Tackling Methane Emissions and Climate Change Through

Energy-Based Solutions

Final Report

CE 105, UC Berkeley

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Team Mission Statement:

Our goal is to establish an inclusive, community-driven framework of resources and action steps to enable reduction in methane emissions due to energy sources such as oil and gas.

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Introduction

Climate change mitigation has been a rising issue in recent years, and critical changes are required in order to slow down the effects. Although reducing carbon dioxide emissions is vital for our future, we should also turn our attention to short-lived climate pollutants (SLCPs), especially methane.

Methane makes up 16% of the world's greenhouse gas emissions and is expected to continue rising ("Short-Lived Climate Pollutants," 2021). Although its atmospheric lifetime is only around 12 years, methane's impact on climate change over 20 years is 86 times greater than CO_2. As well as being responsible for the rise in tropospheric ozone levels, methan is the cause of about 1 million premature respiratory deaths globally. Around 60% of methane emissions are due to human activities (Methane, n.d.). A study done by McKinsey & Company, illustrates the division of 380 metric megatons of methane per year. The leading industries are agriculture, coal mining, and oil and gas (Figure 1).

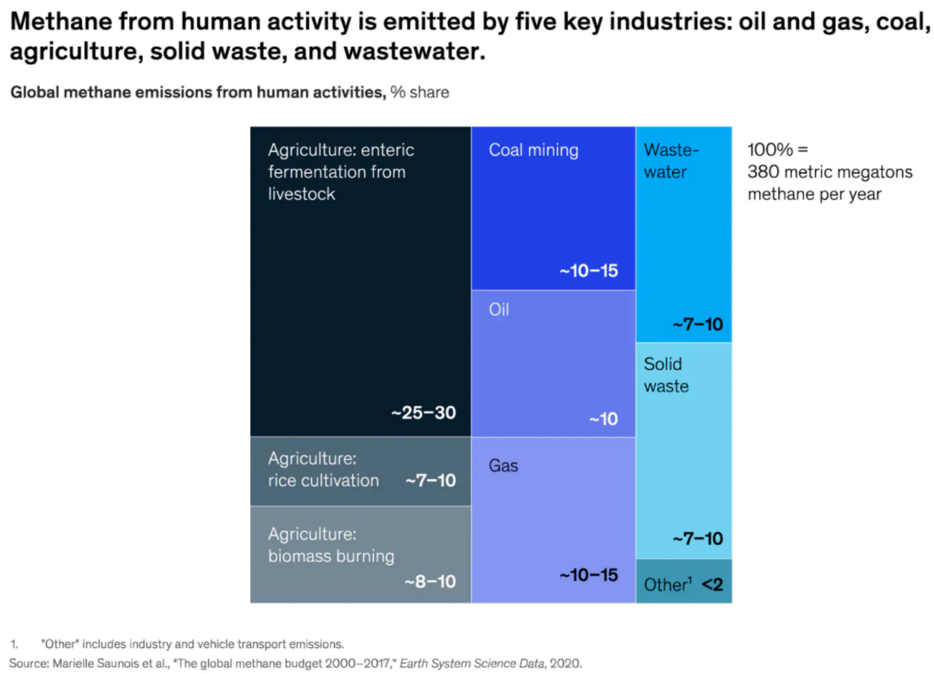


Figure 1: Methane from human activity (Curbing Methane Emissions: How Five Industries Can Counter a Major Climate Threat | McKinsey, n.d.)

In this study, we will focus on California's methane emissions, specifically in the energy and industry sectors, which include natural gas, petroleum systems, and coal mining. The energy sector accounts for 40% of methane emissions from human activities and has been growing every year. This past year it grew 5%, according to the International Energy Agency (IEA) (Methane Emissions from the Energy Sector Are 70% Higher than Official Figures - News, n.d.).

Our Vision for 2025 and Beyond

To ensure that warming is kept within safe limits, it is imperative that by 2025, we are on track to deploying massive reduction projects for greenhouse gasses and short-lived climate pollutants. Within California, it is necessary that comprehensive evaluations are conducted by 2025 to ensure that our target reductions of 40% by 2030 and 80% by 2050 as compared to 2020 levels are met. We have detailed two key mechanisms below:

1. Leveraging technology

We envision technology addressing methane emissions by rapidly identifying emissions and sources. Instantaneous leak detection and repair (LDAR) could be used for the same which would allow regular updates on the system using satellite or sensor networks. This would allow natural gas leaks to be identified immediately and relay the information on relevant platforms, allowing us to take immediate steps to rectify the issue.

2. Community engagement

In terms of community engagement, we value the following 3 forms:

2.1. Accessibility of Data and Educational Materials

People should have access to resources informing them about the current climate state and the causes of the situation, especially in the local context where people would be aware of the potential sources around their area of residence. It is also important to understand the impacts of individual actions on methane emissions. The World Resources Institute (WRI) recommends cutting beef consumption in higher-income countries like the U.S. as one of the most effective food-and-climate solutions.

2.2. Solution-driven Engagement

Community engagement is required in both the policy and action spheres. Considering people's demands regarding ways in which they would want to prevent methane pollution, their understanding and will to address the problem drives political pressure in the consideration of climate change. This would allow relevant issues to be better addressed locally. Additionally, localized solutions on farms are best implemented when action is driven by a bottom-up approach to legislation. Increases in demand for methane capture technology will help contribute to legislation that makes these technologies more accessible to small owners.

2.3. Reparations for Existing Damage

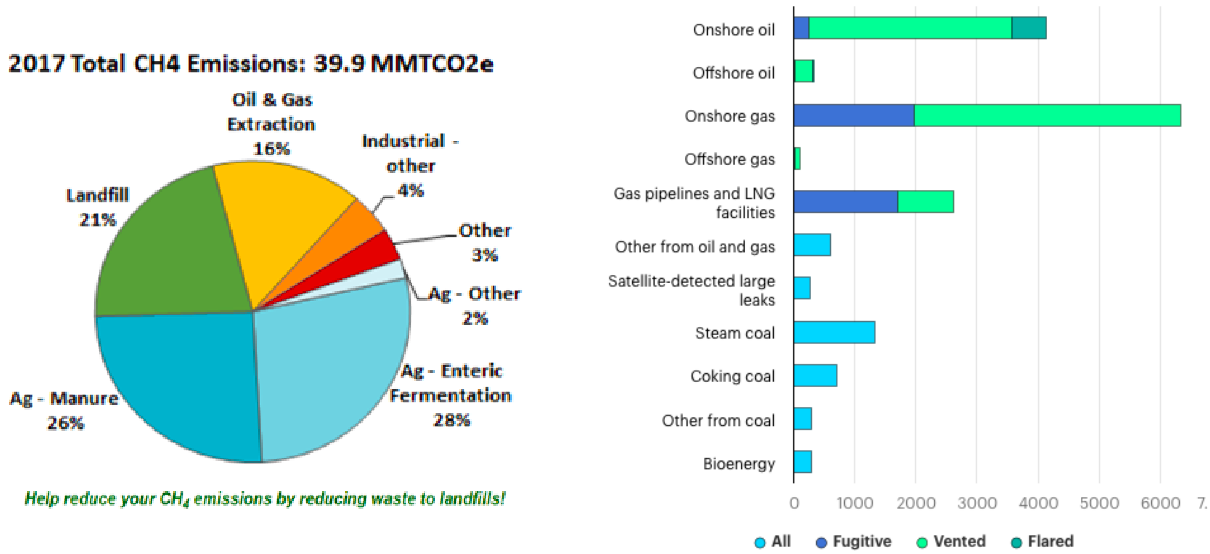
The increase in tropospheric air pollution due to methane emissions causes approximately 1 million deaths per year. Community engagement needs to focus on the adaptation needs of affected populations. Focusing on understanding the local impact of the issue, having programs in schools and community centers with an aim of raising awareness or even organizing regular health check-up camps should be facilitated.

