Evaluating Steel Plant Emissions in the United States

Plant-level data to inform industrial decarbonization and clean energy development under the Inflation Reduction Act

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Objectives

This project will map carbon emissions onto steel plant locations in the US. Students will identify which steel plants are the most carbon-intense based on energy consumption and steel production. Results from this analysis will be used to make recommendations for decarbonization spending under the Advanced Industrial Facilities Deployment Program. The initial work of matching emissions data to steel plant location data is well within scope:

- Join Global Steel Plant Tracker (GPST) data from Global Energy Monitor (GEM) and production data from the American Iron and Steel Institute (AISI) to emissions data from Electricity Maps and the EPA's Greenhouse Gas Reporting Program by plant location.
- Analyze relationship between steel plant size, type, ownership, and carbon intensity.
- Create an interactive dashboard for data visualization and exploration.

Upon completing the central objectives, students can select from the following goals based on interest and time:

- Project steel-related emissions for planned clean energy development. GEM's solar and wind power trackers include the amount of steel required per MW of energy project development that students can use to analyze and predict the emissions generated from increased steel demand for clean energy.[1,2] This analysis will help energy project planners consider their scope three emissions and chose to source steel from the plants with lower emissions intensity.
- Investigate the community impacts of steel plant operations. This will include comparing GSPT data on workforce size across plant types and may involve web scraping to identify community sentiment toward steel plants. Additionally, US census data can be used to find demographic information of the communities surrounding steel plants.
- Use time-series data from Electricity Maps of emissions intensity from 2018-2021 to model and project future emissions intensity of steel plants in the US.

Significance

Globally, iron and steel production account for 11% of carbon dioxide emissions.[3] In the US, most steel plants already use electric arc furnace (EAF) technology, rather than the coal-powered furnaces prevalent in the rest of the world. This energy-intensive industry is facing increasing pressure to decarbonize, and EAF technologies provide a promising path for electrification.[4] However, electrification will only be beneficial if the emissions-intensity of the electricity powering these plants is low. Determining the emissions intensity of steel production is especially critical for the Inflation Reduction Act (IRA), which provides $6 billion in funding for heavy industry decarbonization under the Advanced Industries Deployment Program.[5]

Sharing open-source data on the emissions intensity of individual EAF steel plants in the US will fill a gap in the current public knowledge, enable investors and finance groups to better understand their scope three carbon emissions, and further GEM's mission to track the climate impacts of the steel industry.

Background

GEM has been studying the climate impacts of steel production and maintaining high quality data on steel plants globally since 2020. The 2021 release of the Global Steel Plant Tracker (GSTP) was "the first systematic attempt to document all steel plants on the globe" that meet a capacity

threshold, according to a report from GEM.[6] The 2022 update of the Global Steel Plant Tracker (GSPT) provides location, ownership, capacity, and operations data on 957 of the world's largest iron and steel plants, accounting for 90% of the global steel industry's capacity.[7]

Global Efficiency Intelligence, a consulting firm, published the report, Steel Climate Impact, which benchmarked the energy intensity and carbon emissions of iron and steel production internationally.[8] This report uses national grid averages, but doesn't specify emissions intensity at a more granular level. This Bren/GEM project will fill the need for emissions intensity data at the community and individual plant level. The US has set national goals to shift to a cleaner energy grid, and this will be achieved through the cumulation of smaller scale changes with new renewable energy projects and fossil power plant retirements. The plant-level analysis from this project will empower steel producers and consumers (including clean energy developers) to steer the industry toward a low-carbon future.

Equity

While equity is not the forefront of this project, analyzing the emissions intensity of EAF steel and iron plants will help make the case for decommissioning coal-powered steel and iron plants and for transitioning to a cleaner grid. Coal-powered steel and iron plants are a point-source of pollution that impacts the health of the surrounding communities.

Data

Four primary data sources will be used for this project: GEM's GSPT , the EPA's Greenhouse Gas Reporting Program (GHGRP), Electricity Maps, and AISI. Steel demand for clean energy projects will be provided by GEM's Global Wind Power Tracker and Global Solar Power Tracker. Data for reaching the stretch goal of community sentiment analysis may be scraped from the web (social media, news outlets, etc.), and/or demographic data may be pulled from the US Census Bureau and the US Bureau of Labor Statistics.

GSPT Data. GEM maintains an interactive dashboard of the data, but for this project spreadsheets will be provided (see supporting materials). Data includes information on plant location, size, production method, owner and parent company, operational status, and workforce size for crude iron and steel plants with a capacity of 500,000 tonnes per year. The tracker contains global data, but this project will focus on the US. GEM is committed to providing free and open-source data for all users.[9]

EPA GHGRP Data. The EPA's GHGRP contains facility-level emissions data from industrial sectors, including metals. Data is downloadable as spreadsheets from the GHGRP data sets web page. This project will make use of the "Emissions by Unit and Fuel Type" file which contains 145 rows of data on steel and iron production plants. EPA GHGRP data is all free and publicly available.

Electricity Maps. Electricity Maps, an open-source app that parses and collects real-time electricity data, provides carbon intensity information on electricity consumption in the US (in grams of CO_2 equivalent per kilowatt hour). Electricity Maps offers one country and one year of historical carbon intensity data for free to academic users, and offers a discount for additional data. A data sample is available to view on the request data page.

AISI. Caitlin Swalec, the client, has compiled the regional production values from US steel plants included in AISI's weekly newsletter over the last two years. She has collated this free and publicly available information into a useable database.

Computational Resources

Computing for this project can be done with the Bren server, Taylor. Analysis can be conducted in either R or Python, according to student preference. Dashboards can be made with Tableau or R Shiny. Project deliverables will be maintained on GEM's website.

