complex and sophisticated ways by varying internal conditions of production. These responses include varying the sources, quality, and composition of inputs, choice of technology, etc. The third shortcoming of the output approach is that it gives us no guidance about other important pollution sources outside the production process, especially pollution in use of final goods. The most important example of this category is household consumption. BEAR estimates emissions from both intermediate and (in-state) final demand.

APPENDIX 3
INDUSTRY SURVEY

What follows is a text version of the electronic survey that was deployed to clarify industry expectations and operating characteristics. Results of this survey were used to inform the SRIA narrative regarding anticipated industry costs and expected adaptations to the proposed regulation.

<u>Active California Wells</u>

I. (Section Introduction): "The questions in this section relate to your organization's active in-state wells, including those with a history of well stimulation treatment (WST). (Note that WST in this survey refers to hydraulic fracturing, acid fracturing, and matrix stimulation – not underground stimulation generally)."

II. "Considering your organization's California well operations active at some period in the last 5 years which statement describes their history of well stimulation (WST)?"
   i. None of our wells have a history of WST → *Skip to "Future California Wells" section*
   ii. One or more of our wells have a history of WST → *Continue to next (sub) question*
      1. "Roughly how many of your active in-state well operations have a history of WST?" [Blank Text Box]
      2. "About what percentage of your in-state wells have had WST?" [Sliding Scale 0-100]
      3. "About what percentage of your total in-state Oil and Gas production last year was facilitated by WST?" [Sliding Scale 0-100]
      4. "Considering your wells that ever received WST, were they producing via other extraction methods prior to stimulation treatment?"
         A. No: our WST wells produced only after stimulation
         B. Yes: our WST wells produced before stimulation
         C. Other: our WST wells have no typical pre-stimulation production history

Comment: "The following questions refer to the characteristics of a "typical" WST-receiving well operated by your organization."

      5. "On average, how many instances of stimulation occur during the length of such a well's lifecycle?" [Blank Text Box]

6. "How long is the productive life (total years, past and future) of your average stimulated well?" [Blank Text Box]
7. "Where in a WST well's lifecycle does stimulation typically occur?" [Blank Text Box]
8. "Please select the statement that best-describes the output profile over time for a WST well's lifecycle"
   A. Production declines linearly over time (e.g., 1,000 barrels one year; 900 the next; 800 the next)
   B. Production declines exponentially over time (e.g., 1,000 barrels one year; 800 the next; 400 the next)
   C. Production remains steady until a sudden drop-off near the end of the lifecycle
   D. Other (please describe) [Blank Text Box]

Future California Wells

III. (Section Introduction): "The questions in this section relate to your organization's current plans for future O&G operations in California. (Assume that the state regulatory environment would not dramatically change i.e. that distribution of WST permits would continue)."

IV. "Does your organization plan to begin new well operations in California at any point over the next 10 years?"
   A. Yes, new wells planned → Continue to next (sub) question
   B. No new wells planned → Skip to Current Production & WST Permit section
   C. Other (please describe) [Blank Text Box]
   → Continue to next (sub) question
   1. "Are new wells planned over the next 1-2 years?"
      A. Yes, new wells planned
      B. No new wells planned
      C. Other (please describe) [Blank Text Box]
   2. "… over the next 3-5 years?"
      A. Yes, new wells planned
      B. No new wells planned
      C. Other (please describe) [Blank Text Box]

3. "… over the next 6-10 years?"
    A. Yes, new wells planned
    B. No new wells planned
    C. Other (please describe) [Blank Text Box]
4. "Does your organization plan to apply WST to any of these future California wells?"
    A. No planned WST → Skip to Current Production & WST Permit section
    B. Yes, planned WST → Continue to next (sub) question
5. "Compared to the past, how do you anticipate your future in-state well portfolio will change in terms of the proportion of stimulated wells?"
    A. The future share of actively-producing wells with a history of WST will increase
    B. The future share of actively-producing wells with a history of WST will decrease
    C. The future share of actively-producing wells with a history of WST will stay about the same
    D. Other (please describe) [Blank Text Box]

Current Production & WST permitting phase out Scenario

V. (Section Introduction): "Many of the following questions ask you to imagine a hypothetical scenario in which the state of California has permanently ended its distribution of WST permits (i.e. not a temporary moratorium). (Assume that already-issued WST permits are valid until their established expiration date)."

1. "Ignoring any potential effects of a future ban of WST permits, which statement best-describes oil production trends at your organization's California wells?
    A. In-state oil production has been declining over time
    B. In-state oil production has been rising over time
    C. In-state oil production has stayed about the same
2. "Ignoring any potential effects of a future ban of WST permits, which statement best-describes natural gas production trends at your organization's California wells?
    A. In-state natural gas production has been declining over time

