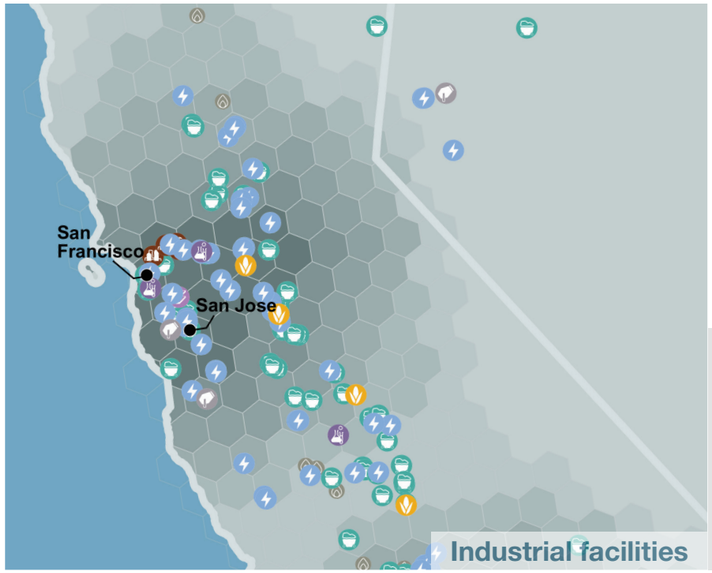
Northern California Hub

The existing landscape of industrial production, commodity transport infrastructure, and geologic carbon storage capacity make Northern California a potential launching point for investment in carbon capture and low-carbon hydrogen deployment.

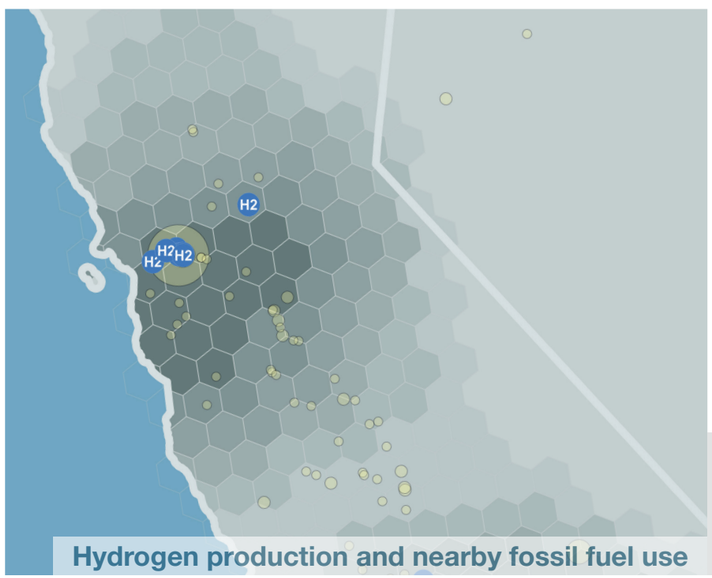
Industrial Emissions and Fossil Fuel Use



Industrial facilities

Northern California is home to a high number and concentration of diverse industries including petroleum refining, natural gas processing, and ethanol production. Facilities in the Northern California hub emit 29.6 million metric tons (Mt) of CO_2e annually, including 9.8 Mt from stationary combustion and 9.6 Mt from process emissions. There are 17 facilities in this regional hub that are eligible for the 45Q tax credit based on their current emissions profile.

- Ammonia
- Cement & lime
- Chemicals
- Coal power
- Ethanol
- Gas power
- Gas processing
- Metals, minerals, & other
- Petrochemicals
- Pulp & paper
- Refineries
- Steel



Hydrogen production and nearby fossil fuel use

There are **eight hydrogen-producing facilities** in the Northern California hub already co-located with the area's central cluster of industrial activity and fossil fuel use. Industrial facilities in this regional hub use a total of 143 million MMBtu of fossil fuels per year.

Hydrogen can be used as a low- or zero-carbon alternative to fossil fuels at industrial facilities. Clusters of hydrogen production and fossil fuel demand can facilitate technology deployment and jumpstart the transition to hydrogen.