Possible Approaches

Data will be cleaned, wrangled, and appropriately joined to allow for in-depth analysis. Emissions data will be matched to GSPT data by location. This project will explore the statistical relationship between plant size, production method, and other related variables with carbon emissions. The workflow for this project will be managed with GitHub and executed on Taylor with an emphasis on reproducibility and contributing to the open-source material that GEM already maintains.

Deliverables

Deliverables for this project will include:

- A tidy dataset created from the combination of the data sources described above.
- Mapped visualizations of carbon emissions and intensity by steel plant, to be shared on GEM's website.
- Updating and redesigning GEM's interactive dashboard to display emissions data.
- A written summary of decarbonization opportunities identified in the data analysis and policy recommendations and key targets for the funding provided for the Advanced Industrial Facilities Deployment program under the IRA.

Deliverables for project stretch goals include:

- Creating a separate dashboard for energy project developers to look at the scope three emissions coming from steel.
- Including community sentiment analysis and demographic data in maps, visualizations, and the dashboard.
- Including projected future emissions within the interactive dashboard.

Audience

The deliverables for this project will augment what GEM already offers to its current client base. NGOs, academic institutions, activist groups, agencies, consulting firms, and media outlets use GEMs data.[10] Users of GEM's data include the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency, Rocky Mountain Institute, universities across the world, and many more. GEM's products allow these organizations to:

- Provide policy recommendations
- Publish reports and maps
- Conduct climate research
- Produce national energy studies
- Support fossil fuel divestment

Supplemental Materials

Citations

1. Solar Power Tracker. Global Energy Monitor. https://globalenergymonitor.org/projects/global-solar-power-tracker/.
2. Wind Power Tracker. Global Energy Monitor. https://globalenergymonitor.org/projects/global-wind-power-tracker/.
3. "Steel Climate Impact." Ali Hasanbeigi. Global Efficiency Intelligence. https://www.globalefficiencyintel.com/steel-climate-impact-international-benchmarking-energy-co2-intensities.
4. "Pedal to the Metal," Caitlin Swalec and Christine Shearer. Global Energy Monitor. https://globalenergymonitor.org/wp-content/uploads/2021/06/Pedal-to-the-Metal.pdf.
5. "Climate Bill Will Invest Big in Cleaning Up Heavy Industry." Sasha Stashwick. National Resource Defense Council. https://www.nrdc.org/experts/sasha-stashwick/climate-bill-will-invest-big-cleaning-heavy-industry#:~:text=The%20Advanced%20Industrial%20Facilities%20Deployment,significantly%20slash%20their%20GHG%20pollution.
6. "Pedal to the Metal," Caitlin Swalec and Christine Shearer. Global Energy Monitor. https://globalenergymonitor.org/wp-content/uploads/2021/06/Pedal-to-the-Metal.pdf.
7. Ibid.
8. "Steel Climate Impact." Ali Hasanbeigi. Global Efficiency Intelligence. https://www.globalefficiencyintel.com/steel-climate-impact-international-benchmarking-energy-co2-intensities.
9. Methodology. Global Energy Monitor, Global Steel Plant Tracker. https://globalenergymonitor.org/projects/global-steel-plant-tracker/methodology/.
10. Who Uses GEM's Data. https://globalenergymonitor.org/about/who-uses-gem-data/.

Budget and Justification

This project does not require any funding. If students are interested in the stretch goal of using time series data from Electricity Maps to create a future projection, $250 could be used to purchase additional years of data from Electricity Maps to analyze how emissions intensity has changed over time (since 2018). However, this is not necessary for the primary objectives and other stretch goals.

More information on data sources

GEM Data:

Samples of the data from GEM's Global Steel Plant Tracker is attached to this submission.

For the stretch goals, data from the Global Wind Power Tracker and Global Solar Power Tracker can be downloaded at the links below:

- https://globalenergymonitor.org/projects/global-solar-power-tracker/download-data/
- https://globalenergymonitor.org/projects/global-wind-power-tracker/download-data/

Electricity Maps

The full list of data sources for Electricity Maps can be found on the git-hub repository electricitymaps-contrib: https://github.com/electricitymaps/electricitymaps-contrib/blob/master/DATA_SOURCES.md.

EPA GHGRP

A sample of the data downloadable from the GHGRP data sets web page is attached to this submission.

Bren School of Environmental Science & Management
University of California, Santa Barbara
October 12, 2022

Dear Bren School Capstone Project Committee,

I am pleased to submit this letter of support on behalf of Global Energy Monitor (GEM) for our capstone project proposal for Bren's Masters of Environmental Data Science. This capstone project proposal was created and drafted with masters student Erica Bishop as lead author.

GEM's mission is to provide high quality, accessible, and open source data to support the clean energy and industrial decarbonization movements. GEM tracks energy infrastructure and power projects, as well as coal mines, iron and steel plants, finance equity, and more. **All our data sets are open and free for public and academic use** so providing our data poses absolutely no barrier to this project. As Project Manager for our Global Steel Plant Tracker and Global Blast Furnace Tracker projects, I have immediate access to these data sets and robust knowledge of the data configuration and any limitations. The external datasets to be used in this project are either publicly accessible or accessible for academic uses, meaning no financial commitment for the Bren School or GEM, and that any products of this capstone project can be openly shared as well (no stipulation for a non-disclosure agreement or restriction for publication).

This project **requires no additional funding** for data sources or computational tools. Deliverables for the project may be hosted on GEM's organization website and/or linked to from the Bren website where they will be shared. GEM agrees to allow the Bren School use of our logo and other "publicly available" intellectual property in connection with this capstone project if selected.

Please reach out to me (caitlin.swalec@globalenergymonitor.org) with any additional questions.

Many thanks,

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