Key Areas of Concern

While methane itself is not a source of public health concern, reducing methane emissions is key to ensuring that warming stays below 2 degrees Celsius. Methane emissions are responsible for increased levels of tropospheric ozone, which is responsible for 255,000 deaths due to respiratory diseases, 26 million tonnes of staple crop losses, 775,000 asthma-related hospital visits, and 73 billion lost hours due to heat exposure globally. In addition, the lack of effective monitoring of fugitive emissions has resulted in losses of up to $27,300,000 and reduced cost-effectiveness of $19 per MT of CO2 equivalent (CARB, 2017).

Methane emissions are a significant environmental justice issue as evidenced by a study done based on 2016-2018 data which showed that 84% of methane super emitters included in the study were located in semi-rural and rural blocks, and the risk of exposure to methane significantly increased in areas with larger Hispanic and Black populations (Casey et al., 2021).

Two of the biggest sources of methane emissions in the US consist of emissions from oil and gas and landfills. According to the EIA, the US attributes 54% of its emissions to energy production. A similar breakup is seen in CA (Figure 2(a)), however, the role of agriculture in CA is higher than the national average. Although venting and flaring of captured methane from oil and gas plants is prohibited in California, this contributes to a majority of emissions nationwide (Figure 2(b)).



Source: CARB

Figure 2(a) and (b) : 2017 Total CH4 Emissions (CARB) and sector-break up specific to the energy sector

Data Visualization and Analysis

Energy Resources

Out of methane emissions occurring from the oil and gas sector, production comprises 40% of methane emissions, and leaks across the natural gas value chain account for the remaining 60% (EIA) (Figure 3). The emissions from oil and natural gas can be broadly classified into upstream and downstream/transportation emissions.

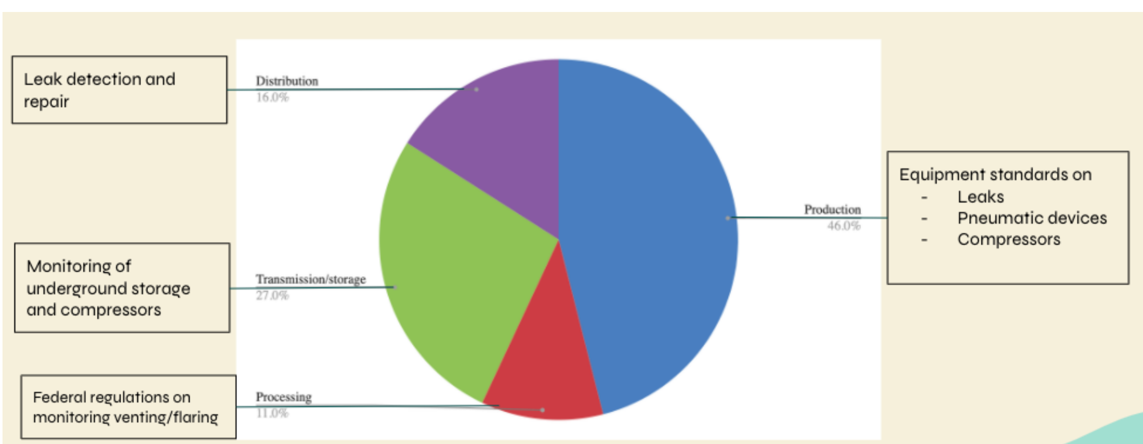


Figure 3: Sectors of methane emissions in the oil and gas sector (Source: NRDC)

1. **Upstream emissions**

Upstream oil and gas ventures include "production, gathering and processing on all onshore or offshore oil and gas facilities" (EIA). Although CA imports 85% of the natural gas used, it is the second-largest oil producer in the US. The California Air Resources Board (CARB) regulates methane emissions in this sector with the Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities, covering natural gas production, separation, and storage. This covers a number of provisions, including

- Collection and use of methane from oil and water separators, storage tanks, and all uncontrolled well stimulation circulation tanks
- LDAR requirements for all components
- Technological standards such as "dry seals", "no bleed" pneumatic pumps, and "no bleed" continuous bleed pneumatic devices

Upstream emissions are due to improper asset management. California has more than 120,000 documented abandoned oil and gas wells (Lebel et al., 2020). In addition, there are a number of wells that were decommissioned prior to the establishment of reporting regulations and hence do not show up on any database. The status of around 9,000 wells in CA has been reported as "unknown", and these numbers have not changed significantly over the past 4 years (Figure 4).

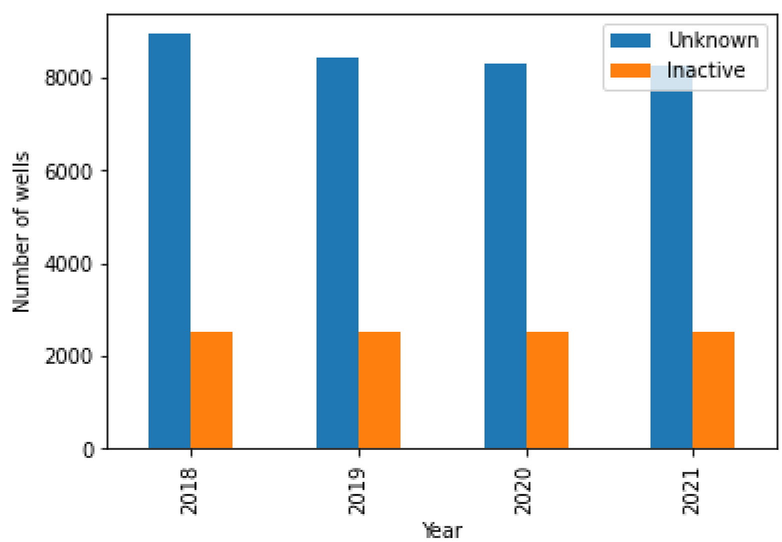


Figure 4: Number of wells with idle or abandoned status

2. **Downstream emissions**

The LDAR program was started in 1999 to attempt to control fugitive emissions. The program's main purpose was to highlight the importance of regulating equipment leaks and effectively managing equipment. As stated in their "Leak Detection and Repair - A Best Practices Guide", last updated in 2007, the EPA estimated that petroleum refineries could reduce emissions from equipment leaks by 63% by implementing the LDAR program ("Reducing Methane Emissions: Best Practice Guide - Equipment Leaks - November 2019," n.d.). However, after analyzing data on greenhouse emissions collected by the California Air Resources Board, we are able to visualize the trend of fugitive emissions (Figure 5).

