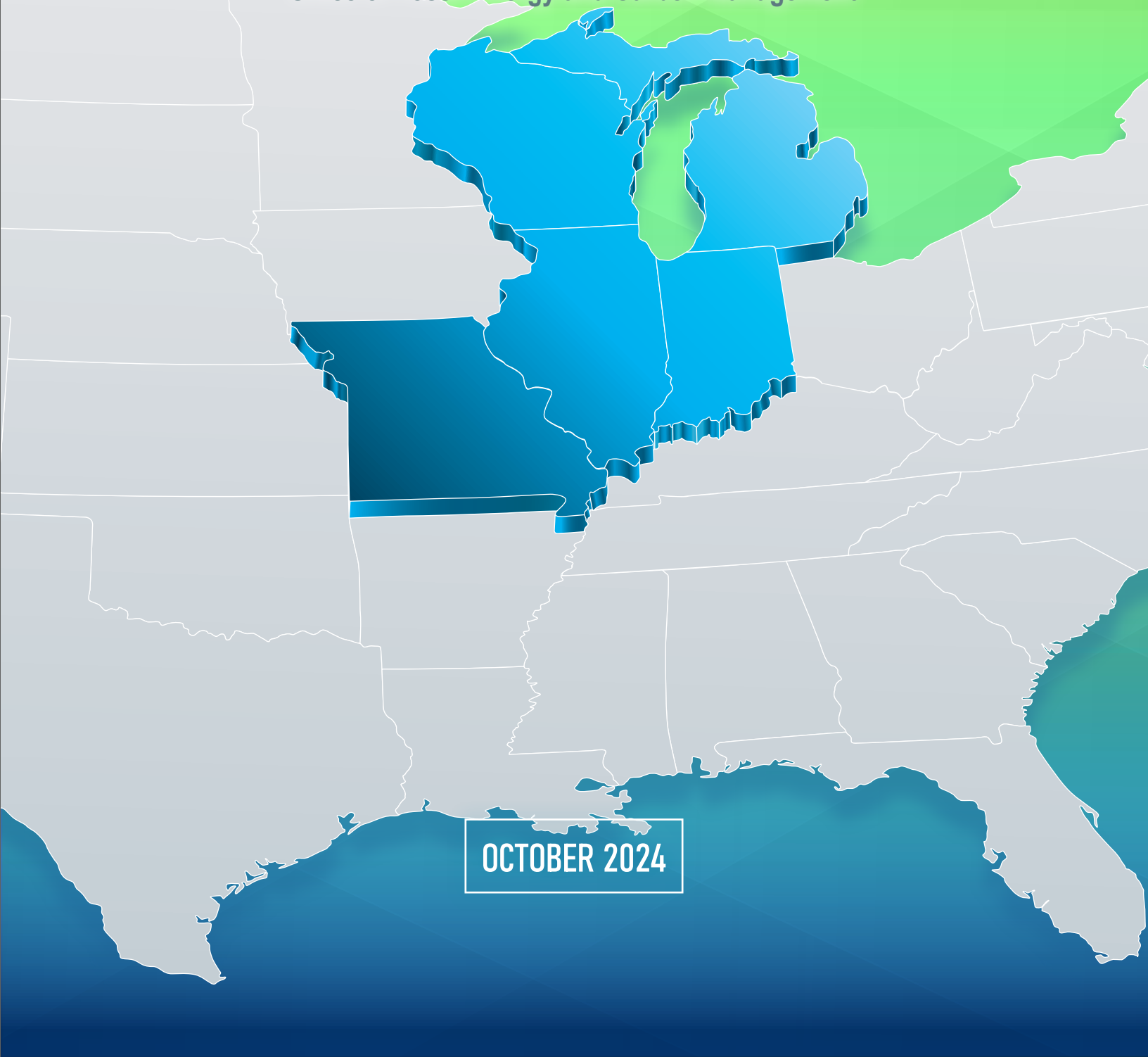
U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management

MIDWEST REGIONAL REPORT

Building A Clean Energy and Industrial Economy and the Supporting Role of the U.S. Department of Energy's Office of Fossil Energy and Carbon Management



OCTOBER 2024

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Purpose of this Report

The "**Midwest Regional Report: Building a Clean Energy Economy and the Supporting Role of the U.S. Department of Energy's Office of Fossil Energy and Carbon Management**" aims to deepen the understanding of the decarbonization opportunities and challenges in the Midwest, supporting broader efforts to achieve a clean energy and industrial future. The Midwest region, as defined in this report, includes **Illinois, Indiana, Michigan, Missouri,** and **Wisconsin**. It draws on the region's extensive manufacturing and transportation landscape to highlight opportunities for the Midwest's development as it relates to the carbon management industry and critical minerals production and processing. Additionally, in addressing the region's unique industry, energy mix, and energy activities, this report identifies priority areas for the Midwest and aligns them with the research, development, and demonstration portfolio of the U.S. Department of Energy's (DOE's) Office of Fossil Energy and Carbon Management (FECM) to curate relevant solutions.

This report was developed by the Office of Fossil Energy and Carbon Management in collaboration with the National Energy and Technology Laboratory (NETL).

This report is being disseminated by the Department of Energy. As such, this document was prepared in compliance with Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) and information quality guidelines issued by the Department of Energy.

Introduction

The U.S. energy portfolio and economy currently depend heavily on fossil energy. It is crucial to advance clean energy and industrial solutions, such as carbon capture and storage, carbon dioxide removal, and other decarbonization pathways, to achieve a net-zero greenhouse gas emissions economy. FECM is dedicated to minimizing the environmental and climate impacts of fossil fuels while working toward a clean energy and industrial future. Its portfolio encompasses the research, development, demonstration, and deployment of technologies that include carbon capture, carbon conversion, carbon dioxide removal, carbon dioxide transport and storage, hydrogen production with carbon management, methane emissions reduction, and critical minerals production.

As part of successfully implementing this portfolio, FECM is engaging with communities and stakeholders across the country where significant project development is expected to occur to ensure community and stakeholder participation, understand and address concerns, and increase awareness regarding FECM funding and opportunities available. FECM focuses on two-way engagement, in which communities and stakeholders are not only informed, but they also have the opportunity provide input and shape the design and development of projects and infrastructure that affect them. This aligns with DOE's broader priority of placing stakeholders and local communities at the center of project development efforts, ensuring that DOE's investments result in tangible benefits for communities.

The Community Benefits Plan framework is one example of a significant initiative that aims to institutionalize this priority. This framework aims to ensure that projects receiving public funding, particularly from the Bipartisan Infrastructure Law and the Inflation Reduction Act, create economic, environmental, and societal benefits for the communities and workers where projects are located. Through close collaboration between developers and communities, Community Benefits Plans can evolve into Community Benefit Agreements, which are legally binding agreements between community groups and developers, stipulating the benefits a developer agrees to fund or furnish in exchange for community support of a project. DOE does not require Community Benefit Agreements but encourages them as an outcome of developing a Community Benefit Plan. Ideally, strong Community Benefit Plans result in formal agreements to create lasting benefits that will continue after DOE's involvement in a project ends.

