Aligning Industrial Decarbonization Technologies with Pollution Reduction Goals to Increase Community Benefits

This brief aims to help policymakers and industry better align the co-benefits of air pollution and decarbonization when making decisions about investments and facility upgrades.

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KEY FINDINGS

- While industrial facilities are often located in disadvantaged communities, there is still substantial geographic variation in the surrounding community demographics and population density proximate to high-emitting heavy industrial facilities.
- Technological interventions at heavy industrial facilities with similar CO_2 and PM2.5 emission profiles could have dramatically different impacts depending on the surrounding community. Facility upgrades aimed at decarbonization and reducing air pollution should be the first priority in locations that have concentrations of marginalized communities and heightened air quality concerns.
- Based on a geographic analysis of U.S. cement facilities, we find that five of the top 11 facilities emitting well above the median levels of PM2.5 and CO_2 per year are located in areas where 66–100% of the population within a three-mile radius meet Justice40 criteria. Such sites are top candidates for early investment in technologies that substantially reduce both carbon and air pollution emissions.
- As awards from early rounds of federal industrial decarbonization funds are announced, organizations that provide technical assistance and expertise—including national laboratories, universities, local or state planning offices, and nongovernmental organizations (NGOs)—can facilitate productive relationships between communities and heavy industry by identifying synergies between industrial decarbonization progress and local air quality needs.
- Federal investments from both DOE and EPA should be aligned, when possible, in locations of greatest need from the perspective of reducing carbon emissions, pollution reduction, and environmental justice. Industry can use DOE funding awards to implement decarbonization technologies and establish formalized community benefit and labor agreements. In coordination with DOE investments, communities can use EPA funds to track the resulting pollution emission outcomes and to pressure industry to commit to ambitious, deep industrial decarbonization pathways that also substantially improve community health and the local environment.

Introduction

In general, decarbonizing the industrial sector is expected to substantially improve local air quality (The Royal Society 2021). Some industrial decarbonization strategies, however, can be more effective than others at reducing air pollutants of concern in a given community. Technical information and strategic decarbonization policy guides typically focus on industrial technologies' greenhouse gas (GHG) reduction potential compared to their implementation costs.[1] Industry—and most of the technical policy and implementation guidance it receives—usually considers air quality improvement to be a *co-benefit* of interventions meant to limit GHG emissions. For community stakeholders, clean technologies' health and social impacts (e.g., reduced air pollution burden or improved access to good-paying jobs) are often a higher priority than the potential carbon footprint reduction (Strunge et al. 2022). Nonetheless, clear guidance around the air pollution benefits of various decarbonization strategies is difficult to find.

Addressing industrial air pollution effectively is a matter of social and racial equity. The majority of heavy industrial facilities are located in marginalized communities and communities already experiencing elevated air pollution (Synapse Energy Economics, Inc. 2023). People of color in the United States are exposed to disproportionately high levels of PM2.5 air pollution from industrial sources; such PM2.5 pollution is responsible for increases in asthma and heart disease, and for the highest levels of human mortality (Tessum et al. 2021; Wang et al. 2023). A recent analysis found that the air quality benefits of industry reducing pollutant emissions from fossil fuel combustion flow at higher than expected rates to majority-Black communities (Gallagher and Holloway 2022). As such, addressing industrial air pollution sources can be a powerful tool for reducing racial inequities in environmental health burdens.

More than $80 billion in federal industrial decarbonization funding is available through recent federal legislation.[2] This offers an opportunity to invest in many of the disadvantaged communities proximate to industrial facilities that are most in need of emissions reduction interventions. The federal Justice40 strategy promises to support communities that are marginalized, underserved, and overburdened with pollution by ensuring that at least 40%

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[1] For example, a commonly used tool, the Marginal Abatement Cost (MAC) Curve, arranges the carbon reduction potential of various technologies in order from least to greatest cost to implement, but it does not reflect the technologies' varying abilities to reduce other air pollutants.