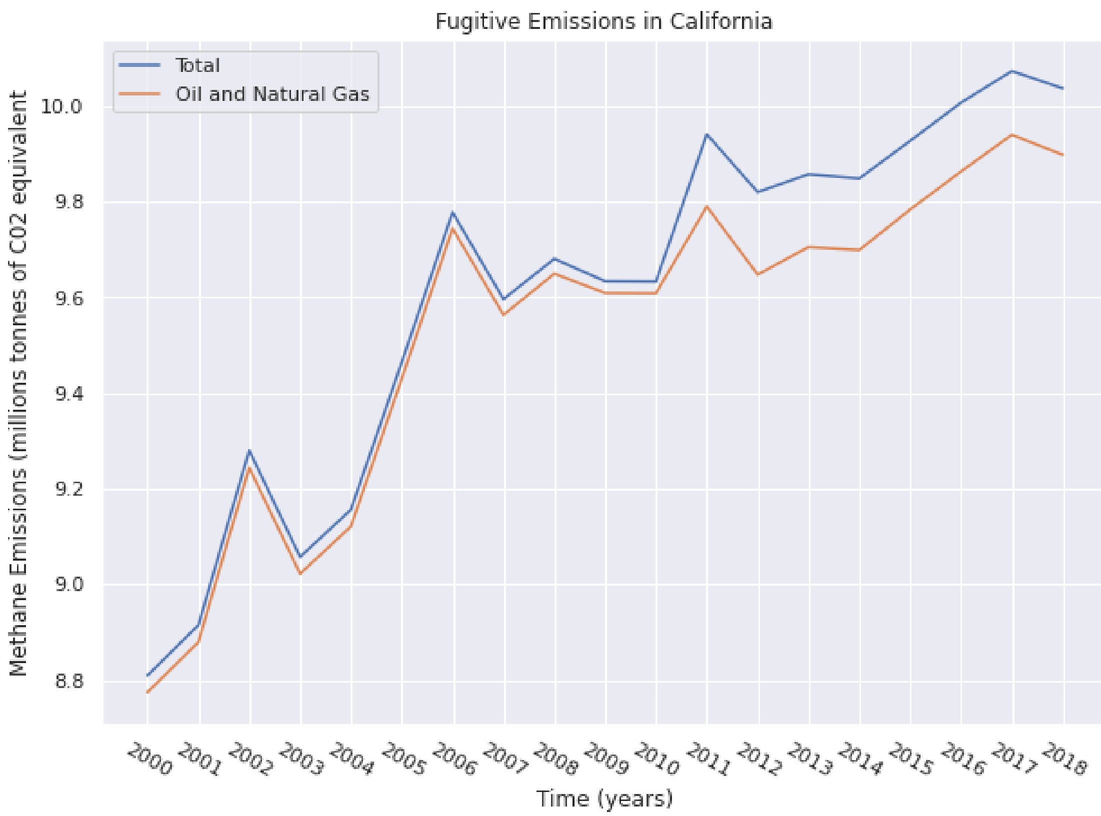


Figure 5: California's Fugitive Emissions from Oil and Natural Gas

The overall trend of California's fugitive emissions has been increasing from 2000 to 2018 and the main sector that is producing them is oil and natural gas. In 2011, California started tracking emissions due to Geothermal Energy production, which is demonstrated in the increased difference between total oil and natural gas. This illustrates that there are several flaws in the LDAR program, which have yet to be highlighted.

As stated in the article, "Fugitive methane emissions from leak-prone natural gas distribution infrastructure in urban environments", downstream emissions due to processing and distribution of natural gas are poorly characterized. Downstream, is the final section of the oil and natural gas industry, which is when we turn crude oil and natural gas into finished products (*UPSTREAM?*, 2017). Leak-prone mains make up about 34% of natural gas infrastructure on the east coast of the United States. Leak-prone distribution is due to outdated pipe materials like cast iron, wrought iron, and unprotected steel (Hendrick et al., 2016).

Gas transportation is a clear issue in California. This includes "emissions from transmission and distribution of gas by pipelines or as liquefied natural gas (LNG) and regasification"(EIA). There are two main types of methane emissions that occur during the transportation and use of natural gas: vented and fugitive. Vented emissions are intentional and are designed releases of methane including the process design flow to the atmosphere through pipes or vent pipes, while fugitive emissions include leaks and other undesirable and undesirable emissions. California currently prohibits venting of methane emissions, but there are few policies for fugitive emissions.

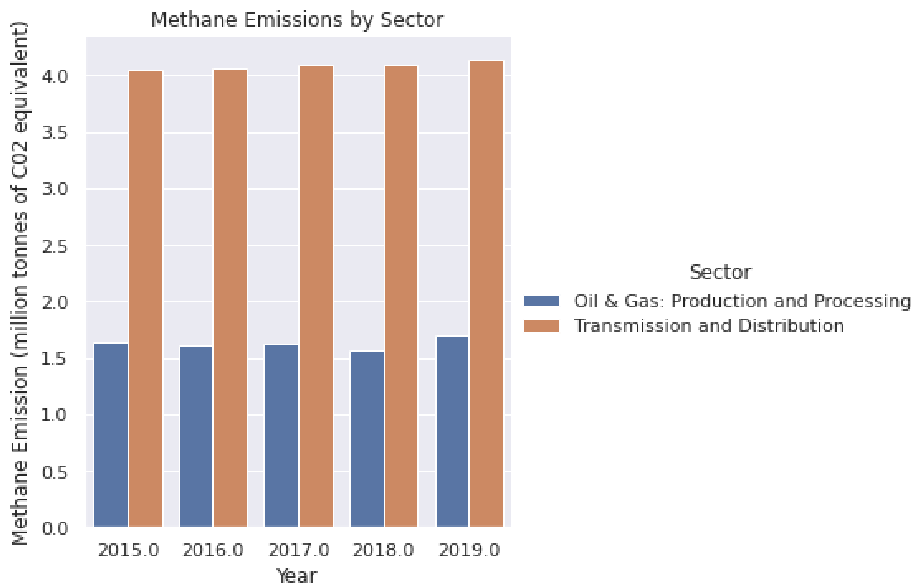


Figure 6: Methane Emissions by Stage of Production

California imports natural gas from seven different sources. Due to California importing 85% of its natural gas from various sources, downstream emissions are highly probable. As shown in Figure 6, methane emissions in the transmission and distribution sector have been double that of the production and processing sectors. However, most present policies focus on upstream emissions, such as flaring, venting restrictions, and equipment mandates (*The Case for Regulating Downstream Methane Emissions from Oil and Gas – Analysis*, n.d.).

Landfill Emissions

Landfill gas (LFG) is caused by the decomposition of organic matter deposited in landfills. LFG consists of around 50% methane and 50% carbon dioxide and water vapor.

Municipal and industrial landfills contribute to 17.8% of methane emissions in the United States, around 109.3 million metric tons of CO_2 equivalent annually (EPA).

Landfill emissions currently contribute to 40% of CA's emissions (CalRecycle). Additionally, the pilot of CarbonMapper found that out of the 270 landfills surveyed in California, only 30 "were observed to emit large plumes of methane" and contributed to 40% of the total point-source emissions detected during the survey, as seen in Figure 7.

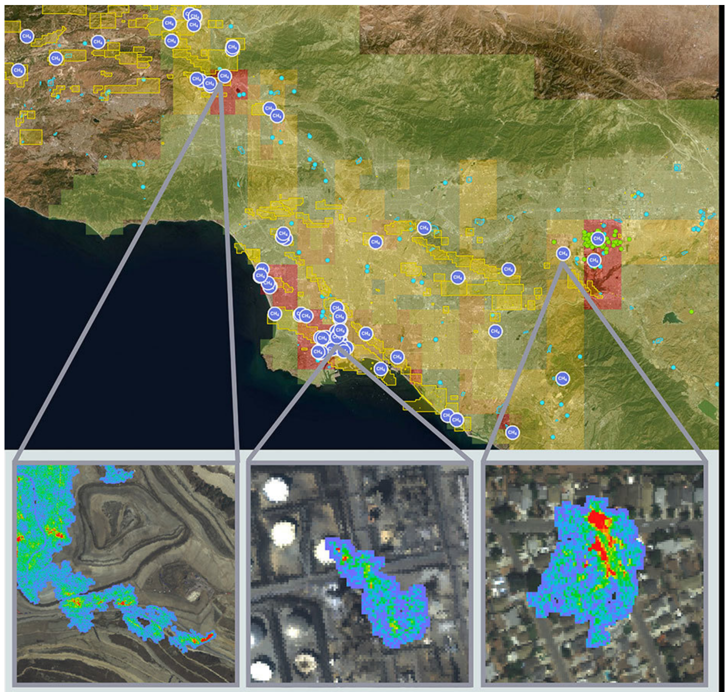


Figure 7: Carbon Mapper (NASA)

Landfill emissions are currently regulated by Senate Bill 1383 which targets statewide reductions in SLCP emissions of 40 percent below 2013 levels by 2030 for methane and hydrofluorocarbons (HFCs). The directives for methane emissions call for a reduction in organic waste disposal by 50% by 2020 and 75% by 2025 and to rescue 20% of surplus food for human consumption by 2025. The bill also calls for reviewing the status of organics recycling infrastructure, reducing regulatory barriers to situating recycling facilities and managing markets for the products of organics recycling, including biomethane and compost.

