Assessing the Socioenvironmental Impacts of Direct Air Capture in California's San Joaquin Delta

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Abstract

Direct Air Capture (DAC) has emerged as a potential climate technology, with major government funding bolstering its development as a critical response to climate change mitigation. However, communities hosting DAC facilities, particularly low-income and BIPOC populations in San Joaquin County, must fully comprehend the potential benefits and risks of this new technology. This white paper serves as a thorough reference for these communities, focusing on environmental justice issues and policy initiatives to encourage involvement and promote knowledge of DAC. It specifically investigates the first operating DAC factory in the United States, which is operated by Heirloom Carbon and is located in Tracy, California. The study investigates DAC technologies and analyzes environmental and community interaction issues critical to DAC's success. The white paper also details how DAC corporations, governments, college students, and environmental groups in the Bay Delta area should work together to ensure that DAC technologies are adopted in ways that promote environmental justice in communities. The document also describes the importance of ongoing community participation and responsibility. Finally, the study recommends criteria for deploying DAC in ways that enhance trust, transparency, and environmental justice, guaranteeing that DAC is a feasible and equitable climate policy.

Keywords: Environmental Justice, Direct Air Capture, San Joaquin County

Glossary:

Vocabulary	***Definition***
Carbon dioxide removal (CDR)	Carbon Dioxide Removal refers to strategies or technologies for removing carbon dioxide (CO2) from the atmosphere. This can be achieved through natural processes like tree planting or artificial ways like direct air capture (DAC). CDR is viewed as a strategy to mitigate climate change by lowering the quantity of CO2 in the atmosphere.
Greenhouse gases (GHGs)	Greenhouse gases are gases in the atmosphere that trap heat, causing the "greenhouse effect" and global warming. The most prevalent greenhouse gases (GHGs) are CO2, CH4, and N2O. These gases are mostly created by burning fossil fuels, deforestation, and industrial activity.
BIPOC	BIPOC represents Black, Indigenous, and People of Color. It is a phrase used to highlight the distinct experiences of diverse racial and ethnic groups that confront structural injustices, but simultaneously uniting them into a collective term for advocacy and solidarity.
DAC Hubs	DAC hubs are buildings or places that support large-scale direct air capture activities. These hubs attempt to remove CO2 from the environment and frequently include numerous DAC systems that collaborate to gather and store CO2. They participate in attempts to scale up carbon removal technology.

CO2	CO2 is the chemical formula for carbon dioxide, a colorless and odorless gas created by fossil fuel combustion, deforestation, and other industrial operations. It is the most major greenhouse gas released by human activities, causing climate change.
NOx	NOx is a collection of gases made up of nitrogen and oxygen. These gases, which include nitrogen oxide (NO) and nitrogen dioxide (NO2), are mostly generated by car emissions and industrial activities. They contribute to air pollution, smog, and acid rain, which can impair human health.
Environmental Justice	Environmental justice refers to the equitable treatment and participation of all people, regardless of race, color, national origin, or income, in the establishment of environmental laws, policies, and regulations. It focuses on alleviating the disproportionate environmental challenges experienced by low-income and communities of color.
IPCC	The IPCC (Intergovernmental Panel on Climate Change) is an international scientific organization founded by the United Nations and the World Meteorological Organization. It evaluates the science behind climate change, its impacts, and viable mitigation solutions.
Particulate Matter (PM)	Particulate matter (PM) is a term used to describe microscopic particles or droplets in the air that can be hazardous to human health if breathed. Vehicle emissions, industrial activities, and wildfires all contribute to the production of these particles. PM is classified as fine particles (PM2.5) and bigger particles (PM10), with smaller particles providing a higher health risk.

DOE	The DOE (Department of Energy) is a US government department in charge of supervising the country's energy production, scientific research, and environmental laws. The DOE backs efforts that improve sustainable energy technology and reduce greenhouse gas emissions.
CEQA	The California Environmental Quality Act (CEQA) mandates state and municipal agencies in California to study and report the environmental consequences of proposed actions or projects. Its purpose is to guarantee that decision-makers examine the environmental effect of proposed projects before approving them, as well as to include the public in these choices.

Introduction

Purpose

With billions of dollars in government investment, Direct Air Capture (DAC) is increasingly becoming relied on as a climate technology[1]. Communities where DAC is proposed should understand the benefits and drawbacks of DAC technologies. Given that San Joaquin County is home to the first operational DAC facility in the United States, this white paper intends to serve as a comprehensive guide for individuals and communities to contemplate DAC technologies, with a focus on burdened BIPOC and low-income areas within San Joaquin County. The paper will give an overview of DAC technologies, offer environmental justice

[1] Climate technologies that help us reduce GHGs include renewable energies such as wind energy, solar power and hydropower. https://unfccc.int/topics/what-is-technology-development-and-transfer

considerations, and provide policy opportunities to raise awareness and foster engagement between DAC companies, college students, policymakers, and environmental groups in the Bay Delta region. The objective of this research is to propose criteria for direct air capture to benefit environmental justice communities, community engagement from direct air capture facilities, and building efforts to gain trust and accountability for DAC technologies to be a successful climate strategy, in part by illuminating learnings from host communities where DAC has been proposed.