   B. In-state natural gas production has been rising over time
   C. In-state natural gas production has stayed about the same
3. "Considering a WST permit-ban scenario, which statement best-describes the likely changes in oil production at your organization's California wells?"
   A. In-state oil production will fall dramatically
   B. In-state oil production will fall modestly
   C. In-state oil production will stay about the same
   D. In-state oil production will rise modestly
   E. In-state oil production will rise dramatically
4. "Considering a WST permit-ban scenario, which statement best-describes the likely changes in natural gas production at your organization's California wells?"
   A. In-state natural gas production will fall dramatically
   B. In-state natural gas production will fall modestly
   C. In-state natural gas production will stay about the same
   D. In-state natural gas production will rise modestly
   E. In-state natural gas production will rise dramatically
5. "Considering your existing wells that have no history of WST, how would a ban on future WST permits affect their production lifecycles?"
   A. Well lifecycles would become significantly shorter
   B. Well lifecycles would be unaffected
   C. Other (Please briefly describe any non-WST well characteristics (e.g., annual production volume, geography, geology, etc.) that would be relevant to the effects of a permit ban on its lifecycle) [Blank Text Box]
6. "Considering your existing wells that have no history of WST, how do you anticipate a WST permit ban would affect the overall intensity of production?
   A. Production would become relatively more intense
   B. Production intensity would not change significantly
   C. Production would become relatively less intense
7. "Considering your existing wells that have received WST, how would a ban on future WST permits affect their production lifecycles?"
   A. Well lifecycles would become significantly shorter
   B. Well lifecycles would be unaffected

   C. Other (Please briefly describe any WST well characteristics (e.g., annual production volume, geography, geology, etc.) that would be relevant to the effects of a permit ban on its lifecycle) [Blank Text Box]

8. "Considering your existing wells that have received WST, how do you anticipate a WST permit ban would affect the overall intensity of production?
   A. Production would become relatively more intense
   B. Production intensity would not change significantly
   C. Production would become relatively less intense
9. "How do you expect a WST permit ban would affect your organization's drilling of new California wells?"
   A. Our organization would drill fewer new wells
   B. Our organization would drill more new wells
   C. Our drilling of new wells would not change significantly
10. "In operational contexts where WST would have otherwise been utilized, would a WST permit ban stimulate a shift to specific technological alternatives?"
    A. No: operations at wells that would have received future WST will likely end entirely → Skip to question XVI
    B. No: operations at wells that would have received future WST will likely continue – but no alternatives to WST will be pursued) → Skip to question XVI
    C. Yes: operations at wells that would have received future WST will likely continue – and WST will largely be replaced by specific technological alternatives → Continue to next (sub) question
    D. "Please indicate the technological alternatives your organization may pursue as a substitute for WST" [Text Box]
11. "How do these technological alternatives compare in overall cost to WST? [Text Box]
12. "Would a WST permit ban affect secondary production techniques (e.g., cyclic steam, waterflood, steamflood, etc.) at your organization's wells? (For example, do you anticipate becoming more / less reliant on specific production techniques?).
    A. No
    B. Yes (Please describe) [Text Box]

13. "Would a WST permit ban prompt a revision of your organization's P1 (proven) hydrocarbon reserve estimates?"
    A. No
    B. Yes (Please describe) [Text Box]
14. "Would a WST permit ban cause a change in the Oil and Gas exploration efforts that inform your organization's P2 and P3 estimates?
    A. No
    B. Yes (Please describe) [Text Box]
15. "Do you anticipate a WST permit ban would meaningfully affect industries that are mid-stream and down-stream to your organization?"
    A. No
    B. Yes (Please describe) [Text Box]

Comment: "Please provide the requested pricing / profitability estimates in the following questions, or otherwise indicate if an answer cannot be given with confidence."

16. "What is your organization's current breakeven price (per barrel) of oil?
    A. Estimate: [Text Box] → Proceed to sub-question
    B. Cannot estimate → Skip to XXI
17. "Does this estimate change in the context of a WST permit ban?"
    A. No
    B. Yes (Please describe and, if possible, estimate the WST-ban breakeven price) [Text Box]
18. "What is your organization's current breakeven price (per barrel) of natural gas?
    A. Estimate: [Text Box] → Proceed to sub-question
    B. Cannot estimate → Skip to XXII
19. "Does this estimate change in the context of a WST permit ban?"
    A. No
    B. Yes (Please describe and, if possible, estimate the WST-ban breakeven price) [Text Box]
20. "Do you anticipate a WST permit ban will meaningfully affect the profitability of your organization's in-state Oil and Gas operations?"
    A. No B. Yes (Please describe) [Text Box]

APPENDIX 4
TECHNICAL SUMMARY OF REGULATORY IMPACT FORECASTS

A4.1. Introduction

The Department of Conservation (Department), Geologic Energy Management Division (CalGEM), released pre-rulemaking draft regulations that will end approval of permits to conduct well stimulation treatments (WST) beginning the first available effective date after formal rulemaking[31]. It is anticipated that the regulatory proposal would have an economic impact greater than $50 million during a 12-month period after its full implementation, requiring the Department to prepare a SRIA for this regulatory package.

The SRIA must include long-term projections of operators' lost profits due to the WST Permitting Phase Out. This first requires preparing long-term projections of Oil and Gas production for the Baseline scenario to compare against Oil and Gas production projections for proposed regulatory scenario and alternatives. Then, these production projections would serve for computing the profit lost due to the phase out of WST permits.

This analysis describes the approach used to estimate operators' profit lost triggered by the WST Permitting Phase Out in two parts. The first part describes the forecasting approach to project California's Oil and Gas production from 2021 through 2039[32], and the second part describes the approach used to estimate profit losses based on the prior Oil and Gas production estimates.