Environmental Justice

To investigate what more can be done with regard to environmental justice issues, we need to understand where new wells are being drilled and which communities are being affected by them. Figure 8 shows a recent analysis by the Center for Biological Diversity which analyzed permits for 4,240 new wells since Gov. Newsom took office and found that 95% of them are in communities already overburdened with high pollution. While this is certainly a staggering finding, the California Geologic Energy Management Division (CalGEM) proposed a regulation in October 2021 that prohibits the development of new wells/facilities within 3,200 feet of homes, schools, hospitals, etc (CA.gov). This 3,200 figure was determined by a public health expert panel that concluded that oil and gas developments within this distance tend to cause serious health impacts like birth defects along with respiratory and heart disease. Although this proposal may marginally improve public health, there is still much more that needs to be done to ensure that new wells aren't being established in communities that are already experiencing the effects of high pollution, as that pollution will only get worse in the long run which would eventually lead to even more adverse health effects.

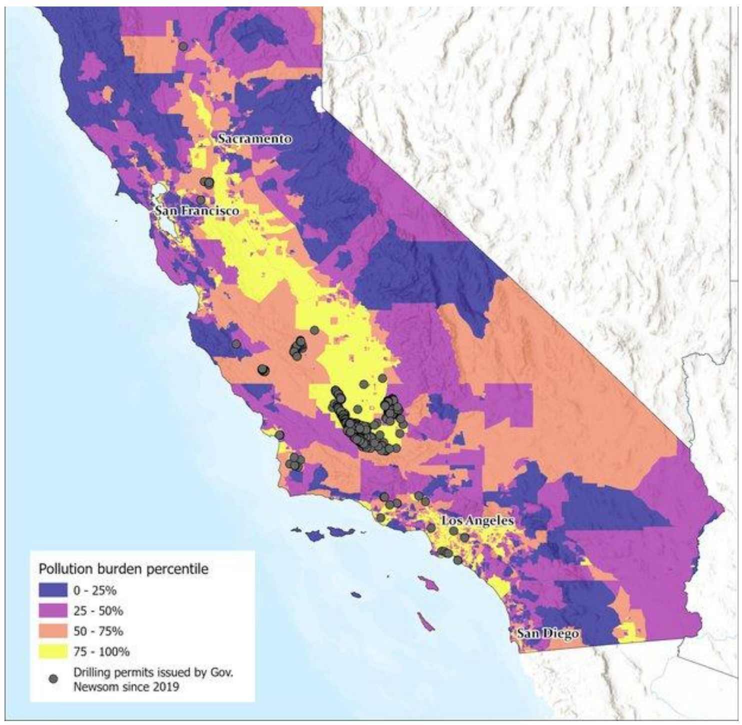


Figure 8: New oil and gas well permits layered against pollution data (Center for Biological Diversity)

Design Plan for California 2025

Systems Map

Our systems map identifies two major pathways to methane emissions - emissions during the production, processing, and transport of fossil fuels, and anaerobic decomposition of waste deposited in landfills. Apart from the contributions to climate change, an increase in methane emissions is also the precursor for higher levels of PM2.5, carbon monoxide, nitrous oxide, and tropospheric ozone, which result in poor air quality and negative public health outcomes. These direct impacts on human health often more quickly influence policy making, leading to better controls on emissions.

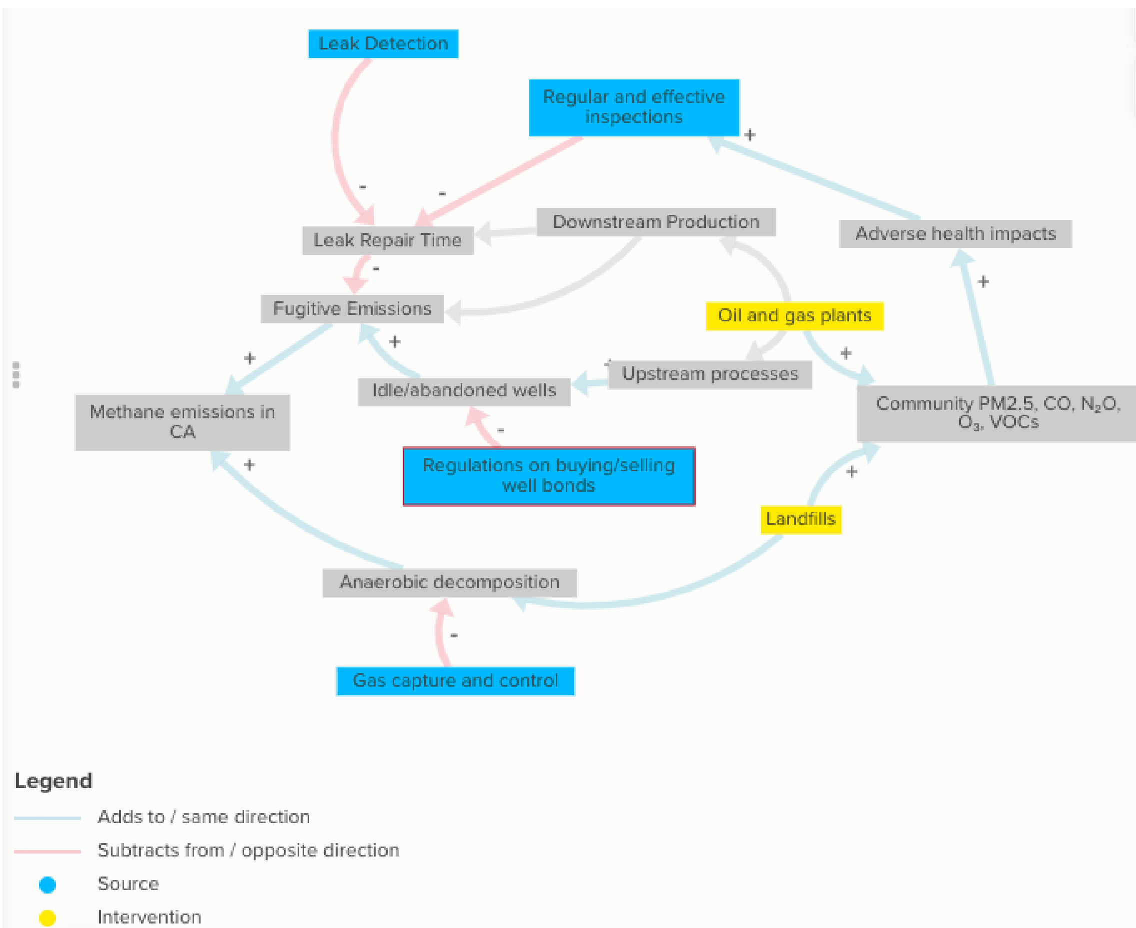


Figure 9: Map of Preferred System

After analyzing the present state and our preferred systems map above, we are bridging the gap by focusing our design plan around four major leverage points:

LP 1) Accountability for LDAR in downstream productions

LP 2) Identification of super emitter landfills and implementing effective gas capture and control

LP 3) Closure of idle/abandoned wells
LP 4) Life Cycle Assessment of wells and preventing idling by predicting the decline period of a well

LP 1: Accountability for LDAR

Implementing an LDAR program has the potential to reduce emissions due to leaks by 63%, but in order for it to be fully effective, we need to establish some form of accountability. As it stands, regulatory agencies are noting many compliance issues when it comes to LDAR monitoring practices. To remedy this, we are looking to establish a stronger management system involving monthly audits to ensure that equipment is being monitored correctly.