[2] Federal programs focused on industrial decarbonization continue to roll out, as a result especially of the Bipartisan Infrastructure Law (BIL), Inflation Reduction Act (IRA), and CHIPS (Creating Helpful Incentives to Produce Semiconductors) and Science Act. These programs have resulted in billions of dollars in tax credits, grant programs, loans, and cross-agency initiatives, including Buy Clean, which leverages governmental purchasing power to create demand for more sustainable, low-carbon materials for construction.

of federal energy and technology investments benefit these communities. Now is an essential time to identify which communities could most benefit from industrial air pollutant reductions—and to ensure that these communities have the tools they need to advocate for industrial decarbonization investments that not only support broader decarbonization goals, but also directly improve their living conditions, especially through improved local air quality.

In this brief, we share the findings of an example geospatial analysis that identifies, for a subset of heavy industries, where proactive community outreach, engagement, and technical support from federal agencies and other third-party stakeholders—including universities, local governmental stakeholders, or NGOs—could have the greatest impact. In strategically selected locations, air pollution reduction benefits from industrial decarbonization investments could provide the greatest benefits for the greatest number of people in disadvantaged communities while still supporting broader economic decarbonization agendas. We also highlight opportunities for federal agencies to better align their funding to both support environmental justice and maximize community benefits.

Geospatial Analysis of Priorities for Plant Decarbonization and Community Engagement

As a first step toward improving the alignment between industrial decarbonization opportunities and community air pollution reduction benefits, we conducted an original analysis aimed at identifying locations across the United States with both high-emitting industrial facilities and significant populations of vulnerable communities. In such places, community needs and opportunities for industrial decarbonization and emissions reductions intersect; these locations also offer the greatest potential advantages for proactive investment in community technical support and engagement around industrial decarbonization's benefits and outcomes. Local industrial facilities in these places should proactively reach out to communities to better understand their concerns and priorities. Further, a range of neutral third-party technical experts (e.g., at universities) could work with local community stakeholders to identify informational gaps that need to be filled to build trust around industrial technologies that reduce both carbon and pollution emissions. For example, technical support could come in the form of fact sheets that clearly outline the local costs and benefits of a range of industrial technology pathways. These fact sheets could be paired with local convenings of interested parties to proactively discuss and address questions and concerns around potential industrial decarbonization investments.

In this brief, we focus on cement manufacturing facilities (see figure 1). We also mapped iron and steel manufacturing facilities, which is available as an interactive online supplement. We focus our mapping exercises on these two sectors because transformative decarbonization technologies are available to both the cement sector and the iron and steel sector but still require implementation support. This support includes messaging that amplifies how these technologies will build a cleaner, more equitable manufacturing ecosystem in the United States.

Both industrial sectors have facilities that vary widely in size and emissions intensity. The facilities are also geographically distributed throughout the country, intersecting with a variety of communities. These communities vary both in their relation to industry and in their primary health, employment, and environmental concerns.

DATA SOURCES AND ANALYSIS METHODS

We first mapped the location of cement and steel facilities in the continental United States using data from the EPA's Greenhouse Gas Reporting Program (GHGRP) and Facility Level Information on Greenhouse Gases Tool (FLIGHT) (https://www.epa.gov/ghgreporting/find-and-use-ghgrp-data).

