Innovation Pathways to Decarbonize Kiln and Furnace Technology

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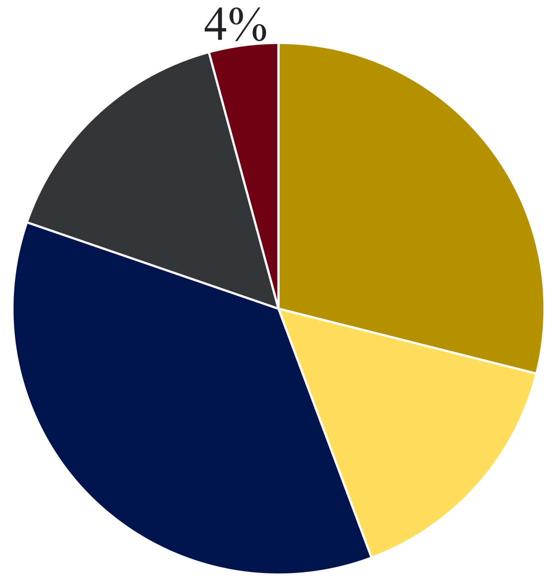
Research Motivation

Industrial Emissions Distribution

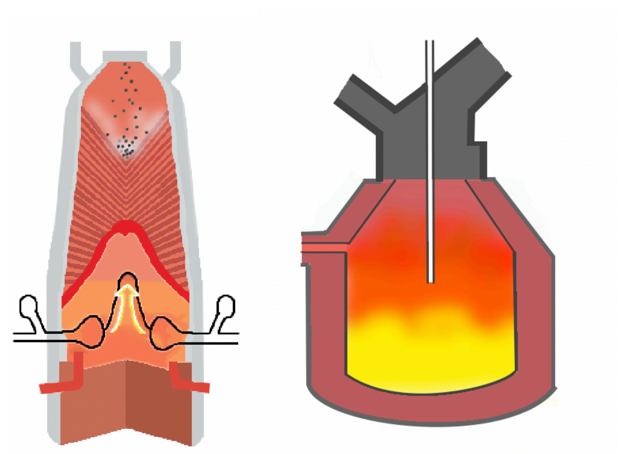


Industrial scale furnaces and kilns are used to heat raw materials to produce lucrative materials such as cement, lime, glass, and iron and steel. Industrial processes such as these make up nearly 22% of all US emissions, of which, cement, lime, glass, and iron and steel are responsible for a third. The CO_2 from these processes stem from raw material chemical reactions as well as the fossil fuel used to provide heat. To ensure demand for these materials can be met while preventing additional emissions, strategic innovation pathways need to be considered.

Background

Iron & Steel: BF/BOF

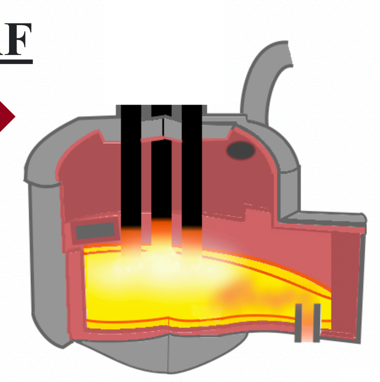
Inputs
- Iron Ore
- Limestone
- Oxygen
- Air
- Coke
- Natural Gas



Outputs
- Steel
- Slag
- CO_2
- H_2O

Iron & Steel: EAF

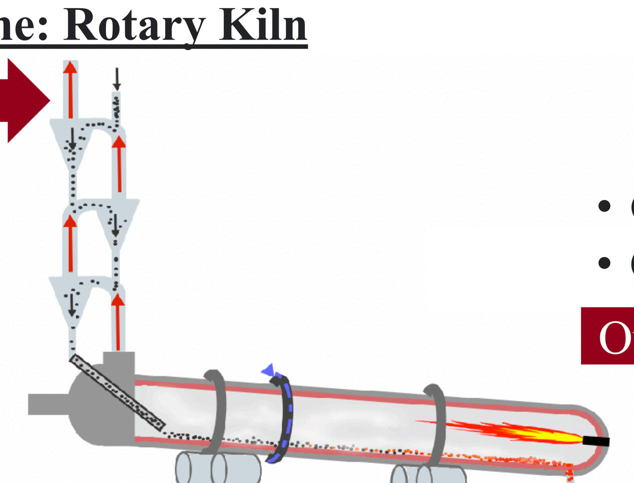
Inputs
- Reduced Iron
- Scrap Steel
- Air
- Electricity