We are also calling for regulatory agencies to ensure that leaks are repaired in a timely manner—this means making a first repair attempt as soon as possible (no later than 5 days after detection). Leaks are currently graded based on their hazard level, or probability of becoming hazardous: Grade 1 leaks are the highest priority since they are typically in denser, higher traffic areas. Grade 2 leaks are not considered an immediate risk but have the potential to become more hazardous, while Grade 3 leaks are deemed non-hazardous to life or property. Figure 10 shows the weighted average of repair days based on the level of grade. This data was collected by Pacific Gas and Electric, SoCalGas, San Diego Gas and Electric, Southwest Gas, and West Coast Gas Co, and was further analyzed by California Public Utilities Commission. A repair time of 730 days can be significantly reduced if policies and regulations are implemented.

Entity	Average Repair Days		
	Grade 1	Grade 2	Grade 3
PG&E	3.5	93.3	842.7
SCG	1.1	207.3	721.5
SDG&E	1.2	22.2	16.2
SWG	1.0	2.0	45.4
WCGC	NA	NA	111.0
2019 - Weighted Average	**2.6**	**129.0**	**730.6**
2018 - Weighted Average	**3.3**	**166.0**	**968.0**
System Wide - YOY Change	**(0.7)**	**(37.0)**	**(237.4)**
System Wide - YOY Percent Change	**(22.7%)**	**(22.3%)**	**(24.5%)**

Figure 10: Average Days to Repair by Entity in 2019 (California Public Utilities Commission)

If Grade 3 leaks are repaired within 1 year, methane emissions can be reduced by 48% and if fixed within 6 months we can see a 70% reduction, as shown in Figure 11. In addition, we would like to assemble stricter criteria to determine if a leak can not be fixed without a process unit shutdown or is too difficult/unsafe to fix. This would allow for more leaks to be fixed sooner instead of being pushed to the "Delay of Repair" list.

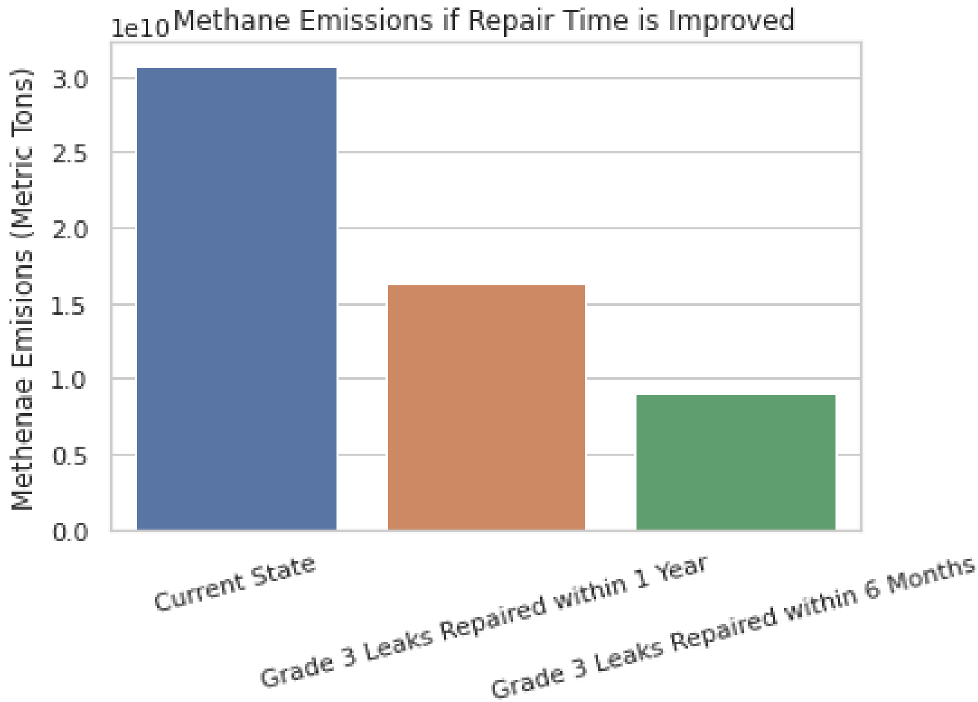


Figure 11: Methane Emissions if Repair Time is Improved

One of the biggest issues with current LDAR inspection is that just reviewing the records usually isn't enough to tell if the monitoring procedures are actually being followed correctly. When it comes to determining diligence, one metric that is very important is the rate at which components are being monitored. This is useful for determining if the probes were used slowly enough to take an accurate measurement. Inspection teams of two should aim for a thorough inspection of 500-700 valves per day—anything higher than that means the inspectors may have rushed the process and cut corners along the way. Unfortunately, many contractors that perform the monitoring are currently compensated based on how many components they monitor, which creates an incentive to rush through monitoring procedures. Our system will emphasize quality over quantity by paying contractors by the hour instead and having regulatory agencies properly train them on facility-specific LDAR procedures. We will also have the contractor's work be reviewed daily to ensure they are monitoring a realistic number of components.

In order to encourage companies to take action, we need to implement emission pricing. This would impose a cost on emitting methane and pressure companies to do more than the bare minimum. In combination with financial incentives for methane reduction, this would promote companies to take action in the fight against methane emissions (IEA).

LP 2: Identification of super emitter landfills and implementing effective gas capture and control

We identified 13 landfills that were suspected to have emitted large plumes during the years 2016-17 (Figure 12). Although all of the landfills identified had landfill gas capture projects currently operational, on average, only 25.4% of the captured gas was utilized, suggesting that flaring of biogas from landfills is a huge problem. Incomplete combustion of flared methane can occur due to crosswinds and has been identified as the biggest source of emissions in the energy industry, and is presumably the source of plumes detected by aerial monitoring (Johnson and Kostiuk 2002; Cushing et al., 2021). In addition, non-white Hispanic populations were found to have a higher probability of being exposed to flared methane when compared to predominantly white areas (Johnston et. al, 2021).

Big emitters to type of project (Features: 13, Selected: 0)

Landfill Name	Ownership Type	Current Landfill Status	Waste in Place (tons)	LFG Collection System In Place?	LFG Collected (mmscfd)	LFG Flared (mmscfd)
Kirby Canyon Recycling & Disposal Facility	Private	Open	11,891,670	Yes	3.06	3.06
Forward Landfill	Private	Open	28,949,149	Yes	5.54	4.00
Kiefer LF	Public	Open	32,438,475	Yes	8.68	0.37
L & D Landfill Company	Private	Open	1,453,000	Yes	0.50	0.50
Johnson Canyon SLF	Public	Open	3,557,549	Yes	1.90	0.98
Monterey Peninsula SLF	Public	Open	13,051,156	Yes	2.12	
Ox Mountain SLF	Private	Open	36,360,312	Yes	6.80	2.00
Potrero Hills SLF	Private	Open	20,616,999	Yes	3.54	0.24
Redwood SLF	Private	Open	16,391,030	Yes	3.49	1.96
Acme LF	Private	Closed	10,800,000	Yes	1.80	
Altamont Landfill & Resource Recovery Facility	Private	Open	65,243,612	Yes	6.46	
Vasco Road SLF	Private	Open	28,189,230	Yes	2.62	
Newby Island SLF Phases I, II, & III	Private	Open	33,338,536	Yes	6.42	6.42

Figure 12: Super emitter landfills of 2016-17

Hence, we propose an annual review of all landfills, with specific data on the quantity of flared methane.