San Joaquin County comprises the Stockton, Lodi, and Tracy metropolitan statistical areas. The county is located in Northern California's Central Valley, just east of the very highly populated nine-county San Francisco Bay Area region, and is separated from the Bay Area by the Diablo Range, having access to the Bay Area via the Altamont Pass. One of the smaller counties by area in California, it has a high population density and is growing rapidly due to overflow from the Bay Area. Before incorporation in 1850, the area now encompassing San Joaquin County was inhabited by the Yokuts and Miwok native peoples. These communities lived in villages throughout the region, consuming diverse diets that reflected the flora and fauna of the California Delta. The county is also home to numerous non-profit organizations like Restore the Delta, Little Manila Rising, and Environmental Justice Program, where they continue to create a voice for the voiceless for ethically sustainable community growth and reduce the impact of climate change in the San Joaquin Valley. The paper analyzes the historical context for socioeconomic disparities in San Joaquin County, with a focus on areas where DAC facilities are being proposed.

Heirloom Carbon is the owner and operator of the first operational DAC facility in the country, based in the City of Tracy. The facility is designed to remove approximately 1,000 tons of CO2 annually. Heirloom's process uses minerals that naturally trap CO2 and speed up the process to improve efficiency. Once gathered, CO2 from the facility is put into concrete by a company called CarbonCure. Aside from concerns about direct air capture technology's novelty, environmental advocates have also worried about potential greenwashing. Shana Lazerow, legal director for the environmental charity Communities for a Better Environment, cited a remark made by Occidental Petroleum's CEO regarding direct air capture (DAC) maintaining their business, which was covered in a recent piece concerning DAC technology in Louisiana. The CEO of Occidental Petroleum indicated that carbon capture technology such as DAC might help "preserve our industry over time," which has sparked worry among environmentalists. They claim that such technology may allow oil and gas corporations to continue functioning without decreasing emissions on the scale required to combat climate change. In other words, Heirloom needs to continue consultation with the community to gain trust and accountability.

Climeworks is the DAC developer for the Calcasieu Parish, Louisiana DAC hub[2] (U.S. Department of Energy, n.d.), which was established by the Department of Energy in 2017. The community of Calcasieu Parish is predominantly low-income, and the petrochemical and manufacturing industries heavily influence the local economy. While these sectors provide jobs,

[2] DAC hubs are a DAC technology or suite of technologies at a commercial scale with the potential for capturing at least 1 million metric tonnes of carbon dioxide (CO_2) annually from the atmosphere. Once captured, the CO_2 will be permanently stored in a geologic formation or converted into new products. https://www.energy.gov/oced/DACHubs

they often have environmental justice implications, disproportionately affecting low-income and minority communities. "Direct air capture allows polluting industries to live on when we should be focusing on a just transition to renewables," said co-executive director of the Climate Justice Alliance Marion Gee, who represents a network of grassroots organizations across the US (Calma, 2023, August 14). "It'll be Black folks, Indigenous communities, and poor BIPOC neighbors sacrificed, yet again in the name of protecting corporate interests." These standards ensure that the captured CO2 is accurately accounted for and that the sequestration or utilization methods meet safety and efficacy criteria.

DAC Technologies

What is Direct Air Capture?

According to the IPCC[3] (2025), Direct Air Capture (DAC) is a chemical process by which CO_2 is extracted directly from the ambient air. Direct air capture systems resemble a "two-in-one chemical sieve and sponge," where the DAC system squeezes the capture "sponge". The captured CO2 can then be injected underground or used in a variety of industrial products. The two primary categories of DAC methodologies are solid sorbent-based systems and liquid solvent-based systems. In liquid systems, CO2 is removed from the air by passing it through a chemical solution that reacts with it. In solid systems, air flows across solid materials that absorb CO2.

[3] The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. https://www.ipcc.ch/about/

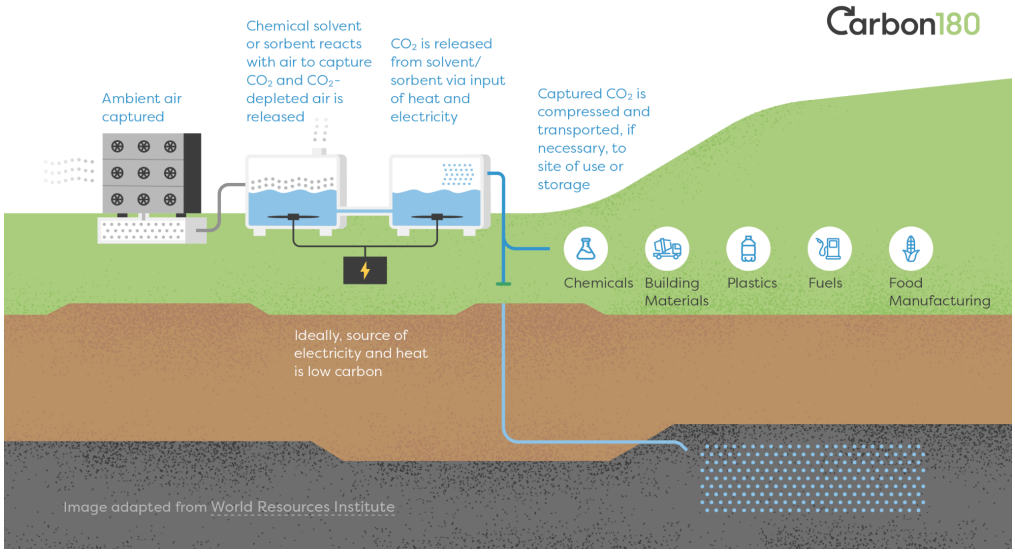


Figure 1: Carbon 180's Infographic Showing the Functionality of DAC

Why is Direct Air Capture needed?