The Oil and Gas production projections include two scenarios, a Baseline scenario and the Proposed Regulatory scenario (PRS). The difference between the Baseline scenario and PRS determines the impact of the WST permitting phase out. The Baseline and PRS

[31] In May 21,2021, the Department has publicly released pre-rulemaking draft regulations for the purpose of receiving public input.

[32] This forecast analysis did the arbitrary determination to develop estimates for two complete decades of oil and natural gas production. Projecting more time in the horizon adds more uncertainty on how operators would respond to the WST ban in the longer term. For instance, the WST ban might trigger alternative technological developments to produce oil and natural gas.

are also broken down by WST-facilitated production and non-WST-facilitated production.

In preparing the Baseline scenario, the analysis separately forecasts 1) total Oil and Gas production and 2) WST-facilitated Oil and Gas production in the absence of the proposed regulation. Then, non-WST-facilitated production in the absence of the proposed regulation is calculated from the difference between total production and WST-facilitated production.

For the PRS, the analysis forecasts 1) WST-facilitated production and 2) non-WST-facilitated production, once the proposed regulation goes into effect in 2024. Here, the analysis estimates non-WST-facilitated production using 1) the Baseline non-WST-facilitated production plus 2) the Oil and Gas production coming from wells that would have been WST-facilitated under the Baseline scenario and that would have been producing before the WST. Finally, total Oil and Gas production under the PRS equals the WST-facilitated production plus the non-WST-facilitated production.

To develop profit loss estimates, the analysis computes the difference between revenues losses and expenses-not-incurred due to the WST permitting phase out. Revenue losses are computed from WST-facilitated Oil and Gas production losses multiplied by their respective Oil and Gas prices obtained from the EIA forecast. Similarly, expenses-not-incurred are computed from WST-facilitated Oil and Gas production losses--measured in barrel of oil equivalent (BOE)—multiplied by the total production costs of WST-facilitated Oil and Gas production per BOE. Total production costs are the sum of operating expenses and capital expenditures that operators incur to develop Oil and Gas production in general, as well as the upfront expenses that operators incur when doing well stimulation treatment works.

A4.2. Summary Estimates

Table A4.1. California's Oil and Natural Gas Production Baseline and Regulatory Proposal Scenarios

	Baseline Oil Production (Barrels)	Proposed Regulation Oil Production (Barrels)	Regulatory Impact (% of Baseline)	Baseline Natural Gas Output (Mcf)	Proposed Regulation Gas Output (Mcf)	Regulatory Impact (% of Baseline)
2020	147,483,758	147,483,758	100.00%	148,577,584	148,577,584	100.00%
2021	137,203,939	137,203,939	100.00%	121,636,332	121,636,332	100.00%
2022	138,019,347	138,019,347	100.00%	122,553,582	122,553,582	100.00%
2023	138,839,600	138,839,600	100.00%	123,477,749	123,477,749	100.00%
2024	135,052,366	134,634,490	99.69%	119,566,478	119,196,440	99.69%

	Baseline Oil Production (Barrels)	Proposed Regulation Oil Production (Barrels)	Regulatory Impact (% of Baseline)	Baseline Natural Gas Output (Mcf)	Proposed Regulation Gas Output (Mcf)	Regulatory Impact (% of Baseline)
2025	131,368,439	130,232,448	99.14%	115,779,100	114,727,814	99.09%
2026	127,785,001	126,079,398	98.67%	112,111,691	110,487,984	98.55%
2027	124,299,311	122,137,852	98.26%	108,560,450	106,476,800	98.08%
2028	120,908,703	118,356,804	97.89%	105,121,698	102,646,729	97.65%
2029	117,610,583	114,705,575	97.53%	101,791,871	98,973,678	97.23%
2030	114,402,429	111,176,169	97.18%	98,567,520	95,434,886	96.82%
2031	111,281,786	107,762,069	96.84%	95,445,303	92,023,916	96.42%
2032	108,246,267	104,455,389	96.50%	92,421,986	88,734,328	96.01%
2033	105,293,551	101,250,868	96.16%	89,494,434	85,561,623	95.61%
2034	102,421,377	98,143,636	95.82%	86,659,616	82,503,498	95.20%
2035	99,627,551	95,129,585	95.49%	83,914,593	79,556,172	94.81%
2036	96,909,933	92,200,812	95.14%	81,256,521	76,713,605	94.41%
2037	94,266,447	89,347,524	94.78%	78,682,646	73,967,518	94.01%
2038	91,695,068	86,568,394	94.41%	76,190,301	71,311,461	93.60%
2039	89,193,831	83,865,238	94.03%	73,776,903	68,738,770	93.17%

Source: Forecast prepared using data from U.S. Energy Information Agency and CalGEM's Data

Table A4.1 depicts projections of oil and natural gas production under the Baseline scenario and the PRS. Over the years, the difference between the Baseline and the PRS represents the Oil and Gas production losses that the WST permitting ban would trigger. These Oil and Gas production losses will increase over the years as the impact of losses from what would have been newly stimulated wells accrue over time. One year after the year of full implementation of the regulation, oil production would be 99.1% of baseline, and natural gas production would be 99.1% of baseline. Five years after full implementation of the regulation, oil production would be 97.5% of baseline, and natural gas production would be 97.2% of baseline. Ten years after full implementation of the regulation, oil production would be 95.8% of baseline, and natural gas production would be 95.2% of baseline[33].