LP 3: Closure of idle/abandoned wells

3.1. Locating wells

Currently, the difficulties in decommissioning wells in the United States have been identified as "limited information on the location, environmental damages, and decommissioning costs" (Raimi et al., 2021). California has a better idea of where these wells are located, and hence, we need to focus on the environmental justice aspect of the location of these wells. By leveraging the community impacts of emissions from oil and gas wells, we aim to encourage the prioritization of wells that have had a historic impact on surrounding areas. Following a health assessment of all idled wells, some possible parameters to be considered are detailed below:

> **Tier 1:** Wells within an unsafe radius of "sensitive receptors" (Department of Conservation 2021), which include high-risk zones such as schools - 4% of California's public schools are within 2500 ft of an oil well. Within this tier, there are degrees of severity that are likely to overlap with under-resourced communities (Figure 13).
>
> **Tier 2:** Wells within 3200 ft of any residential or commercial area proposed in the draft Protection Of Communities And Workers From Health And Safety Impacts From Oil And Gas Production Operations 2021.
>
> **Tier 3:** Wells that have been idle for 10 years or more.

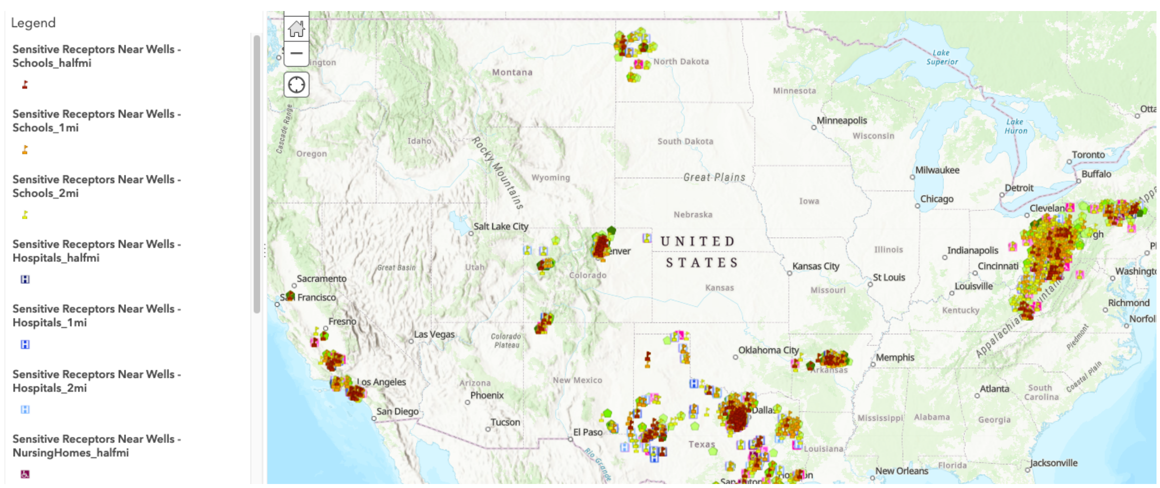


Figure 13: Map of sensitive receptors across the US

3.2. Operator accountability and remediation

Currently, 76.4% of idle and abandoned wells in California are owned by 10 oil and gas companies (Figure 14). These operators were all also identified as buying the lowest bond per well (Figure 15) by the Center for Biological Diversity.

The Bipartisan Infrastructure Bill allocates $1.15 billion to the plugging of abandoned wells, of which CA receives an estimated $165,871,000 (DOI 2022). On average, it is expected that the total cost of plugging the 150,000 wells in CA alone will exceed $10.2 billion. With an extreme deficit in funding, it is clear that sources of funding need to be considered, in addition to careful prioritization of existing funding sources.

Owner	Well count in 2021
Chevron U.S.A. Inc.	8765
Aera Energy LLC	8597
California Resources Production Corporation	3750
California Resources Elk Hills, LLC	2949
Berry Petroleum Company, LLC	2236
Sentinel Peak Resources California LLC	1329
E & B Natural Resources Management Corporation	1221
CalNRG Operating, LLC	1091
Seneca Resources Company, LLC	526
Crimson Resource Management Corp.	512

Figure 14: Top 10 oil and gas companies with respect to owned well count

Top 10 Oil Producers Listed by Lowest Bond Per Well:

Company	Wells	Active State Bonds	$ per well
Aera Energy LLC	24,911	$2,000,000	$80.29
Chevron U.S.A.	27,452	$3,000,000	$109.28
Berry Petroleum Co.	5,413	$2,000,000	$369.48
Sentinel Peak Resources	4,320	$2,000,000	$462.96
E&B Natural Resources Management Corp.	2,918	$2,025,000	$693.97
Seneca Resources Company	2,293	$2,000,000	$872.22
California Resources Corporation (and affiliates)	18,661	$17,250,000	$924.39
HVI Cat Canyon	912	$1,000,000	$1,096.49
Crimson Resource Management Corp.	1,650	$2,000,000	$1,212.12
Holmes Western Oil Corp.	888	$4,000,000	$4,504.50

Figure 15: Top 10 oil producers by lowest bond/well

To identify potential pitfalls, we analyzed the Site Rehabilitation Program set up by the Government of Alberta, Canada in 2020, which allotted CA $1 billion for the cleanup of abandoned and inactive oil and gas wells. Some of the key principles outlined are applicable to the situation in CA:

3.2.1. Implementing the ‘polluter pays principle.’

The report strongly recommends that oil and gas companies be held accountable for cleanup procedures. Hence, we believe that the creation of an analogous Liability Management Framework is necessary to ensure that costs are met prior to well drilling. The fees required for idling wells are described in Table 1 (Ferrar 2021).

Years Idle	Cost ($/well)
3 - 8	150
8 - 15	300
15 - 20	750
> 20	1500

Table 1: Idling fees for oil and gas

These fees are insufficient to cover the cost of plugging wells. Hence, we propose a system of determining bond eligibility that will prevent risky oil and well owners from obtaining ‘blanket bonds’ for drilling, which are often insufficient to fund the proper closure of individual wells. Some of the factors to be taken into consideration before determining a company’s bond rate are detailed in Figure 16.

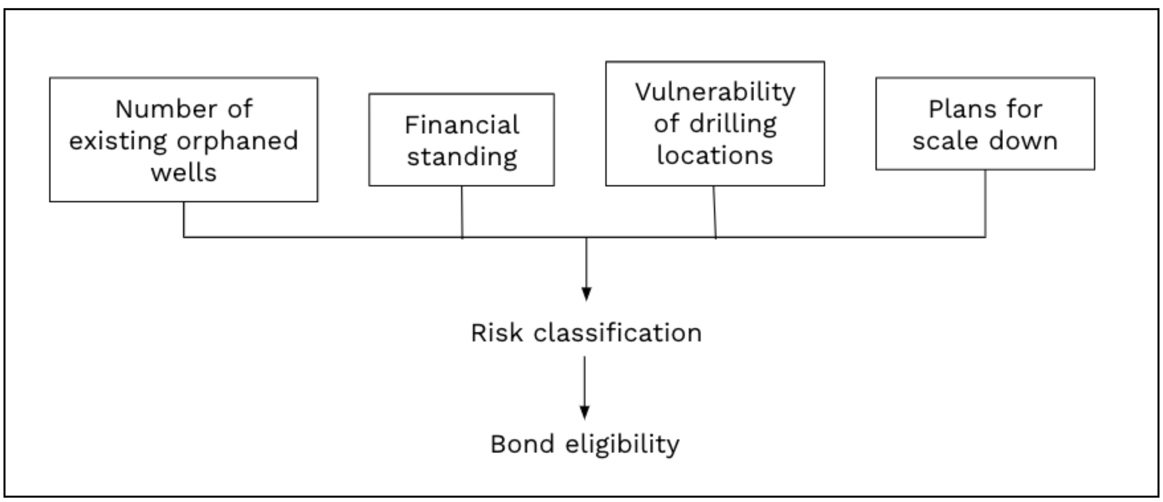


Figure 16 - Bond eligibility for oil and gas companies

3.2.2. Community engagement in well closure and remediation

The social cost of methane accounting for economic inequalities between countries and regions ranges from $130 per metric ton for sub-Saharan Africa and rises to $8,040 per metric ton in the United States (Errickson et al., 2021). We estimate that the social cost of active and idle wells in California when weighted for the prevalence of drilling in vulnerable areas is around $600 million (Table 2).