According to the Intergovernmental Panel on Climate Change (IPCC), carbon removal refers to "...technologies, practices, and approaches that remove and durably store carbon dioxide (CO2) from the atmosphere (IPCC, 2025). Carbon dioxide removal (CDR) is required to achieve global and national targets of net zero CO2 and greenhouse gas (GHG) emissions (Fendt & Ivanova, 2021, June 22). CDR cannot substitute for immediate and deep emissions reductions, but it is part of all modeled scenarios that limit global warming to 2 degrees Celsius[4]compared to pre-industrial levels or lower by 2100 (Fendt & Ivanova, 2021, June 22). The extent to which we rely on DAC and other CDR methods to meet global climate goals will vary considerably.

[4] **2 degrees Celsius (2°C)** threshold is a widely recognized target in international climate policy, such as the Paris Agreement, representing the maximum global temperature increase compared to pre-industrial levels. https://climate.mit.edu/ask-mit/why-did-ipcc-choose-2deg-c-goal-limiting-global-warming

Decisions about scale and timing of deployment will, in part, rely on participation from communities where these technologies are being proposed.

Direct Air Capture (DAC) systems capture CO_2 directly from the atmosphere, however, their infrastructure and operations may introduce additional contaminants into the environment. DAC facilities use energy-intensive procedures that can emit NO_x, SO_2, particulate pollution, and VOCs, whether powered by fossil fuels or bioenergy sources (Realmonte et al.). These pollutants may lead to smog formation, acid rain, and respiratory problems in adjacent areas. Chemical sorbents used to absorb CO_2, such as amines or alkaline materials, can produce hazardous byproducts or degrade into potentially poisonous chemicals, such as nitrosamines, posing concerns to human health and the environment (Realmonte et al.).

In addition to chemical emissions, DAC infrastructure can pollute water and generate waste. For example, several DAC technologies employ huge amounts of water or caustic chemicals in their operations, generating concerns about potential leaks, accidents, or incorrect disposal of waste brine or deteriorated sorbents. These concerns are especially acute when DAC plants are located in vulnerable or overburdened communities, where environmental monitoring may be insufficient and populations already experience cumulative pollution costs (Schäfer et al.). As a result, while DAC intends to combat climate change by reducing greenhouse gas emissions, without effective regulation and community engagement, it has the potential to repeat or exacerbate local environmental inequalities by bringing new sources of pollution.

How New is Direct Air Capture?

Direct Air Capture (DAC) is a relatively new technology in the battle against climate change, although the notion of removing carbon dioxide (CO2) directly from the air has roots that go back several decades (Xu, Yu, Chong, & Wang, 2024). In the early 2000s, researchers explored the notion as a solution to growing CO2 levels in the atmosphere. By the 2010s, improvements in chemical engineering and materials science had enabled the construction and testing of the first small-scale DACs.

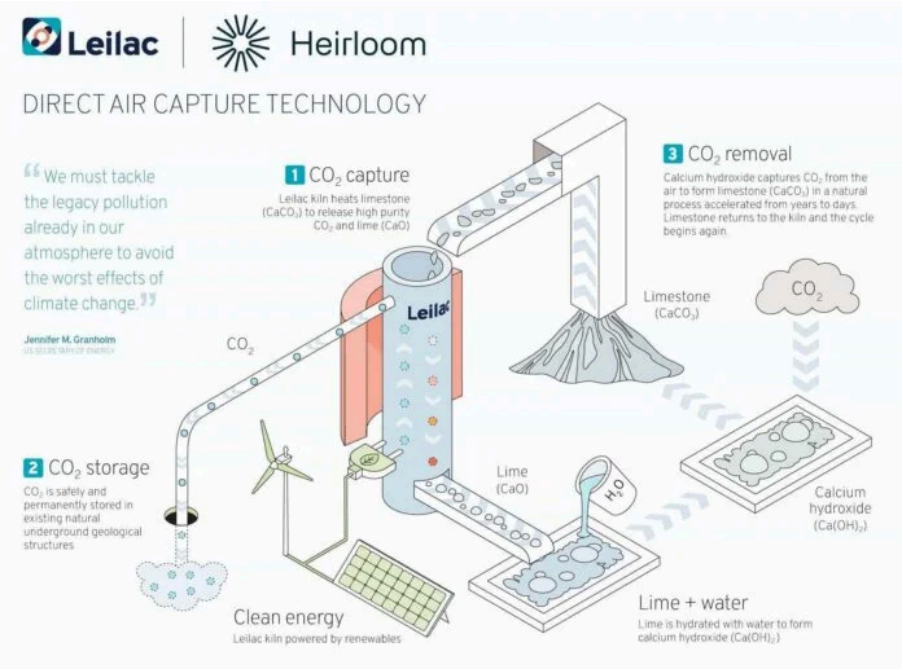


Figure 3: Operations of Heirloom's DAC Technology

Despite its unique appeal, DAC is not without criticism, particularly when considered from the viewpoint of environmental justice. While the technology promises to eliminate CO2

from the atmosphere, its implementation frequently presents fairness problems. For example, many planned DAC facilities are situated in or near historically oppressed neighborhoods. These locations already bear disproportionate environmental loads from industrial pollution, making them less suited to handle extra hazards connected with DAC activities, such as excessive water and energy demand or possible contamination from carbon storage.