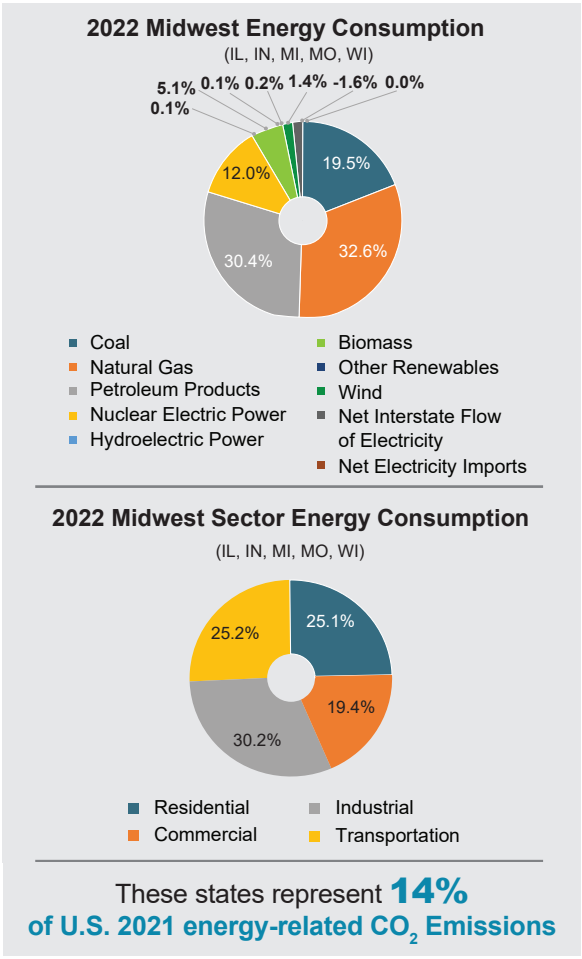
As outlined throughout this report, FECM's focus areas and portfolio of technologies are well-aligned with the Midwest's energy mix, local infrastructure, and resources. These efforts will also help the region engage communities, create new jobs, build new supply chains and industry, and invest in supporting university research and development and innovation. Further, through DOE's Community Benefit Plans and Community Benefit Agreements, FECM illustrates how the design and scope of a project can maximize economic, environmental, and societal benefits for communities in the state, contributing to project success.

The Midwest—Industrial Manufacturing and Transport Center

The Midwest region has a longstanding history as an industrial manufacturing and transportation center. With the convergence of heavy industry, manufacturing, and multiple transportation modes, including road, rail, river, and pipelines, the Midwest has a central role in facilitating the distribution of goods and energy across the United States. The manufacturing landscape in the region is diverse, encompassing equipment, automotive, and food and beverage sectors, as well as energy intensive industries like steel, glass, refining, cement, and pulp and paper. Approximately 70% of U.S. pig iron (i.e., crude iron that is refined to produce steel) production capacity is in the Midwest.

The energy mix in the Midwest is equally multifaceted. Illinois is the fourth largest coal producer, and Indiana is one of the top ten coal producers in the United States. The coal produced in the Midwest is bituminous coal, which has the second highest carbon content (45%-85%) and heating value out of the four types of coal: anthracite (which has the highest carbon content and heating value), bituminous, subbituminous, and lignite. Although not a major producer of oil and gas, the Midwest ships crude to the eight refineries in the region and then petroleum products are distributed across the United States. Illinois also ranks fourth in U.S. crude oil refining capacity. The Midwest region several hosts natural gas pipelines, and Michigan has nearly one-eighth of the U.S. natural gas storage capacity, the largest in the nation. Approximately 25% of U.S. ethanol production capacity is in this region, with Illinois and Indiana ranking as third and sixth in ethanol production capacity. Michigan, Wisconsin, and Missouri also contribute to ethanol production in the region. Nuclear provides more than a quarter of the region's electricity, while coal or gas collectively contribute over 60% to the electricity mix.

Figure 1: Energy in the Midwest Region



83%

Of 2022 energy mix is fossil energy. 19% is nuclear (12%) and renewables (7%). 2% is electricity exports.

30%

Of 2022 energy consumption is industrial from a diversity of industries, including BF/BOF-steel, refining, coal mining, pulp and paper, agriculture, ethanol.

40%

Of 2023 electricity mix was carbon neutral; nuclear (28%) and renewables (12%).

70%

Of the U.S. pig iron producing capacity (crude iron product of the blast furnace refined to produce steel).

4th

In 2022 coal production (Illinois), and Indiana who was 8th. Illinois is also 2nd largest in 2022 *estimated* recoverable coal reserves in the U.S. (15%).

~1.1 tcf

Of underground natural gas storage capacity in Michigan (largest in the U.S.) in 44 natural gas storage fields.

Source: EIA. Energy consumption (also referred to as energy mix) includes fuels consumed and electricity exported (negative net interstate flow). Electricity mix includes electricity generated from fossil, nuclear, and renewable plants. See EIA glossary. Glossary - U.S. Energy Information Administration (EIA)

Approximately 14% of total U.S. 2021 energy related greenhouse gas emissions come from the states in this region with industry as the largest energy consuming sector. As a result, communities in the Midwest that are close to clusters of energy and industrial assets experience exposure to greenhouse gases and harmful criteria air pollutants such as nitrogen dioxide, sulfur dioxide, and particulate matter, including fine inhalable particles.[1] This is further exacerbated in communities close to the transport corridors.

The Midwest has evolved over the last few decades, increasing its share of electricity sourced from natural gas and renewables. The region's manufacturing facilities have also enhanced their energy efficiency and energy productivity, alongside the integration of biofuels into fuel supply chains. Although nuclear and renewables constitute nearly 40% of electricity generation, the energy mix remains predominantly fossil energy based, exceeding 82% due to the region's significant heavy industry and transportation sectors.

[1] Air Pollution Monitoring | Air Quality Planning & Standards | U.S. EPA

The Bipartisan Infrastructure Law and the Inflation Reduction Act established a historic policy framework that, through federal funding, financing, and tax credits, is helping to enable a robust market for clean energy and industrial projects. This framework includes tax credits that support the financing of projects in the carbon management and critical minerals industries, offering significant support to the Midwest's development.

As a part of the Bipartisan Infrastructure Law, DOE will deploy approximately $12 billion in new carbon management funding over five years, including $2.5 billion for six large commercial-scale carbon capture demonstrations and approximately $1.0 billion for large-scale pilot projects under the Office of Clean Energy Demonstrations (OCED); $2.1 billion for CO_2 transportation infrastructure; $2.5 billion for developing large-scale regional geologic storage sites; and $3.5 billion for regional direct air capture hubs. As part of the $2.1 billion in funding for CO_2 transport, FECM is working with the Loan Programs Office (LPO) to offer access to capital for large-capacity, common-carrier CO_2 transport projects (e.g., pipelines, rail, shipping, and other transport methods). Additionally, FECM is offering "Future Growth Grants" as part of the Carbon Dioxide Transportation Infrastructure Finance and Innovation Act (CIFIA) program to extend or enlarge planned carbon transport infrastructure to connect additional CO_2 sources.The Bipartisan Infrastructure Law also allots $8 billion for the Regional Clean Hydrogen Hubs, a program managed by OCED.Of the seven hydrogen hubs selected for funding, at least five have carbon management projects.