Table A4.2. Anticipated Operators' Profit Lost from WST Permitting Phase Out at its Cash Value in 2024

Years after Full Regulatory Implementation	Cumulative Operators' Profit Lost ($ Cash Value in 2024)

[33] These scenarios reflect current historical trends of WST-facilitated Oil and Gas production, as reported by CalGEM databases.

1 year	-12,916,404
5 years	-82,311,932
10 years	-178,163,055

Sources: Forecast prepared using CalGEM data; U.S. Energy Information Administration data; Department data collected on CRC SEC 10-Ks and Chevron SEC 10-Ks; and Williams and Genest (2018), "Economic and Revenue Impacts of a Statewide Oil Production Ban in California"

Table A4.2 reports the anticipated operators' profit lost from the proposed regulations at its cash value in 2024[34], the year the regulations are fully effective. One year after the year of full implementation of the regulation, Oil and Gas operators are expected to lose $13 million in profits. Five years after the regulations are fully implemented, operators are anticipated to lose $82 million in profits. And ten years after the regulations are fully implemented, operators are expected to lose $178 million in profits.

A4.3. California's Oil and Gas Production Forecast Under Baseline Scenario

To prepare Baseline projections, the analysis follows three steps. It first prepares a forecast for all California's Oil and Gas production. Second, it prepares a WST-facilitated production forecast. Finally, non-WST-facilitated production is obtained from the difference between California's total production and WST-facilitated production.

A4.3.1. Total Oil and Gas Production Forecast

California's total Oil and Gas projections leverage historical data reported by the EIA to estimate future production[35]. The Department determined that using past performance to predict future Oil and Gas production in California was the best approach available. Thus, the Baseline projections assume that production from 2021 to 2039 follows the average historical rate of decline in California. The historical rate of production decline

[34] The analysis applies a discount rate of 14% to its projected profits estimates. This discount rate was applied to after-tax future cash-flow estimates from oil field production of the following analysis: Williams, Brad and Genest, Mike (2018) "Economic and Revenue Impacts of a Statewide Oil Production Ban in California," Capital Matrix Consulting. "

[35] U.S. Energy Information Administration (EIA). (2021). Petroleum & Oher Liquids [Data File]. Retrieved from https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm; U.S. Energy Information Administration (EIA). (2021). Natural Gas [Data File]. Retrieved from https://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_sca_a.htm

in California between the years 2000 and 2019 is equal to approximately 2.7% for oil production and 3.2% for natural gas production.

Similarly, the analysis relies on historical data to project Oil and Gas production after the COVID-19 shock on production. In doing so, the Baseline projections assume a COVID-19 production rebound of 6.6% for years 2022 and 2023 to catch up with historical trends prior to COVID-19. Here, it is assumed that California's oil production would have declined 2.7% from years 2020-2023 in the absence of COVID-19, and it is known that California's oil production declined 9.4% in 2020. Thus, to catch up with historical trends, the analysis equally splits a 6.6% rebound for years 2022 and 2023. This rebound would equal 0.6%, considering that 2022 and 2023 would have declined 2.7% in the absence of COVID-19. A similar approach was used to calculate the natural gas forecast.

A4.3.2. WST-Facilitated Oil and Gas Production Forecast

The analysis prepared the Baseline[36] forecast of WST-facilitated Oil and Gas production using CalGEM data from 1977 to 2020[37]. The analysis uses this data to group WST-facilitated Oil and Gas production by years of production and years of well stimulation disclosures. This allows assessing the production life from wells stimulated during different years, which this analysis denotes as the WST-vintages. Each WST-vintage groups all wells and their respective annual production by the year of their WST disclosure. Total WST-facilitated Oil and Gas production is the sum of production across all WST-vintages in each year of production.

The WST-facilitated production forecast model follows two stages. First, the model annually projects 1) the number of newly stimulated wells producing the same year of WST disclosure (this is the year the WST-vintage starts) and 2) the average production of newly stimulated wells producing the same year of WST disclosure. Second, the forecast model fits WST-vintage curves on the average Oil and Gas production over the life of wells stimulated annually. In doing so, the analysis observes the historical performance of WST-vintages, using CalGEM's data on WST disclosures and production from 1977 to 2020.

[36] It projects WST-facilitated Oil and Gas production under the current regulatory framework.

[37] These data sources are collected and customized internally by the CalGEM, which has legal jurisdiction over Oil and Gas production activities in California. CalGEM's data reports production for wells that were stimulated or assumed to be stimulated from 1977 to 2020.

To the extent possible, the forecast analysis relies on the model of crude oil extraction prepared under CalEPA's Carbon Neutrality Study[38]. It specifically leverages 1) the new wells entry approach to project new well stimulation and production and 2) the field-vintage curves to project annual production per WST-vintage. The following sections offer details of each of the forecasting stages that this analysis developed.

A4.3.3. Projecting New Well Stimulations and Production

The forecast model uses oil prices to predict new well stimulations and production[39]. It is assumed that newly stimulated and producing wells are completed when it is profitable to do so. Thus, because the analysis does not have access to data to observe investments and operating cost of new well stimulations, the WST-facilitated production forecast uses historical global oil prices to empirically estimate their relationship with historical newly stimulated and producing wells, as well as with the average production of newly stimulated and producing wells, during the period between 1986 through 2019[40].