Outputs
- Steel
- Slag
- CO_2
- H_2O

Cement & Lime: Rotary Kiln

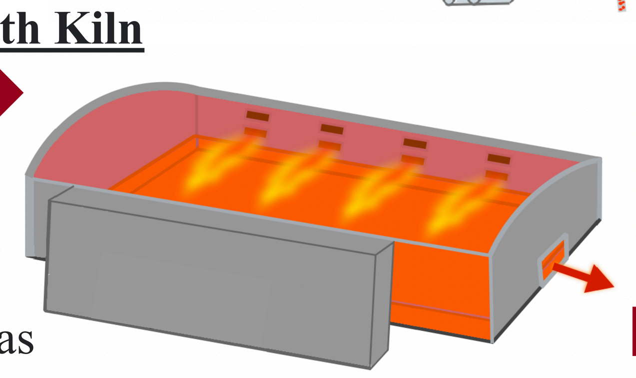
Inputs
- Limestone
- Clay
- Air
- Fossil Fuels



Outputs
- Clinker
- CO_2

Glass: Hearth Kiln

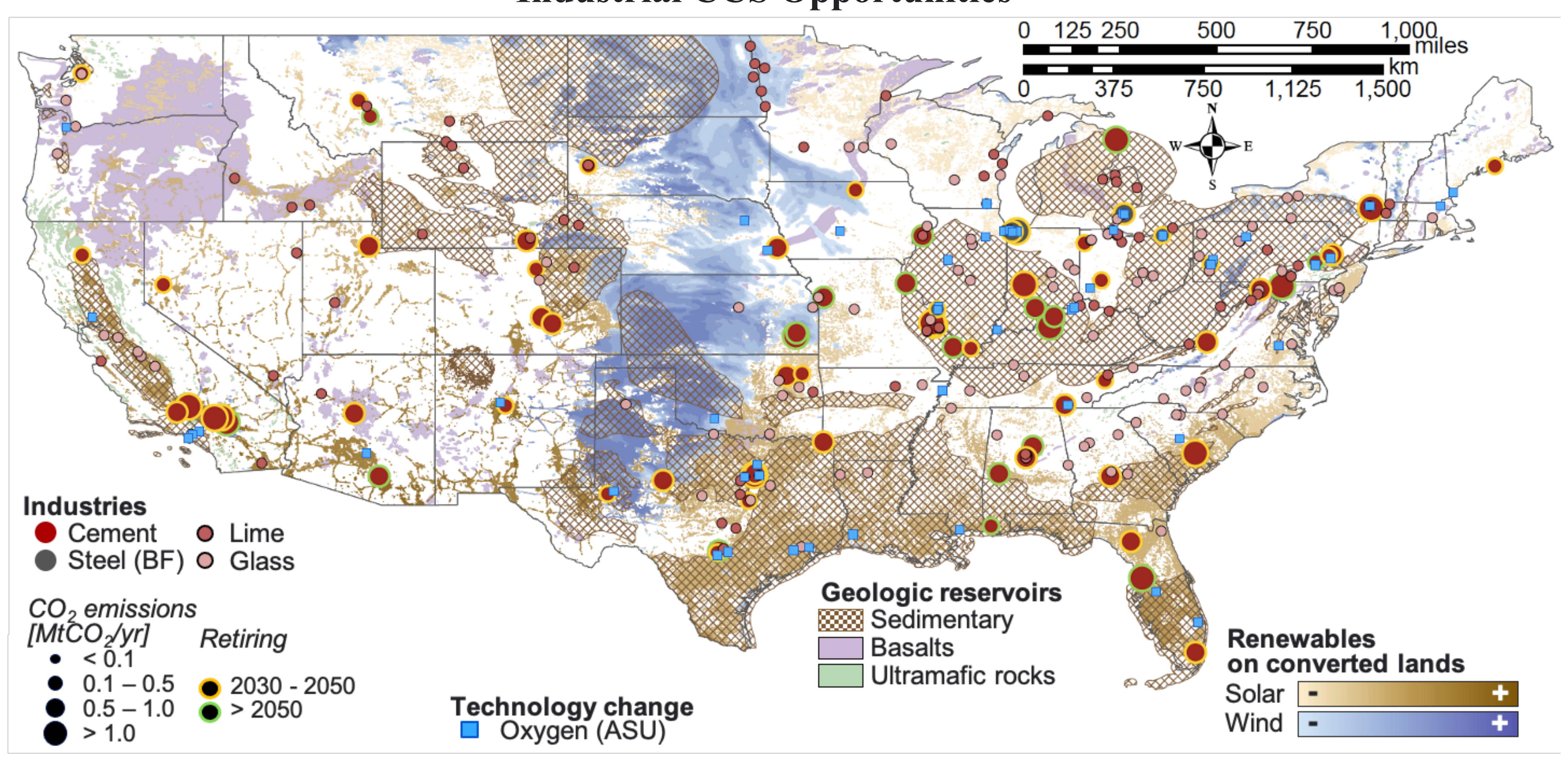
Inputs
- Sand
- Soda Ash
- Oxygen
- Natural Gas