Additionally, the federal 45Q tax credit provides up to $85 per metric ton of carbon dioxide (CO_2) captured from industry and power generation for dedicated storage in geologic formations, $60 per metric ton of CO_2 captured and geologically stored through the process of enhanced oil recovery, $60 per metric ton of CO_2 captured and converted into low carbon products or utilized (subject to the life cycle analysis and CO_2 reduction), and up to $180 per metric ton for direct air capture facilities with dedicated storage in geologic formations. Enhancements to the tax credit include: an authorization of the credit for a full ten years (i.e., all projects beginning construction by the end of 2032 are eligible); the ability to claim the credit for 12 years of operation, directly as a cash payment for the first five years of operation, and the option to transfer the credit to outside investors for the remaining seven years; and expanded eligibility for smaller industrial, power generation, and direct air capture facilities.

Since the Bipartisan Infrastructure Law and the Inflation Reduction Act, the number of U.S. carbon management projects announced annually by the private sector has more than doubled since 2019. Of the 219 cumulative projects in the Clean Air Task Force database, 27 (12%) are in the Midwest region.[2] In 2023 alone, over $6.5 billion was invested in carbon management in the U.S., and just over 8% went to the Midwest region.[3] The application queue for Class VI wells is another indicator of activity. Currently, 148 well applications are under review by the EPA across the U.S., and several are located in the Midwest region. Of those in the region, 26 applications are currently under review by EPA in Illinois, Indiana, and Michigan.[4]

There are a variety of other tax credits as well. For critical minerals, the 45X tax credit provides a 10% credit for the production of 50 different minerals that are essential to our clean energy economy and national security. For clean hydrogen, the 45V tax credit creates a new 10-year incentive for clean hydrogen production of up to $3.00/kilogram. The level of the 45V credit provided is based on carbon intensity (i.e., the lower the carbon intensity, the higher the credit), with a maximum of four kilograms of CO_2-equivalent per kilogram of hydrogen eligible for the tax credit.

[2] CRES illustration with data from IEA, https://www.iea.org/data-and-statistics/data-product/ccus-projectsdatabase. Used in GPI presentation at 2024 NETL Annual Review meeting; U.S. Carbon Capture Project Map – Clean Air Task Force (catf.us) August 28, 2024

[3] https://www.cleaninvestmentmonitor.org/database as of August 28th, 2024

[4] U.S. EPA Class VI Permit Tracker as of September 13, 2024. (Current Class VI Projects under Review at EPA | US EPA)

Industry

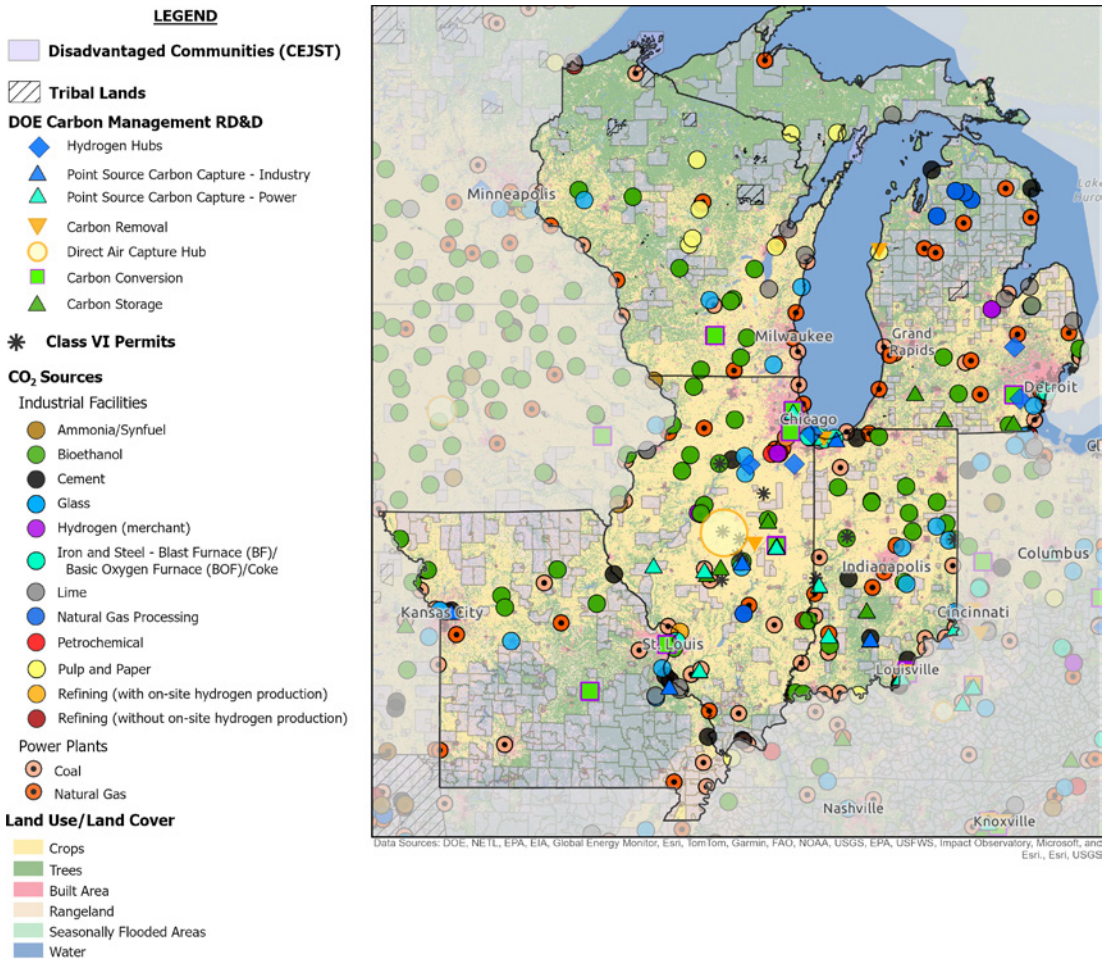
Carbon management is essential for supporting industry decarbonization as the region transitions its manufacturing sector to thrive in a low carbon economy.

Carbon management presents an opportunity for Midwestern companies involved in the manufacture and distribution of products to reduce emissions and develop new low carbon products. The Midwest has leveraged its abundant resources, including the Great Lakes, agriculture and forestry resources, and its expansive river, road, and rail network, to become a U.S. manufacturing and distribution center. Map 1 illustrates the concentration of heavy industries in the Midwest, such as steel, glass, refining, bioethanol, cement, lime, and pulp and paper.