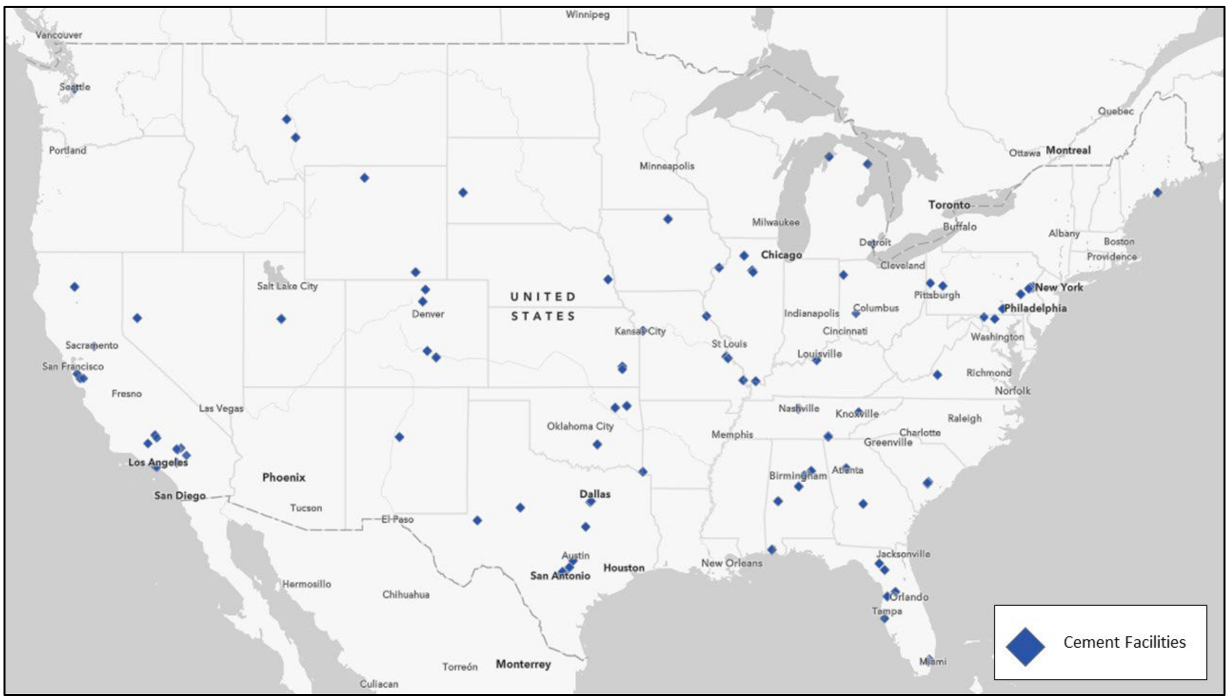

Figure 1. Industrial cement facility sources across the continental United States. Source: EPA FLIGHT.

To obtain facility-level emissions data, we used carbon and pollutant emissions data from two sources: the EPA's GHGRP, which covers approximately 85–90% of U.S. carbon emissions sourced from more than 8,000 high-emitting facilities; and the EPA's National Emissions Inventory (NEI), which provides pollutants beyond just GHGs for these facilities. In the following analysis, we use PM2.5 as our focal industrial air pollutant, as it has welldocumented negative health impacts[3] and is commonly emitted from industrial combustion sources (EPA 2023a).

We visualized how these facilities in high-emitting industrial subsectors intersect with disadvantaged, pollution-overburdened communities as defined by the White House's Justice40 initiative. According to that initiative, a community qualifies as "disadvantaged" if the census tract is above the threshold for at least one environmental or climate indicator as well as for key socioeconomic indicators, or if the census tract is entirely surrounded by communities that fit this description.[4] We calculated the number of individuals living in census tracts identified as Justice40 communities based on this standard, as well as the overall percentage of land area composed of census tracts that fit this definition within a three-mile buffer around each industrial point source included in our analysis.[5]

In this three-mile buffer zone, pollution from high-emitting facilities is most likely to impact vulnerable communities—and therefore reducing industrial emissions in it would have the greatest local benefits. Our analysis does not directly calculate facility emissions' effects on ambient air, as this would require spatially explicit atmospheric modeling. Our study does, however, allow quick screening for where air pollution health benefits and GHG emission reduction benefits are more likely to co-occur, and it sets the stage for more realistic modeling of specific interventions' impact on ambient air quality (Tessum, Hill, and Marshall 2017).

RESULTS

Here, we illustrate the impact of industrial facilities on Justice40 communities. In addition to the maps here, we created an online [interactive map](#) that allows users to explore the data features in more depth and also shows the same data for the iron and steel industry.

[3] https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

[4] To see which communities fall under this classification, see the interactive Climate and Economic Justice Screening Tool (Council on Environmental Quality 2023).

[5] While environmental justice study areas surrounding aerial point sources of pollutants can range from 0.5 miles to 50 miles, we chose to use a three-mile radius as our buffer zone as it is also used in the 2015 *EJ Screening Report for the Clean Power Plan* and other literature focused on environmental justice (see EPA 2016; PSE 2023; Synapse Energy Economics, Inc. 2023).