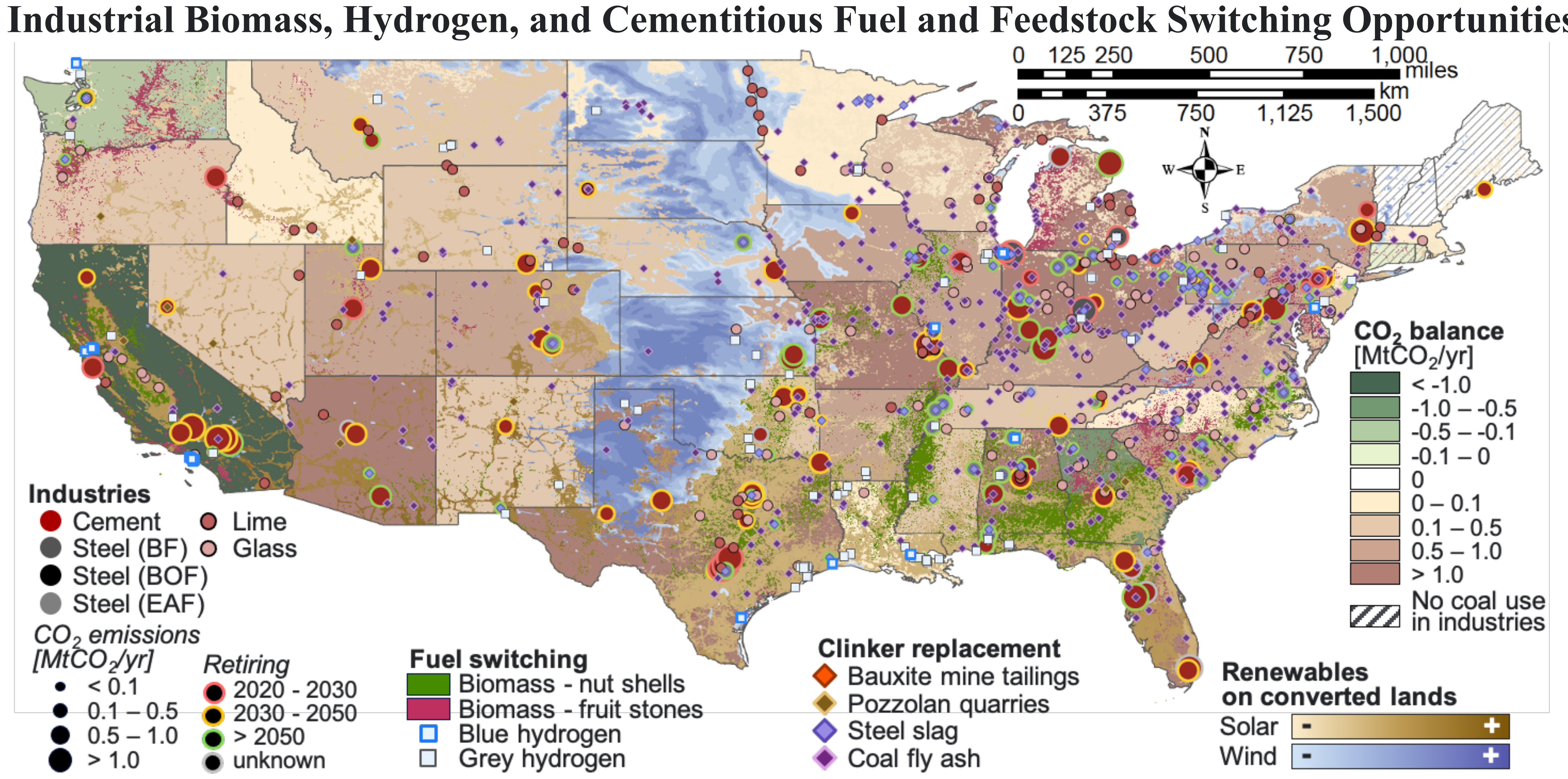
Outputs
- Glass
- CO_2
- H_2O

Co-Location Opportunities

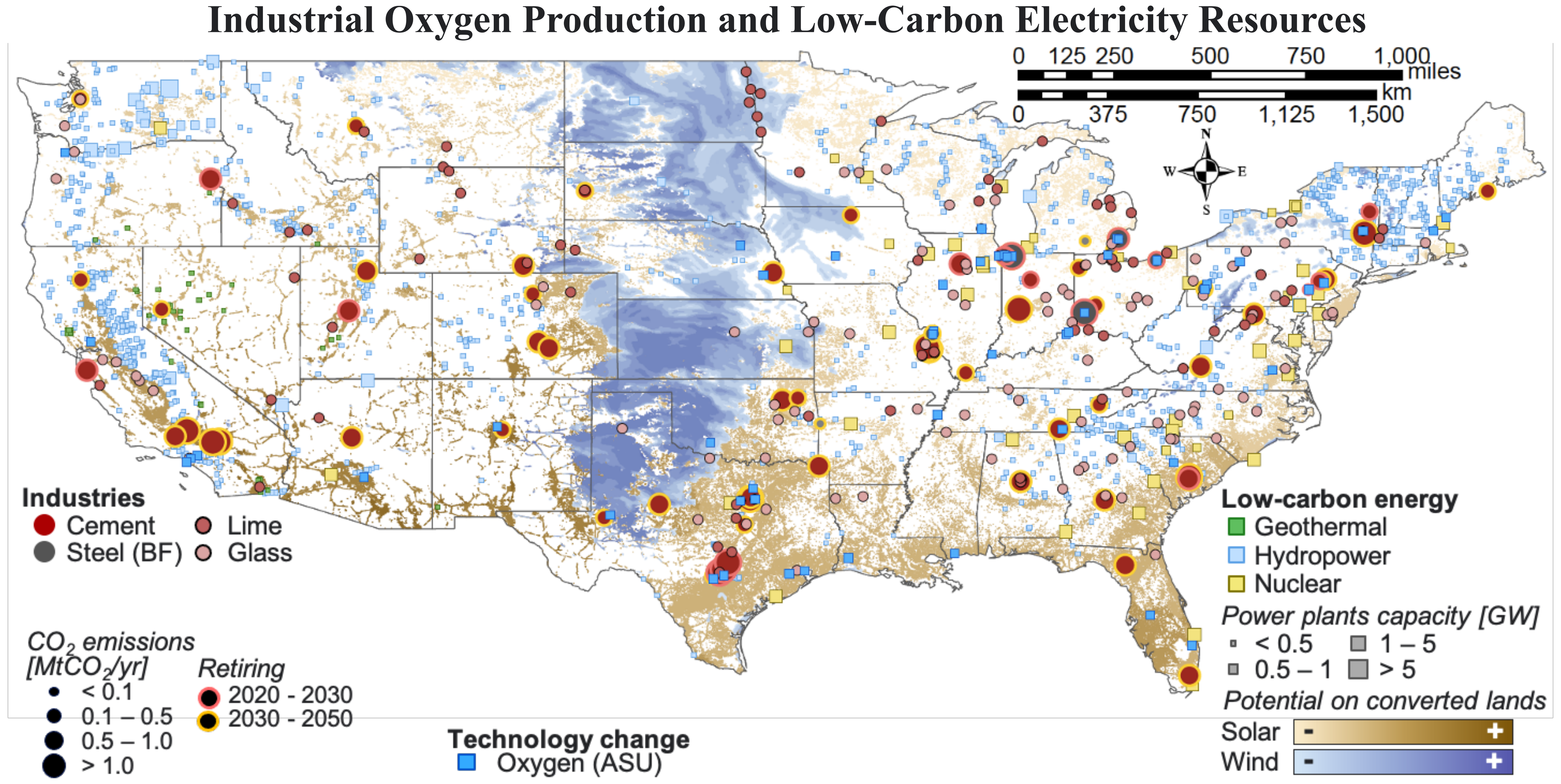
Industrial CCS Opportunities



Industrial Biomass, Hydrogen, and Cementitious Fuel and Feedstock Switching Opportunities



Industrial Oxygen Production and Low-Carbon Electricity Resources



Results

Innovation Pathway	Rotary	Hearth	BF/BOF	EAF
CCS	✚	✚	-	-
Biomass Fuel Switching	✚✚	---	-	N/A
Hydrogen Fuel Switching	---	---	---	N/A
Fluidized Bed	✚	N/A	N/A	N/A
Oxyfuel with CCS	-	✚	✚	N/A
Electric	✚	---	---	✚✚

✚✚ Industrial Scale
✚ Small Scale Research
N/A: Not applicable pathway
- In Development
--- Little Exploration

In addition to the pathways discussed here, other technologies are being investigated to also meet the heating demands of these processes. These include:

- Direct Separation Calcination at Calix
- Steel production through electrolysis at Boston Metal
- Calcination using fuel cell waste heat at Origen Power

Current Projects & Future Work

Current Projects and Implementations:

- Biomass used in US Cement plants today: wood chips, pecan shells, rice hulls, pistachio shells, and peanuts.
- Oxyfuel is at industrial-scale in most of the glass industry
- LefargeHolcim oxyfuel calciner at Retznel Plant (Austria)
- Heidelberg oxyfuel calciner at Colleferro Plant (Italy)
- Al Reyadah Steel plant (Abu Dhabi, UAE)
- Minerals Technologies fluidized bed lime kiln (USA)

Conclusions and Future Work

The more mature technology, such as oxyfuel in the glass industry and CCS, need to deployed soon to avoid increasing atmospheric CO_2 emissions. However, further research and testing of high-grade heating options are needed to validate the use of the emerging technologies in various industries. This research can be facilitated through strategic partnerships between the industrial sector and energy or feedstock producers. These partnerships can then lead to mutually beneficial co-location to further realization of CO_2-reducing pathways. Co-location will lead to a reduction in transportation costs for feedstocks and byproducts, including minerals, oxygen, and CO_2 for storage or utilization.

Resources

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