Well type	CA	Emissions (g/hour), mean	Emissions(MT/year)	Contribution to emissions(MT/year)	Social cost assuming low income
Active	58,667	35.6	0.311856	18295.65595	151670987.8
Idle	33,230	189.7	1.661772	55220.68356	457779466.7
	91,897				609450454.6

Table 2: Emissions and social costs of active and idle wells in California

In addition, the extraction of oil has been both a source of concern and a form of employment for Native American tribes in the United States. 90% of public lands in northern New Mexico were allegedly leased for oil and gas drilling during the Trump administration (Nelson, 2020). There was nationwide pushback on the increase in permits for drilling and transportation of oil on tribal lands. Tribal groups such as the Standing Rock Sioux have criticized fracking on tribal lands and are actively fighting against the construction of the Dakota Access Pipeline, citing the impacts of potential oil spills on the ecosystem and water sources (Plumer, 2016).

However, fracking has also provided a steady source of income for around 12 of 326 tribal reservations, which "view oil as their salvation" (Brown and Fonseca, 2021). Hence, the complexities of the energy transition make it imperative that marginalized groups are constantly consulted in any national planning process for the future of fracking.

Implementation Plan

By 2025, we estimate that California's emissions need to be at around 370 million MT per year for the 2030 goal of 40% GHG reductions from 1990 levels set by the 2017 scoping plan. We believe that aerial sensing will be critical to ensuring that compliance is being maintained in all the sectors discussed. Hence, our 5-year plan largely consists of regular monitoring and goal-setting (Figure 17).

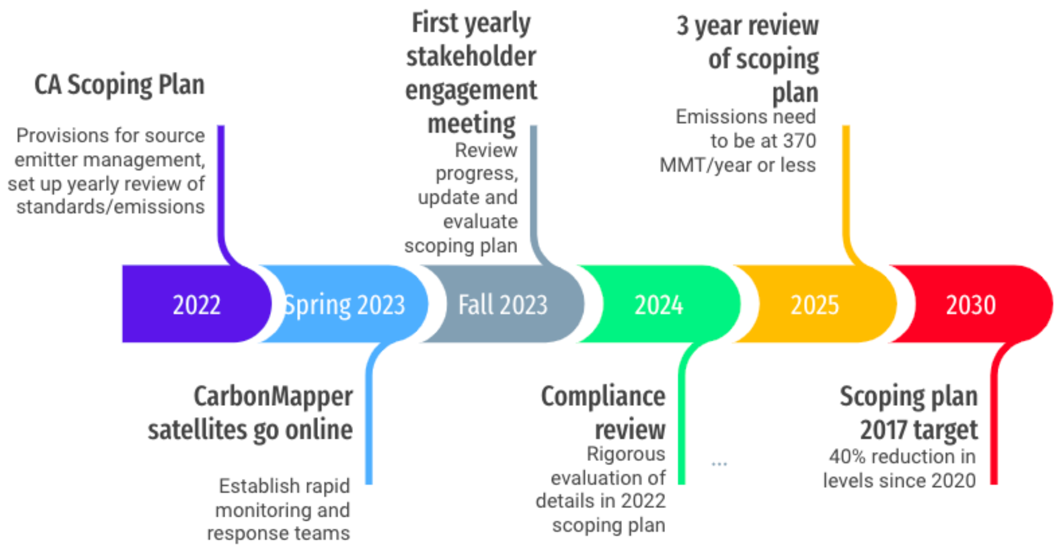


Figure 17: Proposed timeline

In addition, the plans for existing projects need to be evaluated. The SB 1383 program, signed by Gov. Brown in 2016, required cities and counties to ensure their waste transfer/processing operations divert away from organic waste landfills. However, despite being approved in 2016, the bill only began actively mandating compliance in January 2022. Delays like this suggest that there is inadequate correspondence from the state, and ineffective engagement with stakeholders. The proposed timeline for SB 1383 is shown in Figure 18.

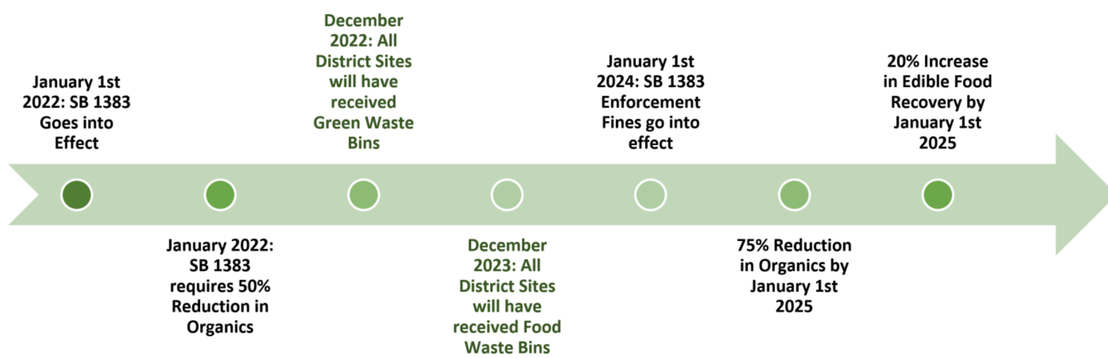


Figure 18: Timeline of SB 1383 Program (LAUSD)

As it stands, penalties for non-compliance will be assessed by the California Department of Resources Recycling and Recovery (CalRecycle) and could be up to $10,000 per day.

Strategies to Share Beyond California

111 countries were signatories to the Global Methane Pact introduced at COP26 (2021 United Nations Climate Change Conference). Globally, the impact of wetlands and agriculture far exceeds the emissions from energy (Figure 19). This is to be expected, as the US is one of the biggest consumers of fossil fuel-derived energy (Figure 20). Hence, we cannot expect a strategy that works in California to be entirely replicable in reducing global emissions.

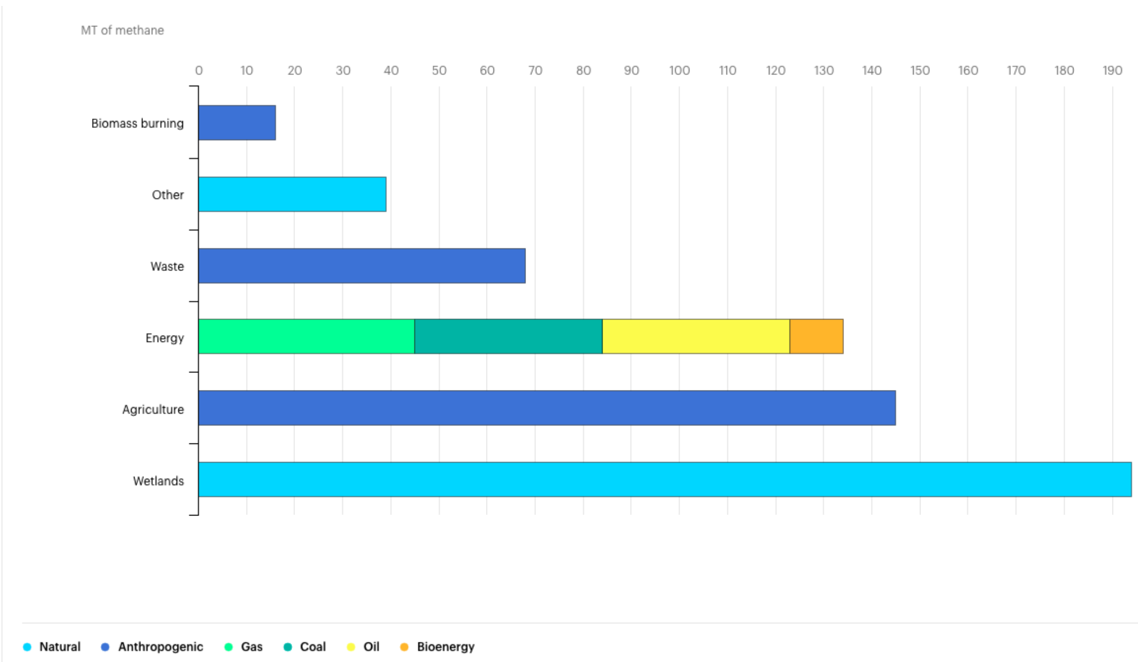


Figure 19: Global methane emissions by source (Source: 1EA)