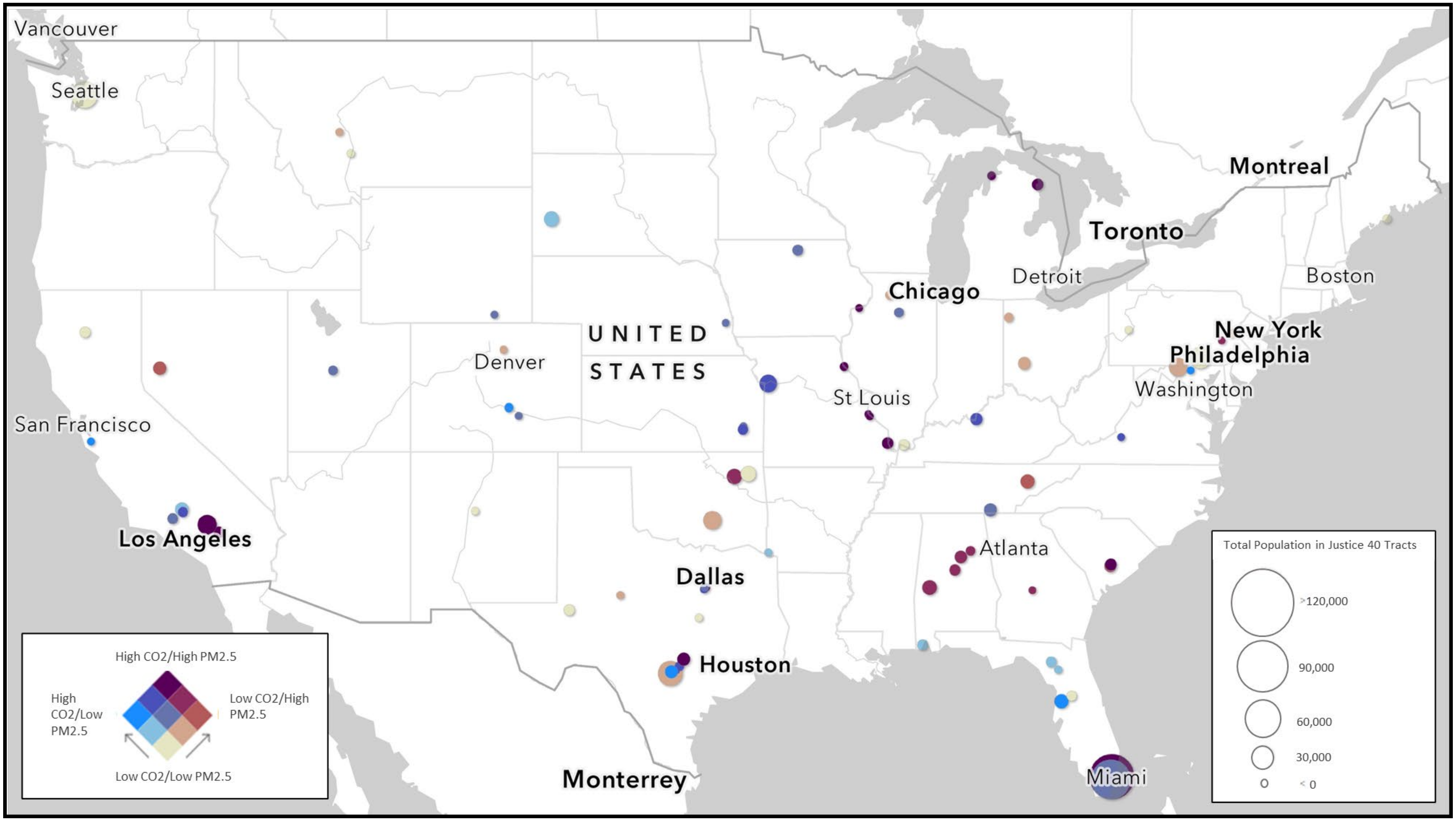

Figure 2. Relationship between total disadvantaged population in a three-mile buffer zone of cement facilities and the CO_2 and PM2.5 emissions

As figure 2 shows, cement facilities are found across the country, with higher concentrations of facilities in Southern California, Texas, Florida, and the Mid-Atlantic region. The size of each facility symbol represents the total population of Justice40 communities within a three-mile buffer zone, with larger circles representing facilities that operate in closer proximity to larger disadvantaged populations.