- H2 Existing hydrogen production
- Fossil fuel use at industrial facility

Industrial facility emissions

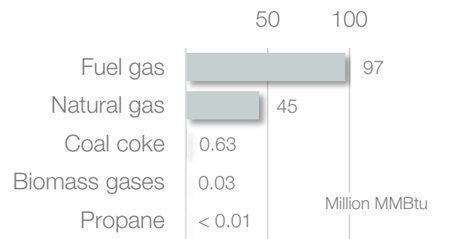
Sector	Total # of Facilities	Total Emissions	Stationary Combustion Emissions	Process Emissions
Cement	1	0.8	< 0.1	0.8
Chemicals	2	0.1	0.1	-
Ethanol	2	0.5	0.1	0.4
Gas power plants	27	11.5	1.3	-
Gas processing	3	1.8	0.0	1.8
Metals, minerals & other	20	1.1	0.9	0.2
Refineries	5	13.8	7.3	6.5
Steel & steel products	2	0.1	0.1	-
Total	**62**	**29.6**	**9.8**	**9.6**

All emissions are in million metric tons CO_2e.

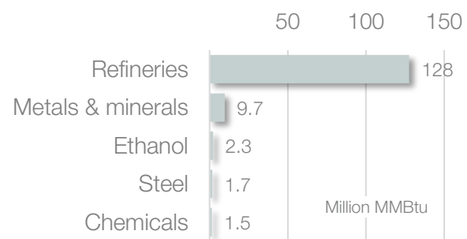
The top industrial fuels consumed in the Northern California hub include fuel gas at 97 million MMBtu per year and natural gas at 45 million MMBtu per year. Refineries are the largest consumers of fossil fuels in this regional hub, consuming 128 million MMBtu per year.

Using hydrogen as a medium- and high-intensity energy source to displace conventional fossil fuels can reduce combustion emissions alongside other solutions like electrification and renewable energy. Process emissions from product manufacture are another major source of GHGs at industrial facilities. These production processes may not involve fuel combustion and would require other solutions such as carbon capture to fully decarbonize.

Top industrial fuels consumed



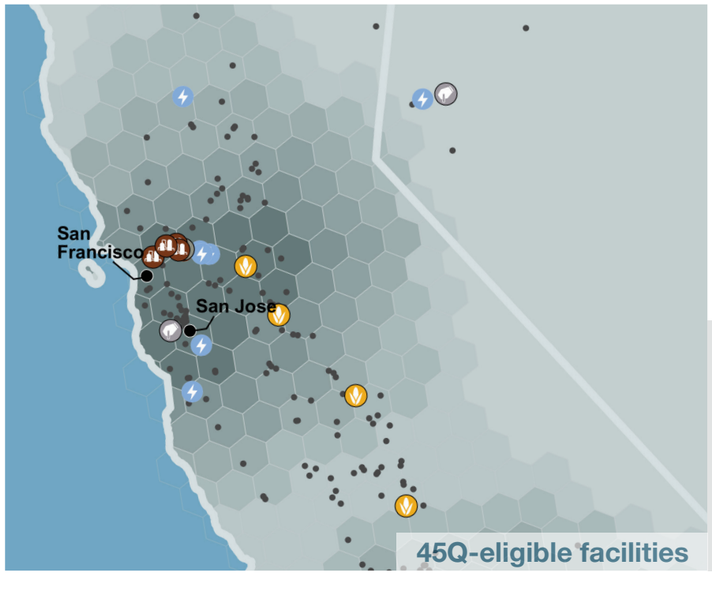
Largest fuel-consuming industries



Northern California Hub

Carbon capture and storage is an essential tool for achieving midcentury climate goals, maintaining the competitiveness of US industry, and protecting and creating high-wage jobs. Carbon capture is crucial in decarbonizing key carbon-intensive industries where CO_2 emissions are inherent to the chemistry of production processes and cannot be eliminated solely by switching to low-carbon electricity. The US has capacity to safely and permanently store thousands of years of carbon emissions in geologic saline formations.