Furthermore, association with the co-opting of DAC by fossil fuel corporations sometimes implies that it is sponsored by firms or groups having a vested interest in continuing carbon-intensive operations. Critics worry that this might prolong the use of fossil fuels rather than push systemic change toward renewable energy. These factors accentuate existing imbalances, since low-income and BIPOC groups are less likely to benefit from the economic possibilities DAC may provide, such as high-paying employment or infrastructure upgrades, due to structural impediments to education and access to specialized training (The White House, n.d.). The United States has greatly boosted its investment in Direct Air Capture (DAC) and associated carbon control technology because of landmark legislation such as the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) (FutureBridge, n.d.). These laws collectively provide billions of dollars for DAC technology research, development, and deployment (The White House, n.d.). The BIL has allocated approximately $3.5 billion for DAC centers, while the IRA offers additional tax credits of up to $180 per ton of collected CO_2 to encourage deployment. Globally, the DAC industry has experienced an increase in activity, with at least 27 facilities active according to the latest estimates.

To guarantee that DAC technology helps both climate and social equality objectives, governments and actors must prioritize environmental justice in their initiatives. This involves integrating impacted communities in decision-making, guaranteeing equitable sharing of economic gains, and requiring transparency on potential hazards and trade-offs. Without such restrictions, DAC risks becoming another climate solution that unintentionally exacerbates inequities.

Life-Cycle Assessments

A Life Cycle Assessment (LCA) is a systematic approach to assessing the environmental effect of a product, process, or service across its full existence (Curran, 2013). This comprises the entire process, from raw material extraction and production to usage, maintenance, and final disposal or recycling. LCAs are used in carbon capture plants to assess the environmental impact of capturing and storing CO2. LCAs take into account energy use, water use, emissions, and the materials needed for facility construction and operation.

To ensure the lowest feasible overall carbon footprint, these assessments examine the full environmental impact of production, use, and disposal. Some factors DAC LCAs need to consider include CO2 emissions from transportation, workers coming and going to work, and the transport of equipment. Analyzing energy utilization, material use, and possible emissions throughout the DAC process is part of this. To evaluate the potential of DAC technologies to reduce greenhouse gas (GHG) emissions in California, the California Air Resources Board

(CARB) has integrated LCA techniques. This aids in establishing rules and guidelines for carbon removal initiatives. DAC is covered under CARB's Low Carbon Fuel Standard (LCFS) program (California Air Resources Board, n.d.), which uses life cycle assessments (LCAs) to calculate the carbon intensity reductions that DAC projects bring. Californian research centers and universities, including Lawrence Livermore National Laboratory (LLNL), are conducting life cycle assessments (LCAs) on DAC technology (Lawrence Livermore National Laboratory, n.d.). The goal of these investigations is to determine the most effective and ecologically friendly DAC procedures.

Here are some policy recommendations that DAC companies could take into consideration in their LCAs:

- **Total Energy Consumption:** Determine the energy needed to run DAC systems, including capture, compression, and transport procedures.
- **Energy sources:** Consider the type of energy utilized to power DAC operations (renewable or fossil fuel-based), since this has a substantial influence on the lifespan carbon footprint.
- **Grid Decarbonization:** Develop scenarios for the carbon intensity of the energy grid during the facility's lifetime to assure long-term reductions.
- **Community Development:** The regulation and industrial process of DAC should be developed in consultation with diversity, inclusion, and equity among historically underrepresented communities.

- **Local Monitoring:** Industries should partner with local public health organizations to conduct health impact monitoring and proactive pollution management in DAC facilities, particularly in communities already experiencing cumulative environmental burdens. Communities may choose to approach the Carbon Removal Standard Initiative to receive independent, third-party help in questioning the validity of LCAs done for DAC.

LCAs are a restricted tool, and LCA specialists vary on recommended practices, such as where to draw system boundaries (e.g., only the DAC facility's operational emissions, like the energy used for air capture and storage processes), what to measure, assumptions, and so on. Experts often disagree on key aspects such as system boundaries (The Climate Center, n.d.), deciding where to start and end the analysis as well as using baseline assumptions that may not reflect real-world complexities, leading to results that might not be universally applicable or equitable.

First Peoples of San Joaquin

Indigenous Communities

The indigenous Yokuts were the people who inhabited the Tracy, California, region of the San Joaquin Valley. Their existence was centered on the rainy and dry seasons, with them depending on the rivers for sustenance and water, the valley oaks for acorns and other plants and seeds, and wild wildlife. They were driven from their homes by European settlers and succumbed to their diseases, just like other indigenous Californians. The San Joaquin County History Museum houses various donated collections in addition to artifacts from the local Native

American culture, like an acorn-grinding mortar and pestle (San Joaquin County Historical Society and Museum, n.d.). Tracy's past is largely similar to California's. Initially occupied by the San Joaquin Valley's Indigenous Peoples, a large portion of the area surrounding Tracy was part of Spanish and Mexican haciendas in the early 1800s. Later that century, railroad land grants took over. Numerous European immigrants settled in the area as farmers and ranchers, after parcels were sold and the remaining land was homesteaded.

Native American groups in California have long been despised as a result of colonial policies that ignored their customs, land rights, and systems of government. Their voices are frequently ignored or undervalued in the current policy-making process, which is a remnant of this. Due to historical exclusion from American decision-making processes, populations of Indigenous and Mexican heritage are underrepresented in municipal, state, and federal government institutions. Because of this systemic isolation, their needs and concerns are not given priority. Living close to industrial facilities, farming areas, and other sources of pollution is more common in Tracy and other places in California. Despite this, they are frequently left out of the decision-making process when it comes to the placement of new facilities, particularly carbon capture projects that raise concerns for the health of the surrounding community.