Notable regions with both high CO_2 and high PM2.5 emissions from cement facilities—that is, sites with more purple colors—include northeast Michigan, south Florida, eastern Missouri, and Los Angeles. Table 1 shows the cement facilities that were in the top 25% of our dataset for both annual CO_2 emissions *and* annual PM2.5 emissions in that industrial subsector. These facilities vary substantially in the number of people and in the overall proportion of the surrounding community that qualifies under the Justice40 standards. Four of these high emissions sites do not intersect with any disadvantaged populations in the three-mile buffer zone. So, while these facilities will be important to invest in to reduce carbon emissions, it may make sense to first prioritize technology upgrades and retrofits for facilities in which decarbonization's local pollution-reduction co-benefits will include more immediate positive health benefit for surrounding disadvantaged communities given that the impact of reducing GHG emissions is geographically neutral. Overlaying information on general ambient air quality—for example, using a county-level ambient air quality index[6]—could further clarify community air quality needs; this could further focus pollution prevention investments in areas that have persistently lagged behind other areas in terms of air quality (Colmer et al. 2020).

[6] https://aqs.epa.gov/aqsweb/airdata/download_files.html

Table 1. Cement facilities in the top quartile for both CO2 and PM2.5 emissions, with the numbers and percentage of Justice40 population within a three-mile buffer zone

State	County	Facility	Justice40 population	Justice40 population (%)
Florida	Miami-Dade	Titan America[7]	103,538	78
California	San Bernardino	CalPortland Oro Grande	32,243	78
South Carolina	Orangeburg	Holcim US—Holly Hill	11,087	100
Michigan	Alpena	Holcim US (DBA Lafarge)—Alpena Plant	10,836	24
California	San Bernardino	Mitsubishi/Cushenbury Plant	10,225	66
Missouri	Cape Girardeau	Buzzi Unicem USA—Cape Girardeau	10,208	71
Texas	Ellis	Holcim US –Midlothian Plant	1,337	14
Missouri	Ste. Genevieve	Holcim US—Ste. Genevieve Plant	0	0
California	San Bernardino	Cemex—Black Mountain Quarry Plant	0	0
Missouri	Jefferson	River Cement Co. (DBA Buzzi Unicem USA)—Selma Plant	0	0

State	County	Facility	Justice40 population	Justice40 population (%)
Iowa	Scott	Continental Cement Company—Davenport Plant	0	0

Discussion and Next Steps

As we have highlighted, industrial decarbonization technology implementations affect more than just industrial operations and corporate and national carbon budgeting. These technologies also have localized impacts—many of them potentially positive—but this fact is rarely a focal point of industrial decarbonization narratives. Universities and other neutral third-party stakeholders can help address this by acting as trusted intermediaries between industry and communities. As such, they can help to bridge gaps between industrial and community goals, clarify the local and regional air pollution benefits of new technology pathways, and build multistakeholder coalitions to achieve federal and private investments in their regions.[7]

INTEGRATING FEDERAL INDUSTRIAL DECARBONIZATION AND ENVIRONMENTAL JUSTICE EFFORTS

Implementation has begun in earnest for new federal programs aimed at decarbonizing our economy and alleviating pollution burdens on communities to address environmental justice goals. While the DOE offers the most opportunities to support industry's transition to clean energy and deploy technologies to decarbonize manufacturing processes, the EPA primarily coordinates programs to support communities surrounding industrial facilities. As a result, coalitions seeking to align local needs (e.g., economic development and improved air quality) with industrial investments that lead to more sustainable, profitable, and resilient manufacturing facilities might need to separately leverage DOE and EPA support. For example, EPA funding mechanisms[8] could support community-led air pollution monitoring,

[7] For example, to apply to DOE's federal hydrogen hub program, new coalitions of industry, local economic development offices, and community-based organizations formed to share progress and achieve broader regional economic and environmental goals.

[8] The EPA's Environmental and Climate Justice Program, for example, offers communities financial and technical assistance for conducting environmental and climate justice activities that benefit underserved and overburdened populations (EPA 2023b).

while DOE funding[9] could simultaneously help to implement transformative industrial decarbonization technologies.