Large regional projects, such as the Midwest Alliance for Clean Hydrogen (MachH2) hub, selected by the DOE's Office of Clean Energy Demonstrations (OCED) for the DOE Regional Clean Hydrogen Hub Program, which aims to produce clean hydrogen from natural gas, and the potential future regional direct air capture hubs (for which funding has been allocated for three feasibility studies), will create an ecosystem of regional CO_2 transport and storage. This ecosystem will integrate carbon capture across industries and power generation sectors. For local emitters, shared CO_2 transport and storage infrastructure could reduce costs and accelerate project deployment and emissions reductions. A recent paper from Princeton University found that when CO_2 pipelines are shared rather than dedicated to individual capture facilities, average transport costs could be reduced by two-thirds. These regional projects will create additional pathways for existing infrastructure to decarbonize in the near-term.

Map 1: Industrial Activity in Midwest

The Midwest's significant concentration of industrial facilities offers the potential for developing shared carbon management infrastructure and supply of CO_2 feedstock. This creates the opportunity to produce low carbon fuels and chemicals as this region transitions its manufacturing to succeed in a low carbon economy.



Source: National Energy and Technology Lab (NETL) Research & Innovation Center (RIC). Developed using publicly available data sources (EPA, USGS, etc.).

Carbon capture will be important for industrial processes with high temperatures that cannot be electrified or decarbonized more economically through other carbon-free methods. Many industrial plants, including integrated steel mills, have decades of useful life remaining, and it would not be economically feasible nor socially beneficial to retire them early. Carbon capture can be applied to a wide variety of industries in the region, including ethanol, steel, pulp and paper, glass, and cement. For example, ethanol production generates a nearly pure stream of CO_2 with very low capture costs. With the large number of facilities in the region, the industry presents a particular opportunity for early deployment, given that many carbon capture projects at ethanol plants can currently be financed on the basis of the 45Q tax credit alone. DOE has already funded a preliminary front-end engineering and design study for a carbon capture project at a steel plant in Indiana, two front-end engineering design studies for carbon capture for cement emissions projects in Indiana and Missouri, and a small carbon capture pilot project at a cement plant in Missouri. The Mitchell Cement plant in Indiana

that received the FECM funding for the front-end engineering design funding for carbon capture has also been selected for OCED's Industrial Demonstration Program and is a great example of moving from front-end engineering design to demonstration. Business models on shared capture solutions are being considered which could be attractive for this region given the high concentration and proximity of emitters. The Princeton University paper also analyzed how pooling emissions streams from facilities with different concentrations of carbon dioxide to a central capture site could significantly reduce capture costs.

The conversion of captured CO_2 and carbon monoxide emissions into fuels and products, and carbon capture with biomass conversion, are also opportunities in the Midwest. Refineries and other facilities in the region can be upgraded to both reduce process emissions and produce low carbon fuels and products using new technologies, CO_2, and biomass feedstocks. Such retrofits and a shift to low-carbon feedstocks can also reduce environmental pollutants resulting from refinery activities. The OCED selected Midwest Alliance for Clean Hydrogen (MachH2) hub planned across Illinois, Indiana, and Michigan could expand access to clean hydrogen in this region and provide a key input for developing clean products and fuels. Given the forestry resources in the Midwest (more than 26% of U.S. forestry waste[5]), carbon management can also be applied to pulp and paper, wood waste, and wood products that may not be suitable for other uses, such as wood waste resulting from emerald ash borer damage.[6] For example, ethanol, wood waste and wood products can be feedstocks for emerging sustainable aviation fuel technologies. FECM provided funding to Wabash Valley Resources for a demonstration project in Indiana involving a gasification plant that is gasifying bio-oil and pairing it with carbon capture and storage. Wabash Valley Resources - has now received a conditional commitment from LPO for loan guarantee of up to $1.559 billion. The loan guarantee would help finance a commercial-scale waste-to-ammonia production facility using carbon capture and sequestration (CCS) technology. The project will have the potential to be the world's first, carbon-negative ammonia production facility.

DOE is also investing in bold industrial decarbonization technologies at each stage of the innovation pipeline to help manufacturers and businesses use clean energy, increase efficiency, and integrate new, innovative processes and technologies. These technologies will support the Midwest in decarbonizing its region while also protecting and creating high-wage industry jobs. This will enable industry to establish additional pathways to decarbonize existing infrastructure in the near-term.

To realize the full potential of these opportunities in the Midwest, engagement with communities and other impacted stakeholders will be critical. Two-way engagement focused on how project design and scope can maximize economic, environmental, and societal benefits for host communities can help with project success. For example, carbon capture technologies can also reduce pollution beyond CO_2 emissions, as they often require co-pollutants, such as sulfur oxides and nitrogen oxides, to be removed from the flue gas prior to capturing the CO_2. DOE recognizes the risk of amine degradation[7] in solvents and is developing monitoring approaches to stay ahead of the risks, as well as investing in a broad suite of additional capture technologies such as solid sorbents, membranes, and cryogenic separation that do not rely on amines. The potential of capture technologies to also reduce co-pollutants

[5] Twin Cities Metro Area Emerald Ash Borer Wood Waste Study, December 2022. https://recyclingandenergy.org/partnership-reports/

[6] Amines are used in some carbon capture solvents and can undergo oxidative or thermal degradation. This leads to solvent loss and the formation of degradation by-products that, if not managed at the facility, could be released into the environment.

[7] BETO: Billion-Ton 2023 | Department of Energy; near-term, $70 per dry ton, all forestry waste (hardwood, mixed wood, softwood)

is of particular importance to energy and industry-adjacent communities that have experienced significant environmental and health burdens due to their long-term exposure to these non-greenhouse gas emissions, and project developers should be transparent in sharing air monitoring data with communities.

Developers should also consider, in consultation with communities, how to support local economic development, through jobs, reskilling opportunities, and other means. For example, the OCED selected Midwest Alliance for Clean Hydrogen (MachH2) hub anticipates creating approximately 13,600 direct jobs. Designing projects that consider the needs and input of host communities will support the deployment pace and scale needed for climate impact and ensure the region continues to prosper as a manufacturing and transportation center.