Indigenous communities in San Joaquin County and around the United States can receive government money for energy and environmental projects through a variety of programs, including those run by the Department of Energy (DOE). The DOE's Justice40 Initiative is critical to ensure that government financing for programs such as the Bipartisan Infrastructure Law (BIL) and other energy transition projects targets disadvantaged areas, including federally

recognized tribes. The effort seeks to direct 40% of the benefits of these initiatives to such communities, which frequently include Indigenous peoples. (U.S. Department of Energy, Justice 40 Initiative, n.d.) These advantages may include energy efficiency improvements, renewable energy access, and environmental cleanup activities that directly promote climate resilience and energy justice.

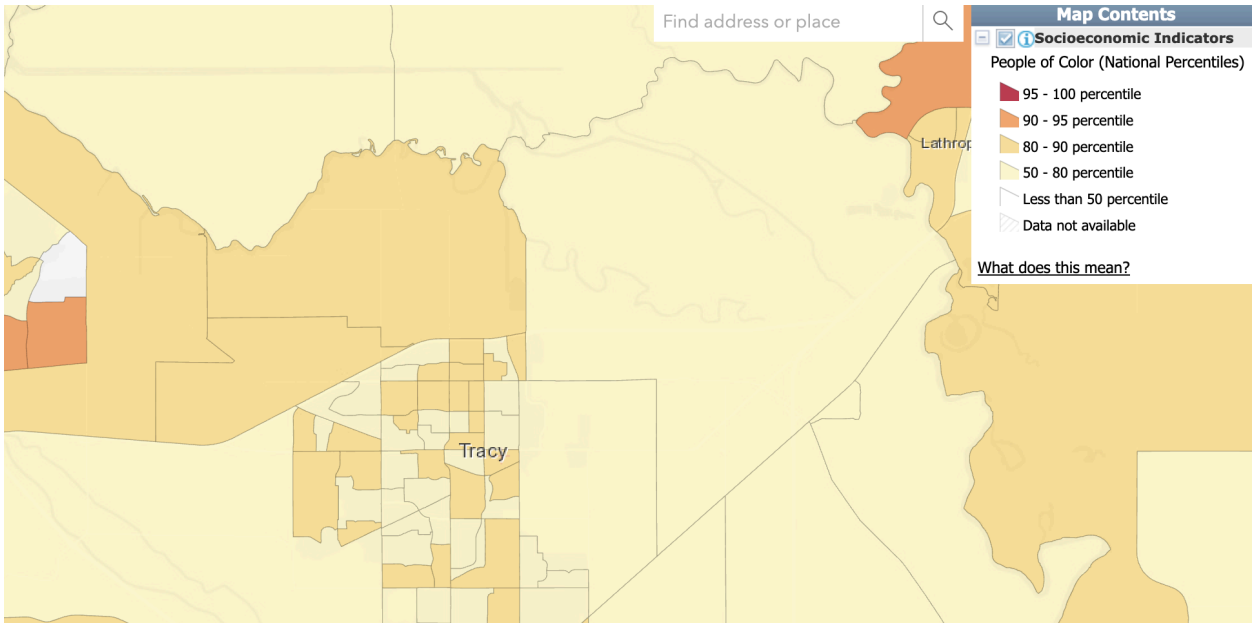
The law does not require Indigenous communities to be classified as Environmental Justice (EJ) communities to receive benefits, but the DOE's definition of disadvantaged communities, which considers factors such as energy burden, pollution exposure, and income levels, frequently includes Indigenous territories (Delta Stewardship Council, n.d.). Furthermore, the DOE supports Indigenous participation in these programs by mandating Tribal consultation as part of any government action that may affect them. This implies that tribes are actively consulted to ensure their specific issues and needs are handled, that they benefit from clean energy initiatives, and that their rights are acknowledged in environmental and energy choices.

Importance of Labor in DAC

What type of jobs does DAC create?

Work has been produced by the Heirloom Direct Air Capture (DAC) facility during the phases of building, operation, and maintenance (Rhodium Group, n.d.). Jobs like civil engineers, project managers, and construction laborers are common throughout the building phase. Chemical engineers, environmental scientists, and plant operators are needed to oversee the

capture process once the facility is operational. Technicians and safety inspectors are among the maintenance professionals who are essential to the facility's continuous maintenance and improvement. These professions are usually of a high caliber, providing well-paying, highly specialized roles with ample opportunity for skill growth and training. For example, postgraduate degrees in related subjects are frequently required for operational responsibilities, whereas technical certificates and practical training are necessary for maintenance roles. Since DAC operations are intricate and sometimes dangerous, workers are required to complete safety training covering emergency response procedures, operating machinery, and handling chemicals.



Source 3: City of Tracy Socioeconomic Status According to CalEnvironScreen 4.0,

Tracy's Heirloom Direct Air Capture (DAC) facility wants to create and show local money and create jobs, among other benefits for the community's economy. Employment

opportunities are available in construction, operations, and maintenance; these fields offer well-paying occupations that support the regional economy. Furthermore, the facility has the potential to draw in associated sectors and businesses, which would increase local economic activity. Making sure the benefits are spread fairly is a difficulty, too, especially in low-income and historically excluded regions. The census tract where the Heirloom plant is located may have higher pollution burdens and vulnerabilities, according to the CalEnviroScreen analysis. This means that targeted interventions are required to mitigate negative consequences and achieve environmental justice.