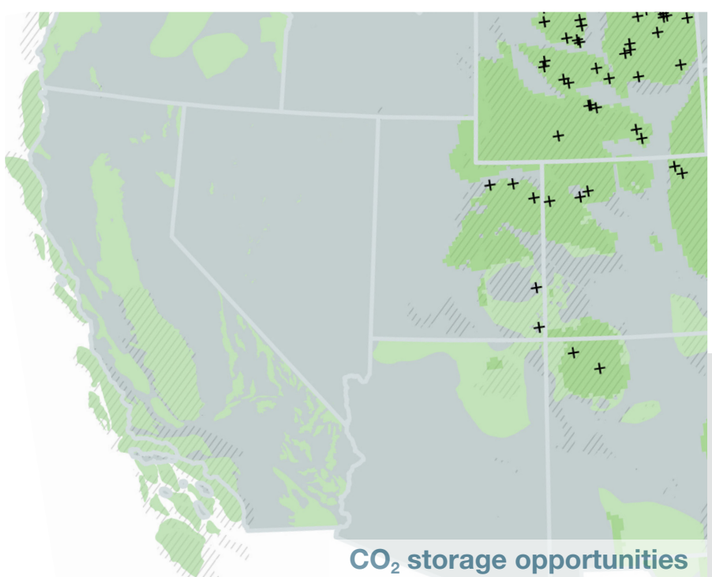
Carbon Capture and Storage



The Section 45Q tax credit lowers cost barriers to carbon capture and storage. Among the 17 industrial and power facilities in the Northern California hub that meet emissions thresholds for Section 45Q eligibility, ten have been identified as near- to medium-term candidates for capture retrofit over the next 10 to 15 years.

45Q-eligible facilities by industry

- Cement & lime
- Ethanol
- Gas power
- Gas processing
- Refineries
- Near- to medium-term
- Additional emitting facility

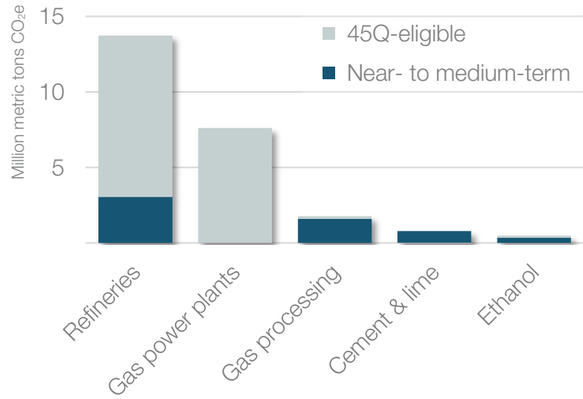


Northern California has potential to act as a carbon storage destination for capture facilities and carbon removal. The state of California has potential to store 148 billion metric tons of CO_2 in secure geologic saline formations, and also has extensive capacity for carbon storage in geologic fossil basins.

Geologic storage opportunity

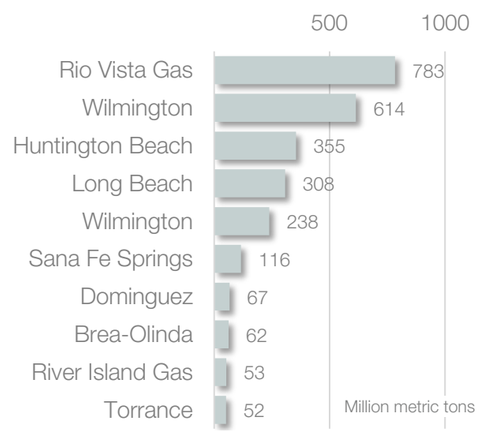
- Assessed low-cost saline storage
- Saline CO_2 storage formation
- Fossil CO_2 storage formation
- \+ Existing petroleum production site

Carbon capture opportunities

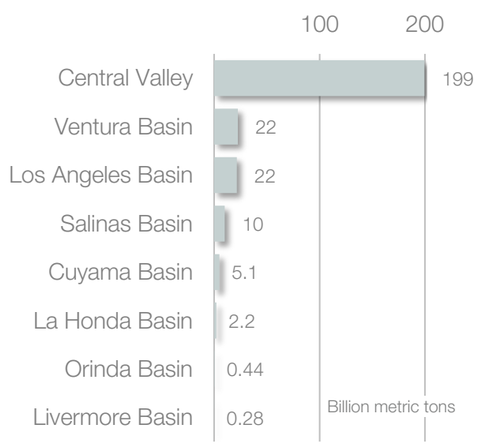


- Industrial and power facilities emit **29.6 Mt CO_2e per year**
- **45Q-eligible** facilities emit **24.5 Mt CO_2e per year**
- **5.8 Mt CO_2 per year** are **capturable** in the **near- to medium-term**