The analysis empirically estimates historical relation coefficients between benchmark global oil prices—with one year of lag—and the number of Oil and Gas producing wells with newly completed stimulations between 1986 and 2019. In doing, the analysis eliminates the impingement effects that SB 4 regulations have on the number of wells

[38] Deschenes, Oliver et.al. (2021, Enhancing equity while eliminating emissions in California's supply of transportation fuels. Zenodo, CalEPA, https://zenodo.org/record/4707966#.YcOT2GDMJaT

[39] The CalEPA's Carbon Neutrality Study uses observable costs, global crude oil prices, and historical entry data to estimates how costs and prices have impacted historical new well entries. Unfortunately, the Department does not have access to historical costs data. Thus, the WST-forecasting model only uses prices to statistically estimate how global prices impact new well stimulations and production. CalGEM's Subject Matter Experts validated the approach of using global oil prices to project future well stimulations and production.

[40] The U.S. Energy Information Administration provides global oil price data starting 1986. Due to this data limitation, the empirical model assesses Oil and Gas-producing wells with newly completed stimulations starting 1986, even so there is WST data starting 1977. Additionally, the model excludes Oil and Gas-producing wells with newly completed stimulations for 2020 due to COVID-19 effects, which are assumed of not being representative of normal well stimulation and production activity.

newly stimulated annually[41]. Then, using EIA's oil price projections[42], the analysis applies the regression coefficients to predict the number of Oil and Gas producing wells with newly completed stimulations from 2022 to 2039. For 2021, the analysis assumes the same number of Oil and Gas producing wells with newly completed stimulations as in 2020. The analysis specifically used the following regression model:

$$\ln NewWellStimulated_t = \beta_0 + \beta_1 \ln WTIPrice_{t-1} + \beta_2 SB\ 4Reg + e_t$$

Where "t" denotes years and "lnNewWellStimulated" is the natural log of the number of Oil and Gas producing wells with newly completed stimulations, constructed from CalGEM's data of WST activity from 1986 to 2019. "ln WTIPrice" is the natural log of West Texas Intermediate benchmark oil price, constructed from EIA's historical data from 1986 to 2019. "SB 4Reg" indicates the years where SB 4 regulations were effective. It takes values in [0,1], where 0 indicates that WST production occurred in years with no existing SB 4 regulations and 1 indicates the years where SB 4 regulations were effective. The symbol "e" is the error term of the model.

The analysis also computes relation coefficients between oil prices—with one year of lag—and Oil and Gas production per well per year among producing wells with newly completed stimulations between 1986 and 2020. Then, using the EIA's oil price forecast, the analysis applies these relation coefficients to predict Oil and Gas production per well per year among producing wells with newly completed simulations from 2022 to 2039. The analysis specifically used the following regression model:

$$\ln ProdperWSTWellperYear_t = \beta_0 + \beta_1 \ln WTIPrice_{t-1} + \beta_2 SB\ 4Reg + e_t$$

Where "t" denotes years and "lnProdperWSTWellperYear" is the natural log of production per well per year among producing wells with newly completed stimulations, constructed from CalGEM's data of WST activity from 1986 to 2019. In "WTIPrice" is the natural log of West Texas Intermediate benchmark oil price,

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[41] The model uses CalGEM's WST data from 1977 to 2020 to estimate Oil and Gas-producing wells with newly completed stimulations and U.S. Energy Information (EIA)'s WTI Benchmark Oil Price data from 1986 to 2020, Spot Prices, Petroleum & Other Liquids [Data File]. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm

[42] U.S. Energy Information Administration (EIA). (2021). Annual Energy Outlook 2021, Table 1. Total Energy Supply, Disposition, and Price Summary, Case: Multiple Cases [Data File]. Retrieved from https://www.eia.gov/outlooks/aeo/data/browser/#/?id=1-AEO2021&region=0-0&cases=ref2021~aeo2020ref&start=2019&end=2050&f=A&linechart=ref2021-d113020a.3-1-AEO2021~aeo2020ref-d112119a.3-1-AEO2021~ref2021-d113020a.5-1-AEO2021~ref2021-d113020a.4-1-AEO2021&map=&ctype=linechart&sourcekey=0 (link here)

constructed from EIA's historical data from 1986 to 2019. "SB 4Reg" indicates the years where SB 4 regulations were effective. It takes values in [0,1], where 0 indicates that WST production occurred in years with no existing SB 4 regulations and 1 indicates the years where SB 4 regulations were effective. The symbol "e" represents the error term of the model.

A4.3.4. Projecting Annual Production of WST-Vintages

To model annual production per each WST-vintage, the model fits average Oil and Gas production curves to estimate production parameters for each year after WST disclosures occur (age of WST). The estimated parameters are obtained using the historical production of all wells stimulated from 1977 to 2020. Then, these parameters are applied to the forecast years. The analysis followed the next steps to create and apply the annual production parameters to each WST-vintage for the forecast years:

WST-facilitated Oil and Gas production is grouped by year of production and year of WST disclosure to denote the production life of WST-vintages. A total of 43 unique WST-vintages were obtained using CalGEM data on WST activity from 1977 to 2020. Each year of production after the year of WST disclosure denotes the age of WST.