Tracy, California, has a long farming history and, because of its advantageous position, has served as a major center for logistics and transportation. Tracy's cultural populace, including a notable Latinx presence, mirrors the Central Valley's wider demographics. The region has historically experienced issues with respiratory health and air pollution. Due in part to pollutants from transportation and agriculture, residents have higher incidences of asthma and other respiratory disorders. To secure local support for the Heirloom facility, community engagement is essential. Heirloom can promote goodwill by being open and honest in communication, entering into agreements for community benefits, and forming alliances with neighborhood organizations. This strategy guarantees that the facility not only attends to environmental issues but also to the economic and health needs of the neighborhood.

The Stigma Between Labor Workers and Environmental Campaigners

In this section, I will be discussing the social issues between labor workers and environmental campaigners that can originate from divergent objectives and viewpoints, even

when both groups share a shared purpose of increasing community well-being. From personal experience, I have seen social and environmental perspectives throughout my life while I was living in Oxnard, California, and living near Sacramento, California. Oxnard can relate to a city like Tracy, where it is constantly a target for industrial profit and systematic racism. In addition, Oxnard has a high number of hard-working labor union workers employed at power plants, ports, and other industrial facilities. However, workers at the Port of Hueneme, for example, have a different ideology than an environmental advocate, where most of the time both advocates and labor workers tend not to see eye to eye. This creates a consistent battlefront in passing and vetoing policies in cities like Oxnard where intentions are not always beneficial for the overlooked community. Advocates often push regulations that limit greenhouse gas emissions and environmental damage, which can occasionally result in the downsizing or closure of polluting enterprises without a transition for workers. Policies that encourage renewable energy, for example, may not prioritize retraining or assistance for displaced workers.

Research on worker transitions and occupational risks in renewable energy and associated industries lays the groundwork for understanding the problems that employees encounter. Reports from organizations such as the International Labour Organization (ILO) and the Energy Futures Initiative (EFI) detail how workers in fossil fuel industries like coal and petrochemicals face job loss and require targeted retraining. The BlueGreen Alliance and the Labor Network for Sustainability (Labor 4 Sustainability, n.d.) also investigate how transitions to renewable energy might overlook worker requirements, noting gaps in training programs and safety standards (BlueGreen Alliance, n.d.). Specific studies include those that analyze occupational dangers in

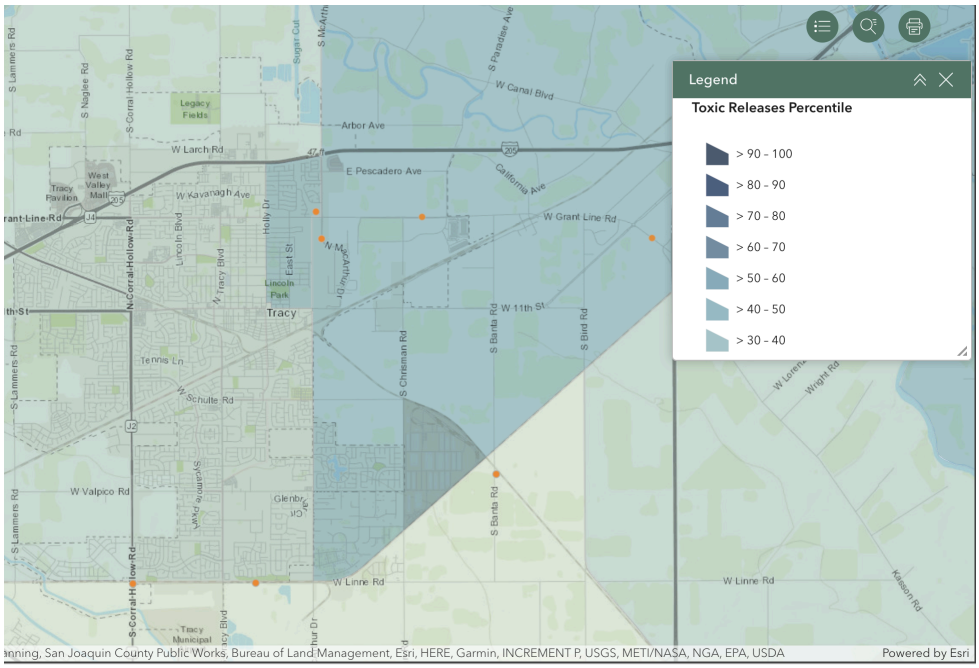
energy transitions, such as "Renewable Energy Jobs and Access" (ILO, 2018), which investigates work quality and safety in emerging energy industries. These tasks frequently include exposure to dangerous materials, large machinery, and physically demanding situations. Workers transferring into new roles in DAC facilities or renewable energy, such as plant operators, maintenance technicians, or material handlers, incur dangers identical to those in their former positions unless adequate training and management are provided.

Workers in the DAC industry, for example, may be exposed to caustic chemicals used in carbon capture, such as those used in petrochemical synthesis. Furthermore, the industrial sector's emphasis on large-scale material production and assembly matches the expertise required to build and manage DAC facilities. Comparing DAC facilities to the electricity, petrochemical, and industrial industries is useful because of common worker implications. For example, just as renewable energy initiatives have highlighted shortcomings in training and control, DAC facilities may fall short without strong rules.

To address these issues, DAC deployment methods must include policies that incorporate worker safety, retraining initiatives, and equal job opportunities. By learning from the transitions to renewable energy and fossil fuels, DAC facilities may prioritize worker-centered initiatives that assure both safety and sustainability.