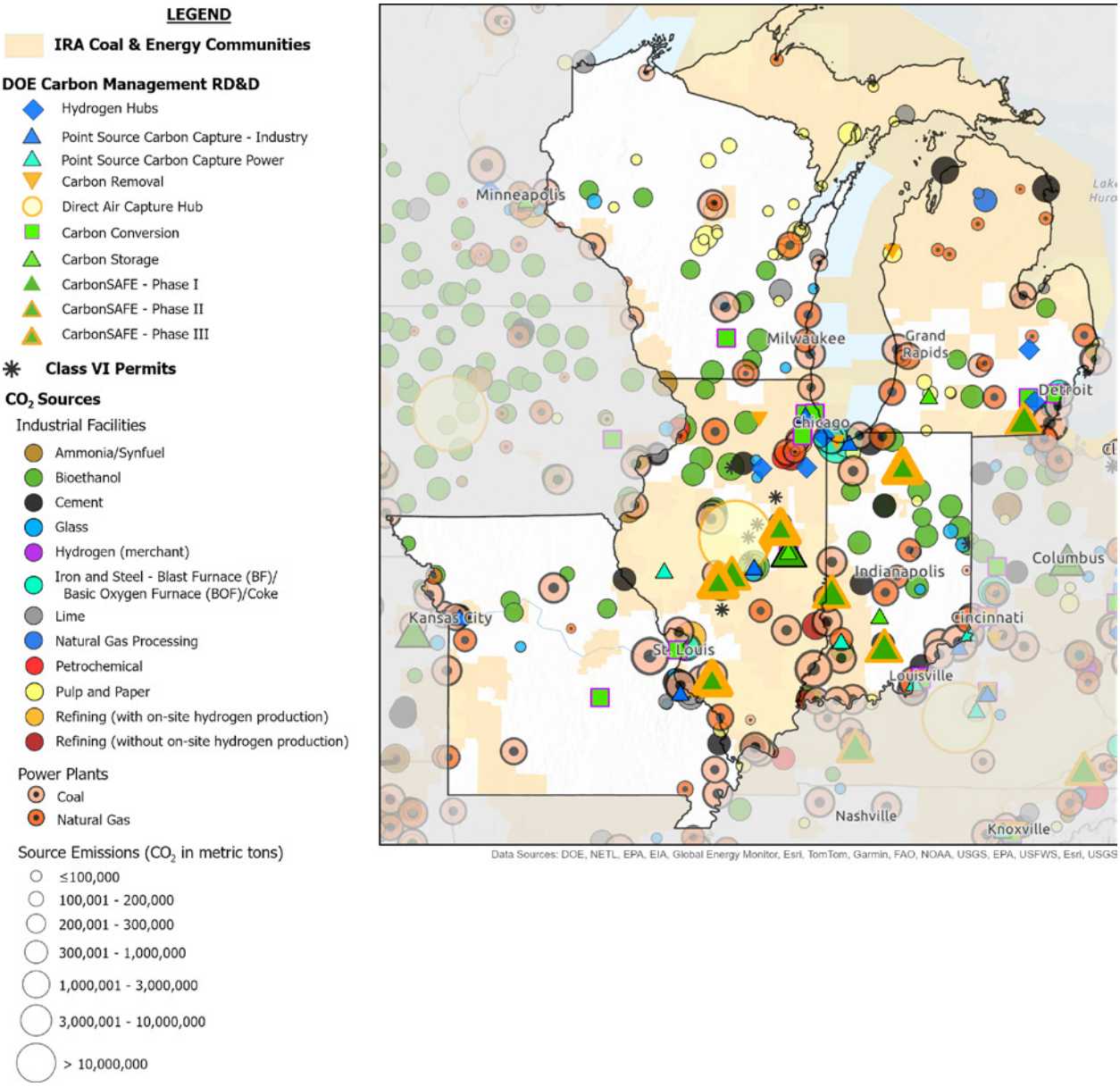
Energy and Resources

The proximity of geologic storage capacity to CO_2 emitters, a skilled industrial workforce, and fiscal incentives, results in competitive dollar per metric ton of CO_2 abated for industry.

The Midwest has significant geologic storage potential, particularly in Illinois, Indiana, and Michigan. As illustrated on Map 2, the region's robust saline formations offer the potential to store billions of metric tons of CO_2 from power plants and industrial facilities, as well as CO_2 removed from the atmosphere via direct air capture. In Illinois in particular, DOE has been supporting the development of storage opportunities in the Illinois basins. There are six different DOE-funded Carbon Storage Assurance Facility Enterprise (CarbonSAFE) projects exploring storage opportunities. This includes more than $50 million for the Illinois Storage Corridor project that will enable multi-industry storage corridors through the development of a storage hub near the One Earth Energy facility in north-central Illinois and at the Prairie State Generating Company site in south-central Illinois. The combined annual CO_2 injection by these facilities could ultimately exceed 12 million metric tons per year.

Map 2: Energy Infrastructure and Resources in the Midwest

Abundant CO_2 storage resources close to industrial and power sector emitters, a skilled industrial workforce, and financial incentives, make this an attractive region for storing CO_2 emissions from industry .



Source: National Energy and Technology Lab (NETL) Research & Innovation Center (RIC). Developed using publicly available data sources (EPA, USGS, etc.).

In addition to the CarbonSAFE projects in Illinois, the Midwest Alliance for Clean Hydrogen (MachH2) hub will produce clean hydrogen from natural gas with carbon capture in Indiana and store the CO_2 in Indiana's saline aquifers. Indiana signed legislation in 2022 (House Enrolled Act 1209) that set up a permitting program to allow companies to capture emissions and store them underground. In addition to the financial support DOE

will provide the Midwest Alliance for Clean Hydrogen (MachH2) hub, there are multiple incentives to take advantage of these storage opportunities.

Scaling carbon management in the Midwest requires broad local support, and the benefits of project development need to equitably flow to local communities, landowners, and other stakeholders. As shown on Map 2, there are a significant number of communities that could be impacted by the closure of coal mines and coal power plants in this industrial region, communities are familiar with energy projects and are likely to be supportive to responsible investment that will support the future of industry and bring development and jobs to the region.

Developers whose projects proceed either with or without federal funding can refer to FECM's "Responsible Carbon Management Initiative" as a guide for how to pursue the highest levels of safety, environmental stewardship, transparency, and community engagement and benefits in project development.

Additionally, in December 2022, DOE announced more than $20 million in funding for projects that will provide stakeholders with crucial resources and information necessary to facilitate the regional deployment of large-scale geologic storage facilities or carbon management hubs. The national network of CarbonSAFE projects is on track for targeted commercial injectivity at the 100 million metric tons per year scale and to identify total contingent storage resources[8] of six billion metric tons by 2035. Projects will support public engagement and dialogue activities, including providing technical assistance and resources to communities.

There is a significant opportunity to expand the skillsets and career opportunities of industrial workers in the region. A workforce development and training plan will be needed to transition the workforce to new technologies. According to Rhodium Group and Great Plains Institutes, the carbon capture and storage industry has the potential to create 23,910 annual jobs across Illinois, Indiana, Michigan, and Missouri (data is not available for Wisconsin). When clean hydrogen and related supply chains are considered, this number will be even more significant.