The analysis divides the WST-facilitated Oil and Gas production by well ever stimulated to compare it across WST-vintages at different ages of WST.

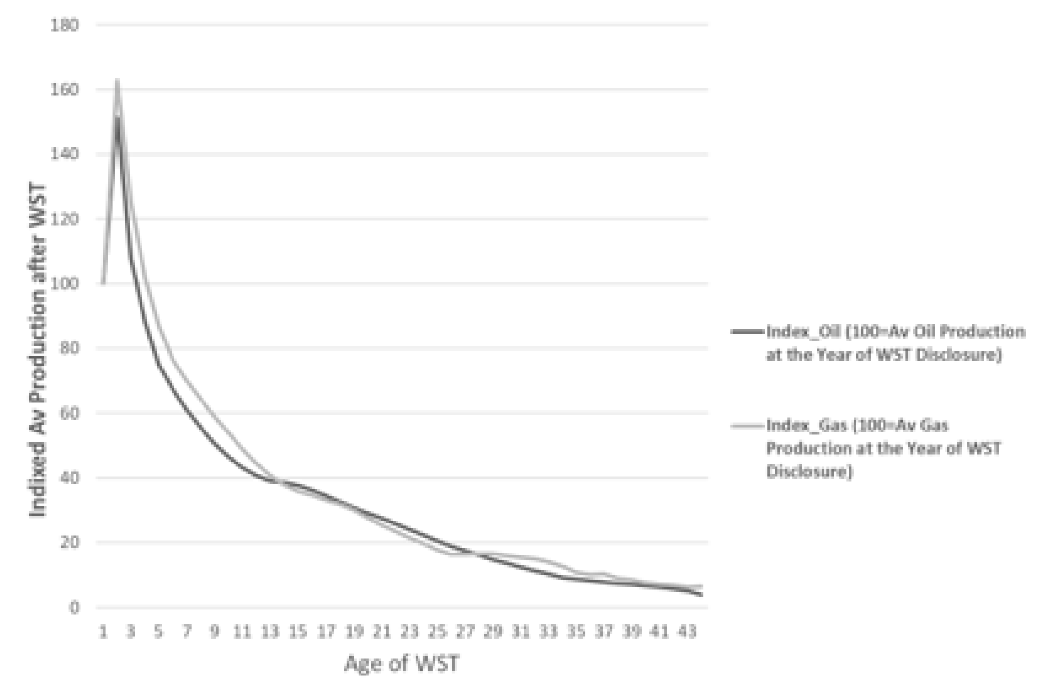
WST-facilitated Oil and Gas production per well is averaged across 1977-2020 WST-vintages at each age of WST. This allows to determine the average WST-facilitated Oil and Gas production curves from wells after their year of stimulation. The analysis exponentially smooths the average WST-facilitated Oil and Gas production curves created using the holt-winters method. The analysis computes final WST-facilitated Oil and Gas production curves until age 6 of WST and from ages 7 to 43 of WST[43].

The analysis calculates the year-over-year percent changes (or annual changes per age of WST) to forecast annual WST-facilitated production after the year of WST disclosure for each WST-vintage, both those that have entered in the historic period and those forecasted to enter in the future. Using as reference the age of WST, year-over-year rates are applied to each initial WST production estimate (production at the year of WST) to project the production life of each of the 2021 to 2039 WST vintages.

[43] The holt-winters model does not correctly fit the first six years after WST disclosures. Thus, the analysis keeps the historically observed Oil and Gas production per well during the first six years after WST disclosures.

To project the remainder life of production for WST-vintages from 1977 to 2020, the analysis combines vintages using timeframes established by CalGEM based on its data sources and data collection methods: "Pre2011", "2011-2013 Combined", "2014-2016 Combined", and "2017-2020 Combined"[44]. Here, the analysis starts with year-over-year growth rates at the age of WST of the upper bound year of each "combined timeframe" (e.g., WST age of 2016 for 2014-2016 Combined). The 2017-2020 combined timeframe is the only exception. It uses the WST age of 2019 because COVID19 primarily muted 2020 contributions to the 2017-2020 combined vintage trajectory.

Figure A4.1: Indexed Average WST-facilitated Oil and Gas Production Curves Prepared to Forecast Annual WST-vintage Production After the Year of WST Disclosure



[44] The CalGEM computed production for wells that were stimulated or assumed to be stimulated during Pre2011, 2011-2013, 2014-16, and SB 4 time periods. Pre2011 data are supplied by Oil and Gas operators; 2011-2013 data was collected from FracFocus Database, which started publishing data in 2011; 2014-2016 data was directly collected by the CalGEM during the interim period prior to SB 4 regulations; and SB 4 period data (2017-2020) was directly collected by the CalGEM since the effective date of SB 4 regulations.

A4.4. California's Oil & Gas Production Forecast Under the Proposed Regulation

The analysis prepares the proposed regulation forecast of Oil and Gas production following three steps. It first prepares a WST-facilitated production forecast. Then, it prepares the non-WST-facilitated production forecast. Finally, total Oil and Gas projections are obtained by adding WST-facilitated production and non-WST-facilitated production.