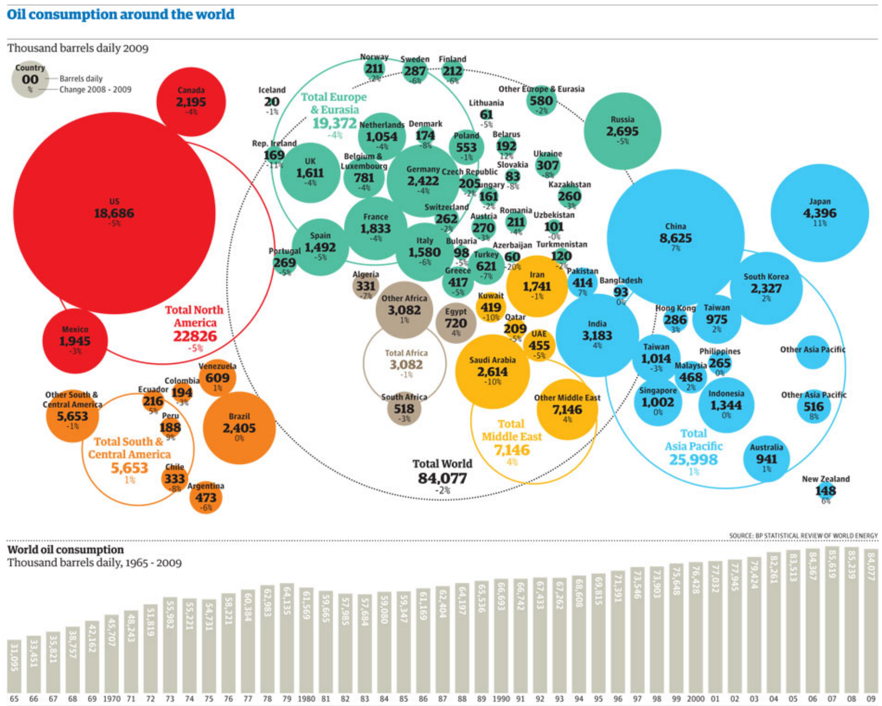


Figure 20: Oil and gas consumption by country (The Guardian)

In the energy sector specifically, California is uniquely positioned. Dependence on oil and gas in the energy sector has decreased by 56% since 1975 (Ackerman et al. 2018), whereas global demand has steadily increased (Figure 21). Super emitters have been identified globally in Russia, Turkmenistan, the United States, the Middle East, and Algeria using aerial imagery, with an estimated 9 million tons of methane lost to leaks per year, not including emissions in China and the Permian Basin (Fountain, 2022). Research in identifying point sources is recent and it is imperative that international accountability is ensured.

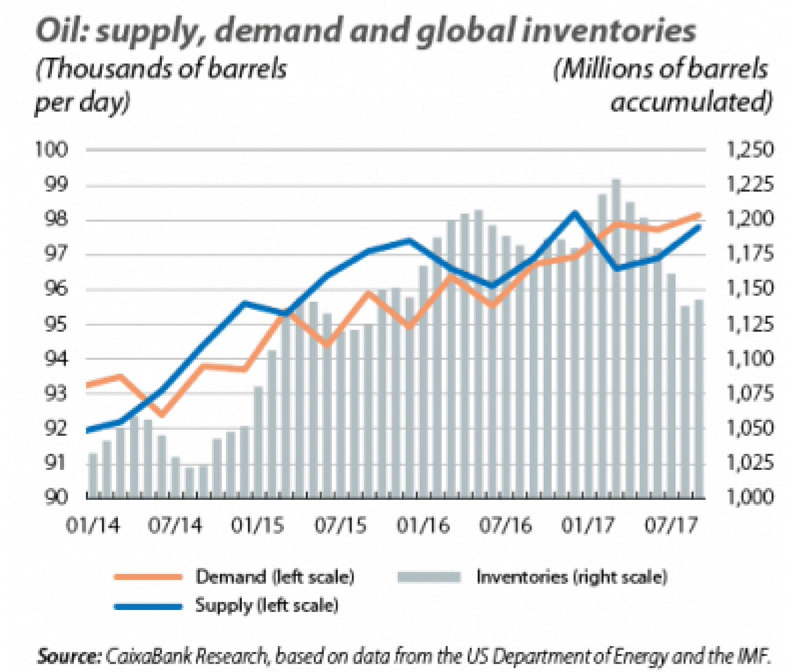


Figure 21: Oil: supply, demand, and global inventories (CaixaBank Research)

However, we see that internationally, the broad framework for ensuring short-term compliance and long-term accountability remains the same. The crisis in Ukraine has exposed the massive dependence internationally on imported fossil fuels. The framework outlined in Figure 22 emphasizes transparency, accountability, and community engagement at all levels, with easy data flow and quick response times. It is imperative that countries both uphold these standards internally and in energy trade, thus incentivizing investment in technical development and environmental justice.

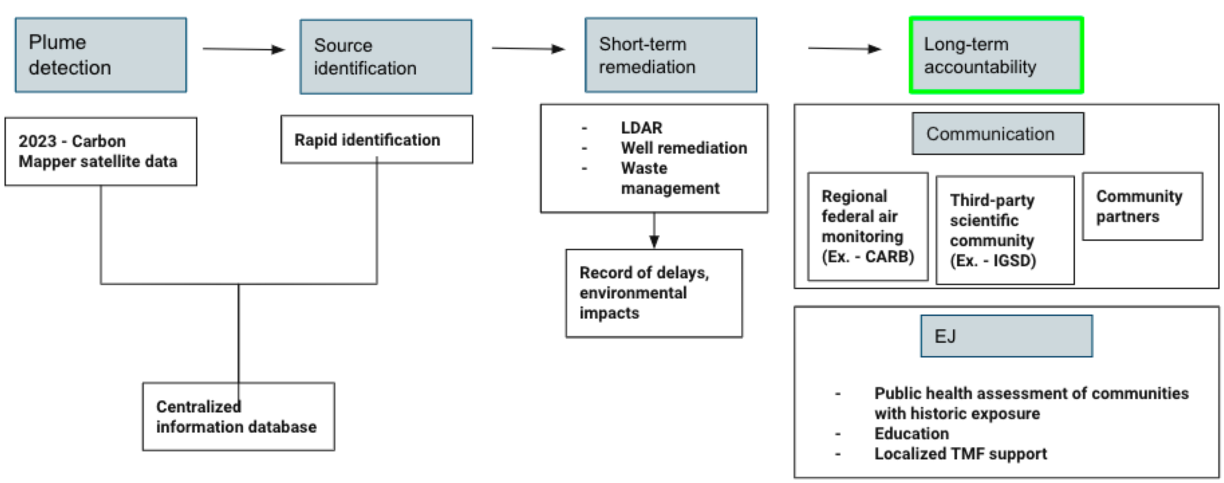


Figure 22: Accountability Framework

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