[8] Contingent storage resources are storage resources estimated to be accessible in known geologic formations, but the applied project(s) are not yet considered mature enough for commercial development, as a result of one or more contingencies. srms_sep2022_w_errata.pdf (spe.org)

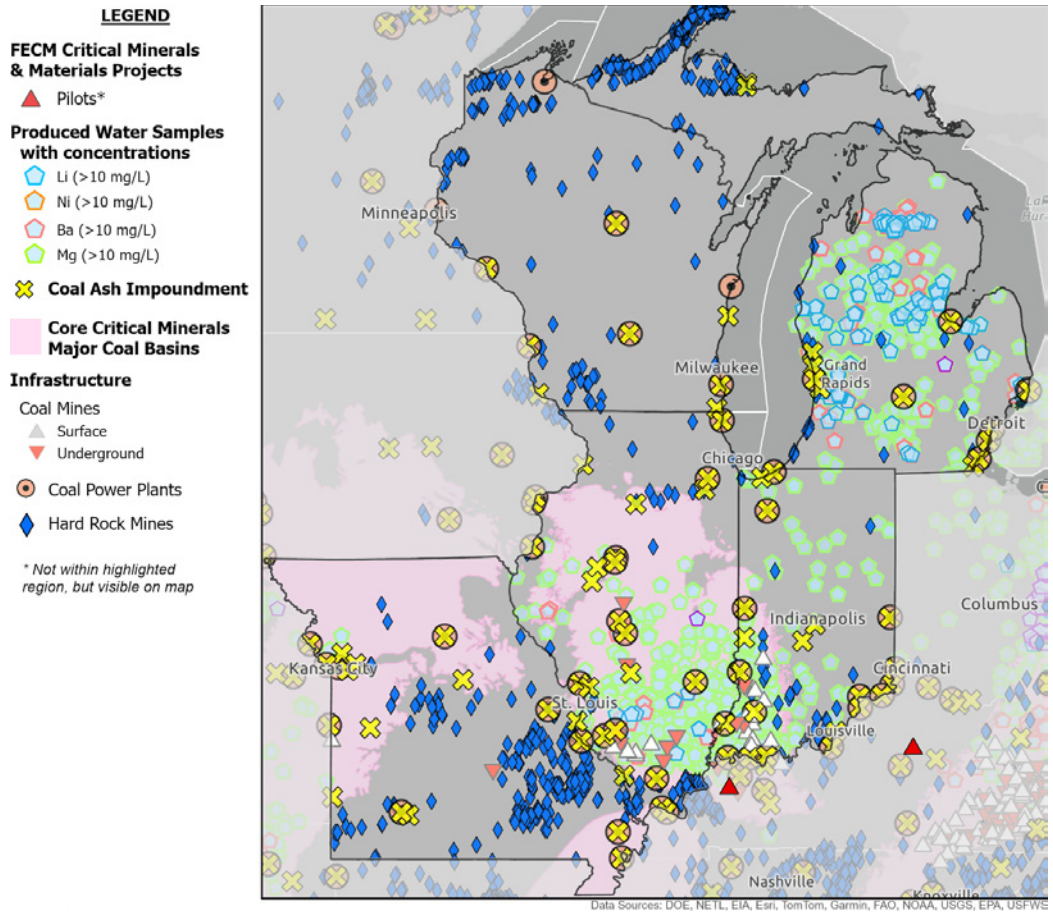
Recovery of Critical Minerals

Coal, coal byproducts, coal mining and other mining waste streams, and hard rock mines in the Midwest are rich in the critical minerals needed for clean energy technologies.

The Midwest is well positioned to have a key role in developing a domestic supply of critical minerals and rare earth elements, which are key to manufacturing clean energy technologies—such as solar panels, wind turbines, electric vehicles, and hydrogen fuel cells—that will help the United States achieve a net-zero emissions economy. They are also essential to the manufacture of technologies and products vital to national security. Demand for critical minerals and rare earth elements is growing, and the United States currently imports over 80% of its rare earth elements from non-domestic suppliers.

Map 3: Critical Elements and Rare Earth Elements Potential

The Midwest has an opportunity to produce rare earth elements and critical minerals from mined coal, coal byproducts, coal and other mining waste streams, and produced water while remediating land and water.



Source: National Energy and Technology Lab (NETL) Research & Innovation Center (RIC). Developed using publicly available data sources (EPA, USGS, etc.).

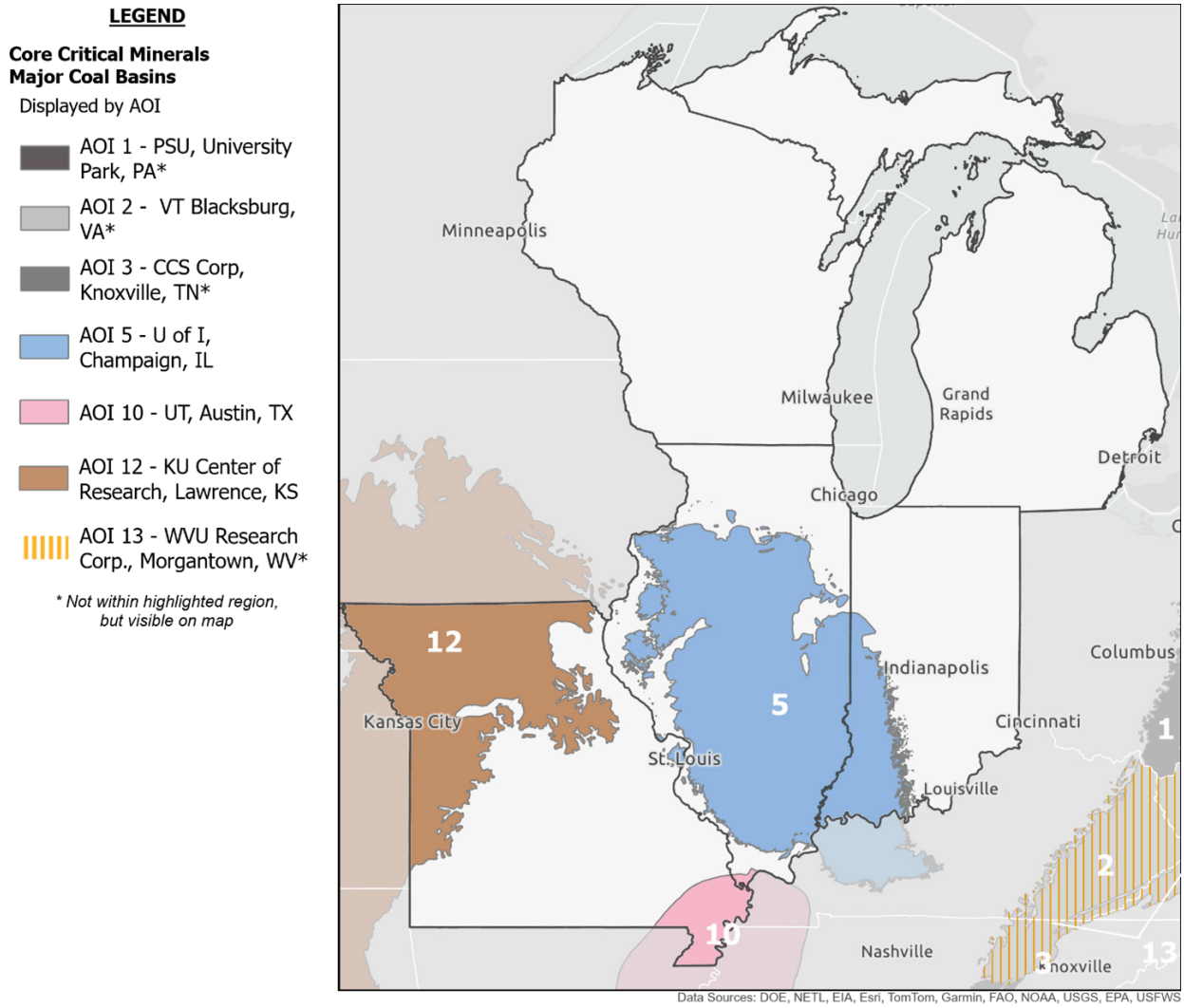
FECM and DOE's National Energy Technology Laboratory have been developing technologies to produce rare earth elements and critical minerals from unconventional feedstocks while remediating land and water from energy and mining byproducts and wastes (e.g., coal, coal ash, acid mine drainage, and produced water) for the past decade. In February 2024, the University of Illinois was selected to support the development of front-end engineering and design studies for potential future intermediate and/or demonstration-scale facilities for the extraction, separation, and production of rare earth elements and other critical minerals and materials from unconventional sources.