Fossil storage formations
by CO_2 storage capacity



Saline storage formations
by CO_2 storage capacity

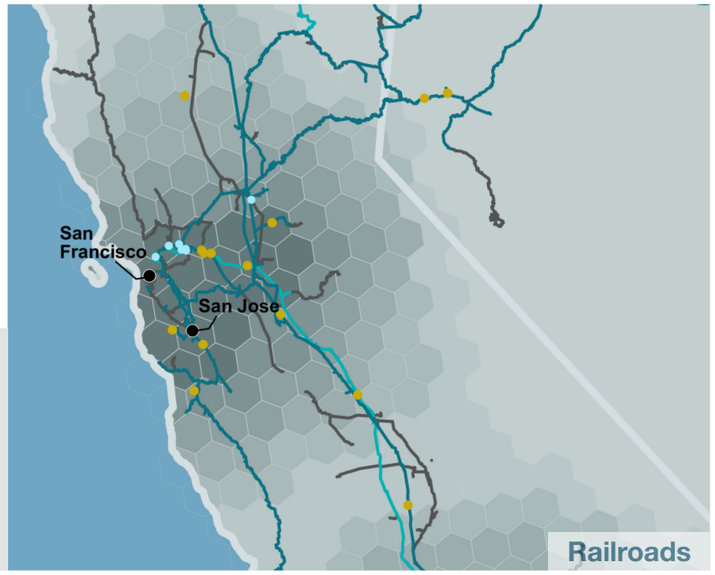


Northern California Hub

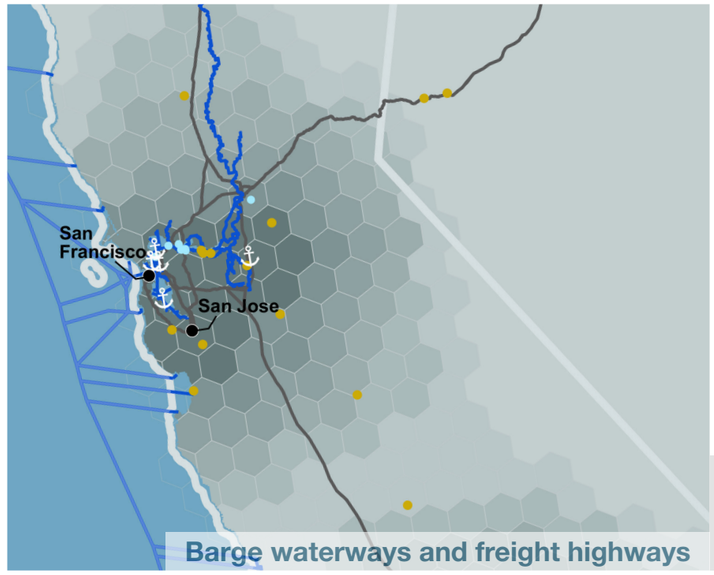
Industrial hubs can offer existing transportation infrastructure, delivery routes, and distribution networks needed for the efficient supply of feedstocks and delivery of products. Hydrogen may be blended into existing natural gas pipelines for co-firing, and both carbon and hydrogen could be transported by rail, freight trucking, or barge. Existing pipeline rights-of-way may be crucial for efficient and equitable routing of new CO_2 pipelines for utilization and permanent storage.

Transport Infrastructure

Many industrial facilities are located along rail lines and often use rail transport to import and export goods. Railroads can also play a role in transporting captured carbon and hydrogen. Many of the facilities in the Northern California hub are located along major rail lines, facilitating connection to markets across the US.



Railroad networks
- Union Pacific Railroad
- BNSF Railway
- CSX Transportation
- Norfolk Southern Railway
- All others