Separate DOE and EPA funding mechanisms also include strategies to broaden impacts across multiple stakeholder groups. To ensure that affected communities can participate in planned industry investments, DOE funding opportunities for industrial decarbonization now require industry applicants to submit community benefits plans (CBPs) that are fully integrated into technical plans for infrastructure deployment. These CBPs require that industry develop strategies to ensure two-way engagement with communities, emphasizing tools such as community benefit agreements, community labor agreements, or community workforce agreements. This gives local stakeholders the opportunity to use these formalized negotiation tools to press companies to achieve more ambitious reductions in both pollution and carbon emissions, while also ensuring that industry makes investments that directly benefit surrounding communities.

Another potential vehicle for implementing forward-facing community-based strategies to mitigate industrial emissions are the Environmental Justice Thriving Communities Technical Assistance Centers (EJ TCTAC), a nationwide network of community support centers established by the EPA and operational as of June 2023. DOE, through its national lab collaborations, also provides proactive technical assistance to communities to strategically address industrial emissions. The National Renewable Energy Lab, for example, is piloting a technical assistance program to plan just and equitable energy transition actions for low-income, energy-burdened communities.[10]

IDENTIFYING TECHNICAL ASSISTANCE GAPS FOR COMMUNITIES IMPACTED BY INDUSTRIAL POLLUTION

More than half of the 2,000 largest companies in the world have enacted, pledged, or proposed net-zero GHG emissions targets,[11] yet few are explicit about how other air pollutant emissions are expected to change as carbon emissions reach net-zero for industrial operations. Third-party technical experts—including national labs, universities, local or state planning offices, and NGOs—can help to address this informational gap by working with industry and trusted community stakeholders to collect and share data responsive to community concerns around the air pollution impacts of industrial decarbonization pathways. To maximize community benefits, technical experts can develop and share information, especially with stakeholder groups representing underserved populations near

[9] Industrial funding opportunities continue to be announced through DOE's Industrial Efficiency & Decarbonization Office (IEDO), as well as the DOE Office of Energy Efficiency and Renewable Energy (EERE).

[10] DOE 2023

[11] Net Zero Tracker 2023

industrial facilities that can dramatically reduce both GHG and air pollutant emissions over the coming decades. Spatial analyses, such as the one we present here, are a useful tool for identifying regions in which GHG and pollution reduction needs are co-located; third-party technical assistance providers can then focus their efforts on connecting community and industry stakeholders in these areas.

To date, few tools or informational sources target non-industrial stakeholders or transparently estimate potential pollutant reduction opportunities from decarbonization technology implementations. Industry often has multiple technology pathways that it can follow to achieve decarbonization goals (Strunge et al. 2022; Goforth and Nock 2022), and some solutions may provide greater pollution reduction benefits directly to fence-line communities than others. For example, while combusting green hydrogen instead of natural gas is expected to substantially reduce many air pollutants—including SO_2—that are associated with natural gas combustion, unless mitigation strategies are incorporated, hydrogen combustion releases water vapor at high temperatures that increases NO_x formation (Kikuchi, Hori, and Akamatsu 2022). For communities already concerned about ozone levels, local facilities that switch to green hydrogen to reduce GHG emissions may not offer community benefits unless they invest in updating their operational strategies and incorporate technologies to mitigate increased NO_x formation.

Conclusion

Our geospatial analysis identified communities that stand to benefit the most from early and sustained DOE and EPA engagement and investment. While the facilities shown in table 1 would significantly benefit from technological interventions that improve carbon and air pollution emissions, retrofits in some of these facilities would deliver much greater benefits to underserved populations. Federal agencies or technical support providers such as universities, NGOs, or local economic planning offices could proactively reach out to these communities and use preexisting funding mechanisms to build capacity in the communities to advocate for industrial decarbonization solutions that also address core public health and environmental issues. Local policy stakeholders could also incorporate industrial decarbonization pathways into broader climate and environmental planning efforts; they could, for example, apply for technical support from EPA and DOE experts, partner more directly with industry, and facilitate engagement with the community to build trust around technology pathways that deliver the greatest and most direct environmental and health co-benefits.

Aligning DOE and EPA funding mechanisms in the locations with the greatest need for carbon and pollutant reduction could help to empower both community and industrial stakeholders to engage productively and to co-create a pathway to clean, sustainable manufacturing. In doing so, they would deliver just outcomes for communities that have carried the pollution burden of industry for so long.

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