The WST-facilitated Oil and Gas production forecast follows the same approach as the Baseline scenario. The analysis computes WST-facilitated production by WST-vintage. However, WST production estimates go from 2021 to 2023, the last year WST permits would be issued if the proposed regulations are approved. For year 2024, the analysis partially estimates new WST production to reflect that 12% of new well stimulation disclosures will come from permits issued in 2023[45]. New WST disclosures decline to zero starting 2025.

The non-WST-facilitated Oil and Gas production forecast is the sum of 1) Baseline non-WST-facilitated production plus 2) the WST-facilitated production from wells that a) would have been stimulated under the current regulatory framework (Baseline) and b) would have been producing before any WST.

To estimate the continuing production among wells that would have been stimulated under the Baseline scenario, the analysis 1) uses the anticipated baseline production from wells stimulated from 2024[46] to 2039; 2) applies the average rate of decline of California's no-WST existing wells from 2010 to 2019[47]; 3) adjusts downwards to account for the share of WST-facilitated production coming from wells that would be producing

[45] This is the average 2017-2020 proportion of WST disclosures with permits issued the year prior to the disclosure, according to CalGEM's WellSTAR database.

[46] For 2024, the analysis only uses 88 percent of new WST-facilitated production because the remaining 12 percent comes from stimulated wells with permits issued in 2023. These proportions are assumed using the average 2017-2020 proportion of WST disclosures with permits issued the year prior to the disclosure, according to CalGEM's WellSTAR database.

[47] The average rate of decline of no-WST existing wells was obtained using CalGEM's WellSTAR database from 2010 to 2019.

before their stimulation[48]; and 4) divides by the ratio of pre-stimulation production compared to post-stimulation production for WST wells producing oil and/or gas before stimulation[49].

The PRS assumes that operators will not find alternative technologies to produce all or some portion of planned WST-facilitated production that would be lost under the permitting phase out. They would only keep producing from wells reporting production before anticipated WST under the Baseline estimates[50].

A4.5. Estimating Operators' Profit Lost from WST Permitting Phase Out

The analysis estimates operators' profit lost from the difference between forgone revenues and expenses-not-incurred by operators because of the WST permitting phase out. To compute forgone revenues, the analysis applies to WST-facilitated Oil and Gas production losses their respective Oil and Gas prices using the EIA's reference case forecast of West Texas Intermediate (WTI) Oil prices and Gas prices at Henry Hub[51].

To estimate expenses-not-incurred, the analysis applies the estimated total production expenses per barrel of oil equivalent (BOE) to the forgone WST-facilitated Oil and Gas production. To do so, the analysis first computes the BOE of the forgone WST-facilitated Oil and Gas production. Here, the analysis converts forgone WST-facilitated natural gas

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48 Analysis performed using CalGEM data reporting production for wells stimulated or assumed to be stimulated from 1977 to 2020. It is assumed that shares from 2015 to 2020 trends are more representative of future trends of the share of production coming from stimulated wells producing before the stimulation. The share of production from WST wells producing before the stimulation has reported a steady decline in the last six years. This share will go to zero if the analysis extrapolates the historical series using a linear regression in time to forecast future share values. Thus, acknowledging the uncertainty of future share values, this analysis made the determination to hold constant the average share of the most recent six years of the historical series and apply it to the 2021-2039 forecast years.

49 Analysis performed using CalGEM data from 1977 to 2020. It is assumed that 2011-2020 trends would provide the most conservative estimates of forgone production due to the regulatory proposal. Before 2011, data does not report Oil and Gas production increases after stimulation among wells producing before stimulation. In contrast, after 2011, data reports an increase of Oil and Gas production among this type of wells.

50 The Department did not have access to reliable information indicating profitable alternative technologies for WST producers. Thus, it decided preparing the worst case-case scenario, where operators forgo all anticipated new well stimulation facilitated Oil and Gas production.

51 U.S. Energy Information Administration (EIA). (2021). Annual Energy Outlook 2021, Table 1.

from thousand cubic feet (Mcf) to BOE[52] and combines it with forgone WST-facilitated oil production. Then, the analysis multiplies this forgone production by the total production expenses per BOE. To compute total production expenses per BOE, the analysis adds operational, drilling, and other expenses per BOE plus WST upfront expenses per BOE.

To compute operational, drilling, and other expenses per BOE, the analysis executes a similar approach to that used by Williams and Genest (2021).[53] This approach prepares estimates on operational, drilling, and other expenses per BOE using the sum of operational expenses per BOE and capital expenditures per BOE. These expenses are collected from SEC 10K annual filings for existing Oil and Gas operators in California[54]. Subsequently, the analysis determines weighted average operational expenses per BOE and capital expenditures per BOE using the contribution of Oil and Gas operators to total California Oil and Gas production.

The analysis proceeds to forecast operating expenses per BOE and capital expenditures per BOE from 2021 through 2039. In doing so, the analysis uses as basepoint the weighted average of operating expenses per BOE and capital expenditures per BOE for year 2019, which is the last year of historical data available prior to the COVID-19 disruption. Then, the analysis applies to this basepoint the real growth rate assumption for operating expenses per BOE and capital expenditures per BOE that Williams and Genest (2018) prepared for the next nineteen years.[55]

A4.5.1. WST Operational Expenses

Finally, the analysis computes upfront WST expenses per BOE using information that CalGEM gathered from Oil and Gas operators when preparing SB 4 regulations in 2013.