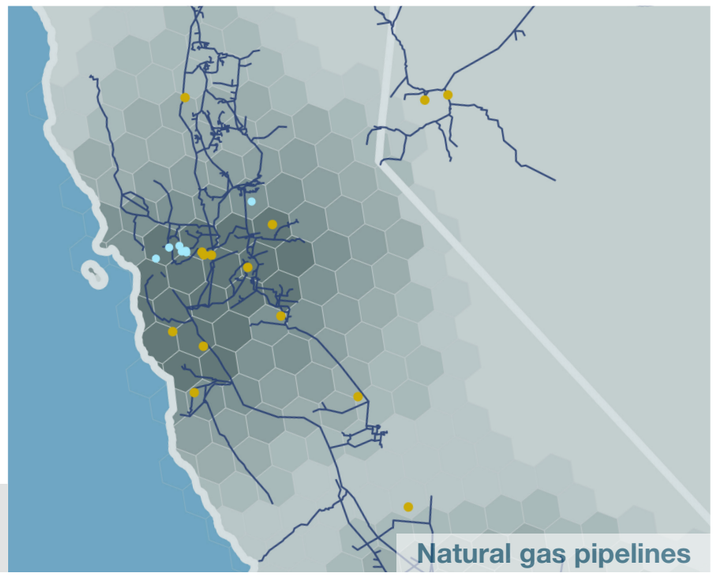


Freight trucks and barges can each play a role in the development of carbon and hydrogen transport networks. Both transport options are flexible, enabling routes to evolve over time and the frequency of transport to adapt in line with the volume of material being transported. With several major ports and extensive access to shipping channels, Northern California has unique access to global and domestic markets for carbon and hydrogen.

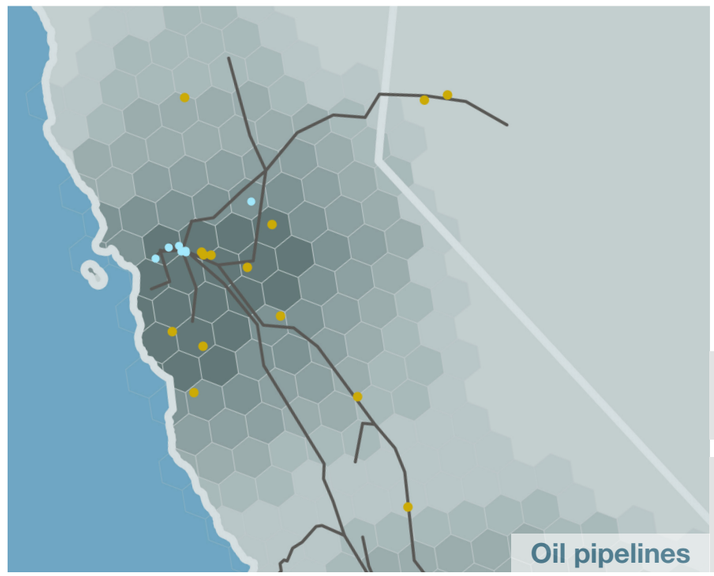
- Interstate highway
- Navigable waterway
- Major port

Logistical challenges to carbon and hydrogen pipeline deployment can be reduced by following existing right-of-way of natural gas lines. The Northern California hub currently has 937 miles of natural gas pipelines.

