Policy Evaluation for Decarbonization of the U.S. Iron/Steel and Cement Industries

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Project Overview

Industrial emissions are a primary contributor to global warming, making up about one-fifth of today's U.S. greenhouse gas (GHG) emissions. Beyond this environmental impact, industrial emissions also have serious health impacts, containing hazardous levels of sulfur oxides, nitrogen oxides, and particulate matter that heighten the risk of lung cancer and respiratory diseases in local communities. Federal efforts to combat climate change have thus far focused on industrial decarbonization, with laws like the Inflation Reduction Act of 2022 and the Bipartisan Infrastructure Law of 2023 allocating billions of dollars to programs and technologies that can reduce GHG emissions from Iron/Steel, Cement, and other high-emitting industries. Funding is concentrated in communities with health and socioeconomic disparities, including the federally-designated Energy and Disadvantaged Communities.

As funds are being distributed, it is crucial to consider which interventions deliver the best balance of environmental, social, and economic impact: Which programs should be prioritized to meet the needs of local and global communities? Our project seeks to answer this question through the creation of a novel policy evaluation methodology that first breaks down facility-level emissions by end-use and process, leading to easy identification of GHG emissions hotspots. This breakdown is then used to model GHG reductions resulting from specific policy interventions. Results were calculated per facility, within Energy and Disadvantaged Communities, and nationwide and were further supplemented with qualitative evidence on each intervention's impacts on community health, labor, and the economy.

Our team's results—along with our underlying methodology, code, and assumptions—were published online as public and open-source resources to be used by U.S. policymakers and future researchers in developing comprehensive, high-impact programs for industrial decarbonization.

Innovative Methodology

Industrial facilities report annually to the U.S. Environmental Protection Agency (EPA) through the GHG Reporting Program. We produced a breakdown of U.S. cement facility emissions according to end-use, based on data from the U.S. Energy Information Administration's Manufacturing Energy Consumption Survey. We produced a similar breakdown of U.S. iron and steel facility emissions according to process steps, based on U.S. Department of Energy estimates for the energy intensity of various steelmaking processes. These breakdowns allowed us to construct reasonable models of policy implementation that showed which end-use or processes would be impacted and by how

much. We aggregated facility-level results to produce long-term GHG reduction estimates at the U.S. facility level, within Energy and Disadvantaged Communities, and nationwide. This quantitative analysis was supplemented with qualitative analysis to produce a comprehensive review of the potential impacts of each policy. Our results were published online as a public, open-source resource for use by policymakers and future researchers.

Quantitative Results

This table summarizes the long-term (2050) emissions savings that could result from the policies evaluated in our project, according to our innovative methodology:

	GHG Reductions (millions mt CO2e)		
Policy	Nationwide	Energy Communities	Disadvantaged Communities
EPA Standards (Cement)	60.9	4.8	20.3
EPA Standards (Steel)	50.0	15.5	33.4
CCS (Cement)	62.0	4.9	20.6
CCS (Steel)	37.2	10.2	25.9
Hydrogen (Cement)	13.8	1.1	4.6
Hydrogen (Steel)	38.8	11.3	27.4
Energy Efficiency (Cement)	20.3	1.6	6.8
Clinker Substitution (Cement)	34.4	2.7	11.5
Energy Efficiency (Steel)	0.6	0.2	0.3
Buy Clean (Cement)	33.8	2.7	11.2
Buy Clean (Steel)	27.8	8.6	18.5
Low Carbon Fuels (Steel)	5.1	1.6	4.3
Low Carbon Fuels (Cement)	2.5	0.2	0.8

Our project also considered several other interventions not listed in this table: steel circularity, cap & trade, increased funding to environmental justice communities, just transition, and carbon border adjustment. These interventions lacked quantitative evidence to produce estimates for emissions savings and so were evaluated only through qualitative analysis. See the full methodology and results in our Final Report.

Research Impact

This project synthesizes a large body of research on industrial GHG emissions, decarbonization technologies, and policy interventions. Most research on industrial GHGs looks at their contribution to U.S. emissions in the aggregate, glossing over variations between facilities and geographical regions. Meanwhile, research on decarbonization technologies can be highly specific, targeting only certain equipment and processes in industrial facilities. Our project bridges this gap by evaluating the performance of policy interventions based on expected facility-level changes. This makes it possible to quantify GHG reductions at the facility, community, or nationwide level. In particular, we can quantify GHG reductions within Energy and Disadvantaged Communities that receive federal funding for industrial decarbonization. Our methodology, R code, and results are published online as an interactive dashboard for policymakers and future researchers. We hope they will serve as a valuable resource in the development of smart policies that maximize both GHG reductions and community welfare.