In addition, the labor workers are working for their families and themselves, there is a need for better collaboration between environmental advocates and unions. Toxic masculinity is a term used to refer to societal norms and actions that produce a negative or limiting perspective of masculinity. These standards frequently put pressure on males to adhere to assumptions about

what it means to "be a man," which may have a harmful influence on both individuals and society at large.



Source 4: City of Tracy's Toxic Release Percentile from Facilities CalEnvironScreen

The Importance of Policies

For DAC facilities to function, particularly those that use carbon capture and geologic storage (CCS), regulatory guidelines are required. For instance, storing CO2 underground requires a Class VI permit under the Safe Drinking Water Act (U.S. Environmental Protection Agency, n.d.). Policies can help ensure the facility conforms with safety standards and environmental regulations, protecting public health and local water sources. The potential for unintentional environmental harm or negative effects on public health could rise in the absence of strict controls.

The San Joaquin Valley is home to several low-income, BIPOC communities that are already experiencing significant levels of pollution, particularly in Tracy (PolicyLink, n.d.). Policies requiring environmental justice evaluations and community engagement ensure that these groups' perspectives and demands are heard in DAC projects. For example, California's Environmental Justice Act and the Justice40 Initiative at the federal level seek to direct 40% of the benefits of climate investments to underserved regions. These policies serve to prevent increasing marginalization and promote equitable sharing of benefits and liabilities.

Direct Air Capture is still a new technology, and without enough financial incentives and government support, it may struggle to grow. Tax credits such as 45Q in the United States, subsidies, and grants can provide financial support to make DAC initiatives commercially viable (Congressional Research Service, n.d.). These incentives assist businesses in managing the high energy and material costs associated with CO2 capture and storage. Local or state-level legislation in California (e.g., bills seeking to create carbon removal compliance markets) may offer additional economic benefits, making DAC more attractive to investors.

The San Joaquin Valley contains a combination of agricultural, industrial, and residential regions. Land use and zoning policies assist in defining where DAC facilities may be built so that current businesses and communities are not disrupted. Local laws must take into account the region's specific geographic and socioeconomic structure to balance the economic advantages of DAC with possible repercussions on agricultural land, housing, and industrial activities. Because the San Joaquin Valley has traditionally been economically challenged, policies boosting DAC

can help boost local economies by providing new, high-quality employment in the clean energy sector. To guarantee that this occurs fairly, workforce training programs and just transition plans should be implemented to provide community members with the skills required for employment in these new industries.

Environmental Considerations at DAC facilities

Transportation

Additionally, the transportation of construction materials can emit more pollutants due to transporting significant amounts of materials (steel, cement, and equipment) to DAC sites that emit greenhouse gases (GHGs) as well as local pollutants like nitrogen oxides (NOx) and particulate matter (PM). Industrial facilities are frequently located near low-income and BIPOC communities, which already have higher rates of underlying health issues as a result of structural injustices and environmental injustice. Increased pollution from transportation worsens respiratory ailments such as asthma and bronchitis, as well as cardiovascular problems, exacerbating existing health inequities and putting additional strain on populations with limited access to healthcare (U.S. Environmental Protection Agency, n.d.). This emphasizes the importance of thorough consideration of transportation consequences in DAC project development, as well as steps to reduce harm to vulnerable communities.

Workers' Commute

Direct Air Capture (DAC) facilities are frequently placed in rural or remote places due to the requirement for huge tracts of land, closeness to geologic carbon storage sites, or access to renewable energy infrastructure. While these sites may reduce direct impacts on urban neighborhoods, they bring distinct issues with worker transportation and its accompanying emissions.

Laborers' commute tends to be overlooked. Daily travel by the personnel also contributes to cumulative emissions, especially in rural or remote areas where DAC facilities are frequently found. A lack of public transit may exacerbate vehicle reliance, raising emissions due to public transit being frequently unavailable or severely limited in rural or remote areas. With this being said, these pollutants disproportionately affect areas already struggling with poor air quality and inadequate healthcare services. Low-income workers may bear a disproportionate share of the costs of commuting, such as gasoline, car maintenance, and insurance. Long commutes can diminish the time available for family and community activities, which may exacerbate socioeconomic stress. Workers who live in disadvantaged neighborhoods near roads or industrial corridors may face a dual burden: exposure to pollutants from their journeys as well as cumulative pollution from larger industrial activity. To make sure we care for the labor workers, industries should create incentive programs for the employees to receive a reimbursement whenever they need to commute long distances and create company-sponsored shuttle networks or encourage carpooling to minimize single-occupancy vehicle journeys.

Construction Products

Cement production contributes to around 8% of worldwide CO_2 emissions (World Economic Forum, 2024). This is owing to the energy-intensive procedures needed in manufacturing clinker, a crucial element in cement, and the chemical reaction that releases CO2 during manufacture. Facilities that rely extensively on concrete for infrastructure development, such as Direct Air Capture (DAC) sites, naturally contribute to these emissions, prolonging the carbon footprint associated with cement manufacture. Steel and other materials used in DAC facility components need energy-intensive procedures, which frequently rely on fossil fuels. Furthermore, the mining and refinement of raw materials for steel and other components can harm the environment while disproportionately affecting vulnerable, generally low-income populations across the world. These challenges perpetuate cycles of environmental harm and socioeconomic unfairness.

Water Considerations

DAC facilities work by sucking in air, removing CO2, and then storing it, generally with chemicals that must be cooled or cleaned, which uses water. The amount of water utilized varies according to the technology and cooling requirements Mirza et al., 2023). For example, certain DAC processes require a substantial quantity of water for CO2 absorption or desorption, while others may utilize water for industrial cooling. The energy-intensive nature of these facilities frequently necessitates the use of water to cool the power plants that operate the DAC systems.