Infrastructure	Miles
Natural gas pipelines	937
Oil pipelines	906



- Existing CO_2 pipelines
- Natural gas pipelines

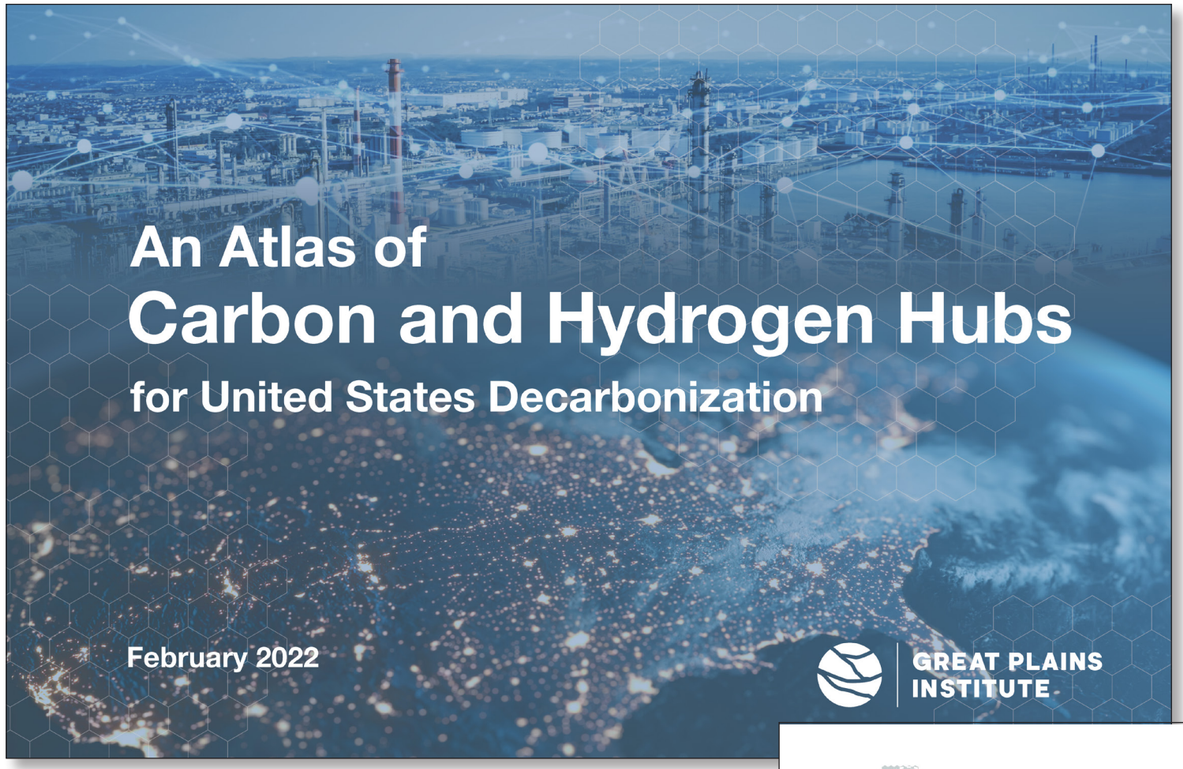


Collocating new CO_2 and hydrogen pipelines along existing pipeline routes can maximize efficiency and reduce surface impacts. New CO_2 and hydrogen pipelines could follow existing right-of-way established along the Northern California hub's 906 miles of oil pipelines to achieve efficient buildout.

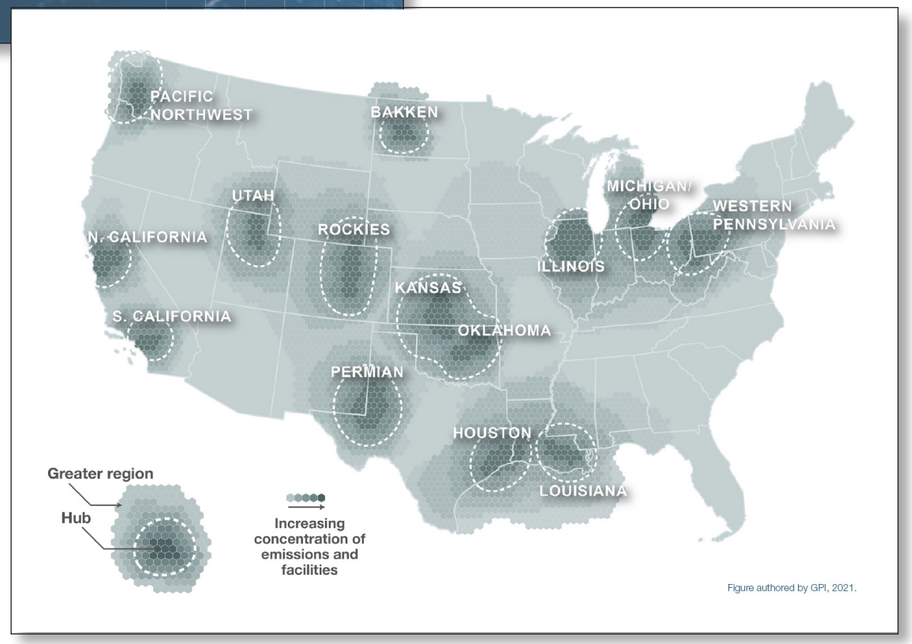
- 45Q-eligible facility
- Existing hydrogen production

- Existing CO_2 pipelines
- Hydrocarbon gas liquids pipelines
- Petroleum pipelines

GPI's Atlas of Carbon and Hydrogen Hubs



Download the report at carboncaptureready.org



About the Great Plains Institute

A nonpartisan, nonprofit organization, the Great Plains Institute (GPI) is transforming the energy system to benefit the economy and environment. Working across the US, we combine a unique consensus-building approach, expert knowledge, research and analysis, and local action to find and implement lasting solutions. Our work strengthens communities and provides greater economic opportunity through creation of higher paying jobs, expansion of the nation's industrial base, and greater domestic energy independence while eliminating carbon emissions.

Learn more: www.betterenergy.org

GREAT PLAINS INSTITUTE

February 1, 2022