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52 The analysis divides Mcf of natural gas by 6 because 1 Barrel of Oil Equivalent equals 6 Mcf of natural gas.

53 Williams, Brad and Genest, Mike (2021), "The Economic Impacts of Oil Production Tied to Well Stimulation Treatments in California", Capitol Matrix Consulting.

54 The analysis relied on data SEC 10(k) historical expenditure data gathered by the Department in 2020.

55 Williams, Brad and Genest, Mike (2018) "Economic and Revenue Impacts of a Statewide Oil Production Ban in California," Capital Matrix Consulting. The authors anticipated that per-barrel of oil equivalent cost for operating expenditures rise about 1.7 percent annually in constant-dollar terms between 2018 and 2030. Additionally, the authors anticipated that per-barrel of oil equivalent capital expenditures rise about 2.8 percent annually in constant-dollar terms between 2025 and 2030. These percentages are applied to project future costs of WST-facilitated Oil and Gas production because this analysis does not have alternative information to empirically assess future WST-facilitated costs by each of its components (i.e., operating expenses and capital expenditures).

At the time this information was collected, existing California operators and service providers reported that a typical WST in California cost $40,000 per stage of well stimulation. Knowing the typical cost per stage of well stimulation, this analysis calculates aggregated expenditures for WST for years 2017 to 2020 combined using data on well stimulation disclosures and their respective number of stages[56]. Subsequently, to compute upfront WST expenses per BOE, the analysis uses the aggregated upfront WST expenditures and divides them by the BOE baseline projections of WST-facilitated Oil and Gas production coming through the life of wells stimulated in years 2017-2020 combined. Then, using this basepoint estimate of upfront WST expenditures per BOE, the analysis applies the real growth rate assumption for capital expenditures per BOE that Williams and Genest (2018) prepared for the next nineteen years.

In producing these estimates, the Department relied on the best available data given time and resource constraints. Consequently, the data gathered for the SB 4 rulemaking process in 2013 (a rule that added environmental and health safety restrictions to WST permits in California) represent the most reliable existing information to determine the costs of doing WST.

The 2013 WST cost estimates must be adjusted to reflect evolving market and technical changes of the Oil and Gas industry. All cost drivers for conventional and nonconventional Oil and Gas production move in tandem with factors such as the supply and demand of Oil and Gas, the availability of services and goods supplies for conventional and nonconventional operations, operational innovation driving production efficiency over time, and technological shifts. All these market dynamics are reflected in the price of oil and the prices that consumers finally pay for goods derived out of Oil and Gas production such as gasoline[57].

Given the resources available, the usage of California's Consumer Price Index (CPI) Gasoline represents the most reliable approach to reflect changes in the costs of WST over the years. To determine this, the Department assessed total production costs and capital expenditures per barrel of oil equivalent (BOE) for three public companies with different Oil and Gas production compositions: Chevron's cost per BOE for all its

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[56] The analysis obtained 2017-2020 WST disclosure counts using the CalGEM's WellSTAR database. However, this database does not provide information about WST-stages. The CalGEM provided data on disclosures and well stimulation stages for year 2019 only. Thus, the analysis can only assume that WST-stage patterns of 2019 apply for 2017-2020 WST disclosures combined.

[57] U.S. Energy Information Administration (2016), "Trends in U.S. Oil and Natural Gas Upstream Costs," U.S. Department of Energy, Washington, DC 20585, retrieved from: https://www.eia.gov/analysis/studies/drilling/

production in the United States, constituted of both conventional and nonconventional production; California Resources Corporation's cost per BOE, with most of its production being conventional Oil and Gas in California; and Whiting Petroleum Corporation's cost per BOE, with all of its production being unconventional and located in Colorado and Delaware. Even despite their production differences, all three companies reported similar strong historical relations (coefficients 0.7 and over) of their total cost per BOE with both California's CPI for Gasoline and the WTI Crude Oil Price (See Table A4.3). However, as DOF requires use of its economic forecast for the SRIA, this analysis uses California's CPI for Gasoline instead of WTI crude oil price. DOF's economic forecast only projects California's Gasoline CPI.

Table A4.3. Correlation Coefficients of Production and Capex Costs per BOE with Price Indicators from 2007 to 2019

Item	California's Gasoline CPI	WTI Crude Oil Price
CRC's Production and Capex Cost (per BOE)	0.84	0.97
Chevron's Production and Capex Cost (per BOE)	0.79	0.68
Whiting Petroleum Corporation's Production and Capex Cost (per BOE)	0.71	0.88
Gasoline CPI	1.00	0.79

Source: Historical Expenditures Data from 10Ks of selected public companies; Gasoline CPI data gathered from DOF's Inflation Forecast, 2022 May Revised; and WTI Crude Oil data gathered from U.S. EIA Database.

Although a naïve approach, California's CPI Gasoline represents the best and most reliable approach that the Department has available to adjust the WST costs gathered in 2013 through the years, given the time and resources available. Furthermore, using California's CPI Gasoline will fulfill the requirement of using DOF economic projections for the preparation of the SRIA.