FECM's Carbon Ore Rare Earth and Critical Minerals (CORE-CM) Initiative brings together coalitions of universities, industry, state agencies, and others to provide assessments of these feedstocks in coal basins across the country (refer to Map 4). Two different coalitions are working in the Midwest to evaluate the potential for coal, coal wastes, and other secondary and unconventional resources in the region to support domestic supply chains for electric vehicles, wind turbines, valuable carbon products, and other clean energy, defense, and high-tech technologies used in our everyday lives. Initial estimates suggest that unconventional and secondary sources could provide significant amounts of the rare earth elements and other critical minerals needed to reach the nation's clean energy goals. Nationwide, our nation's coal reserves and wastes and byproducts from energy, mining and other industries are estimated to contain more than ten million tons of rare earth elements, which is equivalent to more than a 300-year supply at the current rate of U.S. consumption.

Additionally, recovery of critical minerals and rare earth elements in the Midwest is being addressed through recent awards in FECM's University Training and Research Program. Michigan Technological University was selected to receive an award to investigate the environmental, community, and technical feasibility of recovering aluminum from a landfill mining operation, incorporating a multidisciplinary team of engineers and social scientists to determine whether site selection is key to operational feasibility. The Washington University in Saint Louis was selected to receive an award in which researchers and students will systematically characterize coal-based materials, develop new technology to extract, recover, and enrich rare earth elements, and create a model to predict the performance of the recovery process.

Map 4: CORE-CM Coalitions in the Midwest Region

The Areas of Interest (AOI) assess the regional opportunity for critical minerals as part of the CORE-CM initiative, and there are two AOIs working in the Midwest.



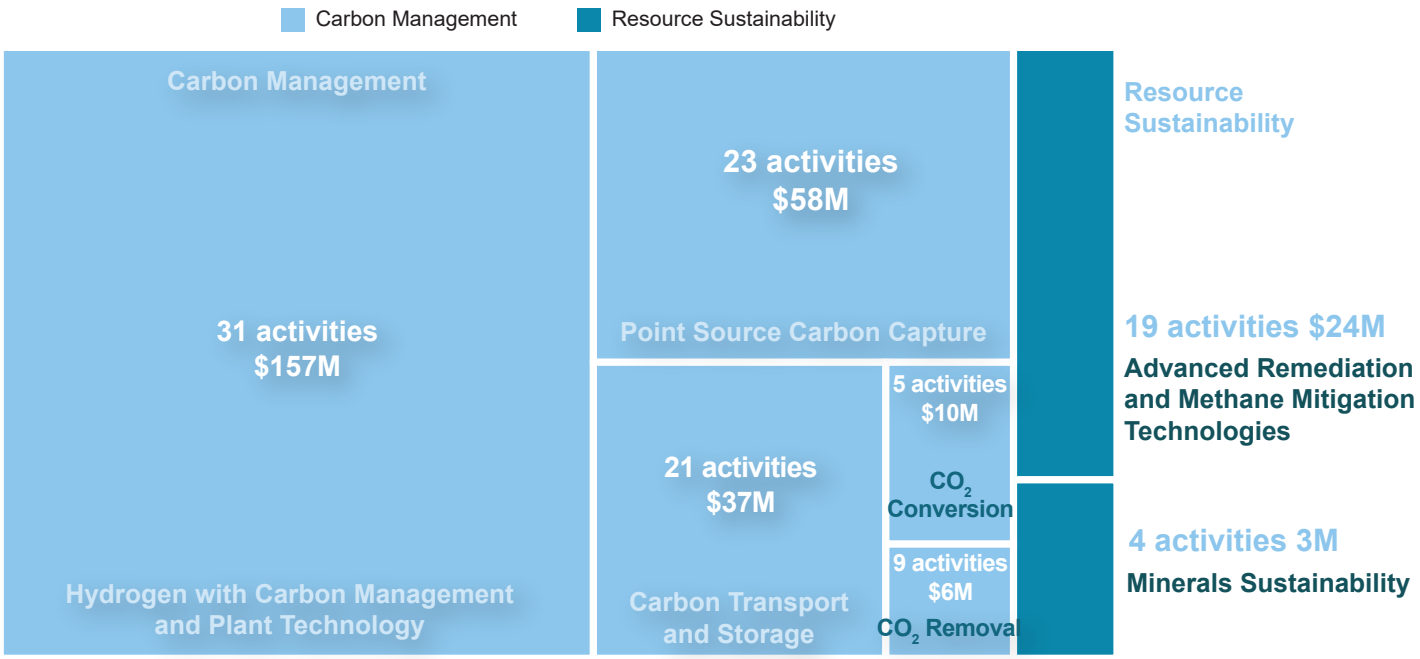
Source: National Energy and Technology Lab (NETL) Research & Innovation Center (RIC). Developed using publicly available data sources (EPA, USGS, etc.)

This is an opportunity to bring a new industry of critical mineral recovery, processing, and refining to the Midwest, find a new use for coal wastes and other energy and mining waste streams that would otherwise be discarded, and help remediate those portions of the region where legacy ash and mine waste remains an environmental problem.

Spotlight on Investment and Support in the Midwest Region

FECM's Midwest portfolio is instrumental in advancing technologies and protocols for carbon management and resource sustainability programs. As of May 2024, the region hosts 112 project activities valued at approximately $295 million. The individual state shares include the following: Illinois (62 projects, $194 million), Indiana (15 projects, $58 million), Michigan (21 projects, $13 million), Missouri (9 projects, $14 million), and Wisconsin (5 projects, $16 million). Industry leads or supports 55 of these project-related activities. 49 are led by academia and 8 are led by government entities. These projects not only boost innovation, but also lead to high-quality and long-term jobs, positioning the region as a hub for sustainable economic growth. The investment is detailed in Figure 2.