The disproportionate impact of water usage for DAC facilities on low-income and marginalized communities, particularly those of color, is a major concern. Environmental justice

campaigners frequently note that these areas already face increased environmental dangers, such as poor air and water quality, and may have restricted access to clean water. In locations where water resources are scarce or stretched thin, such as California's Central Valley, diverting water for industrial use can worsen already existing imbalances. Local communities may see a decrease in water supply for agricultural or domestic usage, disproportionately affecting persons who are already economically vulnerable.

Renewable vs. Fossil Fuel Energy Sources

Although Direct Air Capture (DAC) technology can reduce atmospheric CO2, it requires a lot of energy. Capturing and concentrating CO2 from the air needs a significant amount of energy, often from electricity. As a result, DAC operations rely heavily on the availability of low-cost, sustainable energy sources (Belfer Center for Science and International Affairs, n.d.). DAC systems require significantly more energy per ton of CO2 eliminated than other carbon mitigation measures, such as renewable energy transitions or energy efficiency improvements.

DAC facilities may lower their carbon footprint by using renewable energy sources, including wind, solar, and geothermal power. These energy sources create little greenhouse gas, contributing to climate protection by minimizing CO2 emissions from DAC's energy consumption. However, the reliance on renewable energy for DAC has concerns. Renewable energy is a scarce resource, and there is a huge worldwide need for it, especially as other industries like transportation, heating, and power generation migrate to low-carbon energy sources (ScienceDaily, 2024). Prioritizing DAC's energy demands may shift clean energy

resources away from other essential businesses, impeding the overall transition to a low-carbon economy.

Furthermore, the widespread deployment of renewable energy infrastructure, such as wind farms and solar fields, may have unforeseen social and environmental repercussions (Belfer Center for Science and International Affairs, n.d.). These projects need extensive land use, which may displace disadvantaged groups, notably low-income and BIPOC people. Furthermore, the concentration of renewable energy resources in regions designated to DAC may limit access to clean energy for these low-income communities, compounding concerns about energy equity and cost.

However, it is critical to balance its growth with investments in more cost-effective options, such as energy efficiency and renewable energy transitions. DAC is now more expensive per ton of CO2 removed compared to tons of CO2 avoided by energy efficiency and renewable energy infrastructure, which can provide faster and less expensive climate benefits

How Can You Make a Difference?

For most people who do not have much experience with public speaking or advocacy work, it can be intimidating to walk in front of a podium and speak in front of a crowd so that your voice can be heard. Relating to that, if one wants to advocate for their community, they may wonder to themselves, "Where do I start?". Researching and connecting with local non-profit organizations like Restore the Delta and Little Manila Rising can be a stepping stone to becoming an advocate for the environment and your community. Take the time to discover your

hobbies and interests. For example, if you're interested in environmental justice and want to learn more about its implications, consider attending local events and seminars or contacting organizations for information. If you're in high school or college, attending youth groups can help you connect with others in your community who share your interests and beliefs. From there, you may choose how to participate in advocacy, whether through policy work, social justice activities, or areas such as carbon management.

The California Environmental Quality Act (CEQA) is crucial in ensuring that proposed projects, such as Direct Air Capture (DAC) facilities, receive a full environmental study before implementation (California Environmental Quality Act, n.d.). CEQA requires authorities to examine a project's possible environmental implications and suggest mitigation strategies. This procedure includes public comment periods, which allow communities to express their concerns or suggest alternatives. Engaging with CEQA is a critical step for a DAC facility in San Joaquin County to address possible implications on air quality, water consumption, energy demand, and local ecosystems, especially in low-income and marginalized populations that are frequently plagued by environmental disparities.

Viewing CEQA via a social justice lens entails pushing for the inclusion of community voices, particularly those of historically marginalized groups, throughout the assessment process. Residents of San Joaquin County, particularly those in disadvantaged areas, can attend public hearings, provide feedback on draft Environmental Impact Reports (EIRs), or work with local advocacy groups to ensure that the project corresponds with community goals. CEQA establishes

a framework for requiring that any DAC infrastructure contribute favorably to local well-being, avoid worsening environmental inequities, and emphasize fair resource allocation.

In this context, social justice advocacy includes ensuring that all residents of the community have access to the advantages of a DAC plant, such as job generation and carbon reduction. This involves advocating for workforce development initiatives that promote local employment, proper training, and equitable pay. Furthermore, addressing issues about energy usage and environmental trade-offs in DAC operations ensures that the facility does not impose extra obligations on vulnerable communities. Engaging with CEQA not only helps to avoid negative consequences, but it also allows citizens to co-create solutions that advance climate objectives while upholding justice and equity in San Joaquin County.

Conclusion

It would be troublesome to primarily rely on direct air capture (DAC) as a means of reducing our fossil fuel footprint for several reasons. Although carbon dioxide (CO_2) removal from the atmosphere by DAC is a promising technology, it cannot and should not be the only tactic used to prevent climate change. In other words, a multifaceted, all-encompassing strategy is required. Since it treats carbon emissions after they have already been released into the atmosphere, DAC is a corrective technique. But to tackle climate change head-on, we need to concentrate on stopping emissions at the source, which means cutting back on fossil fuel consumption in important areas like transportation, energy, industry, and agriculture. If the core

causes of emissions are not addressed, DAC would merely be a band-aid solution that permits the unrestricted use of fossil fuels.

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