Figure 2: Distribution of Investment across FECM Program Areas
(includes value of awards to companies and organizations based in the region, both prime and sub-contracted)



FECM and NETL database

The Midwest, with its rich history of diverse collaboration and pioneering research initiatives, has established itself as a focal point of regional excellence in the fields of energy technology and carbon management.

Selected projects shown in Figure 3 represent many opportunities discussed in this paper, including:

- Carbon capture of steel and cement emissions,
- Gasifying bio-oil and pairing it with carbon capture and storage to produce carbon-negative hydrogen,
- Midwest Alliance for Clean Hydrogen (MachH2),
- Multiple CarbonSAFE storage projects
- Recently selected front-end engineering and design study to produce critical minerals and materials from coal-based resources.

Importantly, although often in early stages, many of these projects have Community Benefits Plans to ensure that projects receiving public funding, particularly from the Bipartisan Infrastructure Law and the Inflation Reduction Act, create economic, environmental, and societal benefits for the communities and workers where projects are located. By fostering collaboration across various sectors and driving transformative research, the region is shaping the future of energy and positioning itself as a model for successful collaboration between academia, industry, and government entities.

Figure 3: Selection of Key Projects

Point Source Carbon Capture Industrial Sources | Power Sources

- $1.5M for pre-FEED studies to CO_2 from iron and steel at Arelor Mittal's facilities in Burns Harbor, IN
- $3.7M for FEED to capture CO_2 from cement at Heidleberg Materials' facilities in Mitchel, IN
- $3.7M for FEED to capture CO_2 from Holcim's cement facilities in Bloomsdalem, MO
- $5M for a small pilot to CO_2 emissions from cement in Sugar Creek, MO
- $13M for a small pilot to capture CO_2 from a Chevron natural gas plant in Marissa, IL
- $51M for a large pilot to capture CO_2 for a coal plant in Springfield, IL

Hydrogen with Carbon Management Hydrogen Fuel | Gasification | Solid Oxide Fuel Cells & Gas Turbines

- Wabash Hydrogen Negative Emissions Technology Demonstration - Co-firing an existing gasification facility with biomass to achieve net-negative carbon emissions while producing hydrogen, with CCS
- Fluidized Bed Gasification for Conversion of Biomass + Waste Materials to Renewable Hydrogen with GTI
- Intensification of Hydrogen Production Enabled by Electrochemical Pumping Module for Purification and Compression with Washington University in Missouri
- FEED Design Study for Hybrid Gas Turbine and USC Coal Boiler Concept (HGCC) Plant with Post Combustion Carbon Capture and Energy Storage System at City, Water, Light, and Power Plant
- Midwest Alliance for Clean Hydrogen (MachH2)* *OCED selected

Carbon Dioxide Removal Direct Air Capture | Mineralization

Regional Direct Air Capture Hubs Research Projects

- University of Illinois- Coordinate regional efforts to capture carbon dioxide from the atmosphere and store it in the Illinois Basin
- Northwestern University- Test the feasibility of a direct air capture hub powered by nuclear energy
- Siemens Energy- Multi-technology direct air capture hub using solid sorbent capture technology

Carbon Transport and Storage Monitoring, Verification, Accounting, & Assessment of Long-Term Storage | Storage Infrastructure Demonstration | Accelerating Regional Initiatives | CarbonSAFE

- Two awards of $18.4M to the University of Illinois to develop the Illinois CarbonSAFE Storage Corridor in Marissa County, Illinois
- $11.1M to the University of Illinois for Wabash CarbonSAFE
- $9.2M to Illinois Geological Society for CarbonSAFE Illinois Macon County
- $1.1M to University of Illinois for CarbonSAFE in the East Basin
- $1.2M to Battelle for an integrated feasibility study in Northern Michigan

Critical Minerals Efficient Rare Earth Element and Critical Mineral Recovery, Extraction, and Separation | Cost-Competitive Domestic Supply

- Recently selected University of Illinois to perform a FEED study to produce Critical Minerals and Materials from coal-based resources to establish a fully integrated, vertical supply chain for several critical minerals found entirely within Illinois. The objective is to produce lithium, scandium, neodymium and praseodymium, high-purity dysprosium, as well as other rare earth oxides, nickel, zinc, cobalt, manganese, and potentially high-purity aluminum

Methane Mitigation Advanced Materials | Date Management Tools | Dynamic Compressor R&D | Direct & Remote Sensors

- $6M to GTI Energy for a Storage Tank Emissions Assessment and Quantification project
- $1M to Argonne National Laboratory for an project on an on-board Reformation Device for Methane Abatement from Gas Engines

University Training and Research Education & Training | Novel, Early-stage R&D | Building R&D Capacity | Preparing the Future Workforce

Three active projects with total award value over $1.6M and least 4 students trained:
Michigan State University, Michigan Technological University
One institution selected for UTR negotiation in FY24: The Washington University of Saint Louis
Eight additional institutions are past recipients of UTR awards:
Illinois Institute of Technology, Indiana University, Purdue University, Southern Illinois University, University of Illinois, University of Illinois-Chicago, University of Missouri, University of Wisconsin

* OCED Funded Program

Conclusion

The Midwest has a long history of manufacturing and logistics where goods are produced and distributed across the United States. The decarbonization of the region's industrial sectors creates the opportunity for new and lower carbon products and fuels. With the robust framework of federal funding, financing, and incentives for energy and industrial investment now available through the Bipartisan Infrastructure Law and Inflation Reduction Act, it is an exciting time for communities, workers, and businesses in the region.

FECM is committed to supporting the development of the Midwest, leveraging the region's existing industries to turn challenges into new economic opportunities, build clean energy and industrial supply chains, and sustain and create high-wage jobs. FECM's focus areas and portfolio of technologies are well-suited to the region's energy and industrial mix, local infrastructure, and resources. These efforts will also help the Midwest engage communities, create new jobs, build new supply chains and industries, and invest in supporting research and development and innovation.

Together, these opportunities will support the Midwest, leveraging its strengths to advance a range of carbon management and resource sustainability solutions, moving the industry forward as it emerges as a leader in the clean energy and industrial transition.

The Midwest Regional Report is one of six regional reports that highlight resource sustainability and decarbonization solutions in fossil energy-producing and industrial regions. Given the rapidly evolving market, technology, and policy environment, the regional reports are intended to be "living documents" and will be updated as the outlook on each region evolves. Please note these reports and regional decarbonization workshops do not represent DOE policy or strategy, but rather are a representation of DOE's current understanding based on a synthesis of available facts.

FECM welcomes input and feedback on content for each of the reports. Please direct all inquiries and input to FECMRegionalReport@hq.doe.gov. Input and feedback should not include business-sensitive information, trade secrets, proprietary, or otherwise confidential information. Please note that input and feedback provided is subject to the Freedom of Information Act.

U.S. DEPARTMENT OF ENERGY | Fossil Energy and Carbon Management