Plains CO_2 Reduction (PCOR) Partnership
Energy & Environmental Research Center (EERC)

SOCIOECONOMIC OVERVIEW OF THE PCOR PARTNERSHIP REGION

Plains CO_2 Reduction (PCOR) Partnership Initiative
Task 4 – Deliverable 12

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SOCIOECONOMIC OVERVIEW OF THE PCOR PARTNERSHIP REGION

EXECUTIVE SUMMARY

The Plains CO_2 Reduction (PCOR) Partnership, funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL), the North Dakota Industrial Commission's Oil and Gas Research Program and Lignite Research Program, and supported by more than 250 public and private partners, is accelerating the deployment of carbon capture, utilization, and storage (CCUS) technology. The PCOR Partnership is focused on a region comprising ten U.S. states and four Canadian provinces in the upper Great Plains and northwestern regions of North America. It is led by the University of North Dakota Energy & Environmental Research Center (EERC), with support from the University of Wyoming and the University of Alaska Fairbanks.

The PCOR Partnership region is home to abundant and diverse sources of anthropogenic CO_2 (e.g., coal- and gas-fired power plants, gas processing plants, ethanol plants), fitting geology for CO_2 storage and utilization, and an existing network of CO_2 transport pipeline infrastructure. Energy development continues to evolve as society pursues low- or no-carbon solutions to energy needs. While renewable energy development such as wind, solar, and hydroelectric continues to increase in popularity, fossil fuel usage will continue to be the backbone for energy supplies for the foreseeable future. The supply and demand for energy varies across the PCOR Partnership region. Some states may transport fossil fuels (i.e., coal) to nearby states for energy generation (e.g., electricity), while other states may produce the energy (e.g., electricity, ethanol) in-state and transport the energy product to another jurisdiction.

CCUS offers one approach to reducing energy-related CO_2 emissions from fossil fuel use. The level of support for CCUS project development varies widely across any given segment of the population. Project developers need to understand this dynamic, and understanding the landscape of the region can offer valuable insights for helping to advocate for a given project. Public understanding of the economic benefits tied to CCUS development (e.g., creating and retaining jobs, capital investment, tax revenue) can help illustrate the direct benefits to local communities. The PCOR Partnership region has multiple active CCUS projects that demonstrate these benefits. Construction-phase activities have employed several hundred to thousands of employees for local communities, while projects that move to the operational phase provide dozens of long-term, stable jobs. Near-term developing projects have the potential to drastically increase these levels of employment across the region as larger-scale CCUS hub projects are expected to come online over the next several years. These hub projects involve a greater network of capture facilities and more

extensive CO_2 pipeline networks that may require greater construction and operational employment opportunities. These hub projects are currently under development across Iowa and surrounding states as well as across Alberta. In addition to these employment opportunities, CCUS deployment can extend the lifespan of facilities (e.g., reducing CO_2 emission from a coal-fired power plant), thereby extending existing employment for local communities.

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INTRODUCTION

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The PCOR Partnership region consists of ten U.S. states (Alaska [AK], Iowa [IA], Minnesota [MN], Missouri [MO], Montana [MT], Nebraska [NE], North Dakota [ND], South Dakota [SD], Wisconsin [WI], and Wyoming [WY]) and four Canadian provinces (Alberta [AB], British Columbia [BC], Manitoba [MB], and Saskatchewan [SK]) (Figure 1). The U.S. states of the PCOR Partnership region contain about 8% of the nation's population but account for over 36% of U.S. land area, and the five least populated states (AK, WY, MT, ND, SD) are all within the region. Similarly, Canadian provinces in the PCOR Partnership (MB, SK, AB, BC) contain just over 30% of the nation's population while accounting for nearly 50% of the land area. A closer look at what are commonly thought of as "flyover" states reveals crucial industries, dynamic communities, and enormous potential for contributions to pressing global issues.

CCUS offers one avenue for reducing carbon dioxide (CO_2) emissions and allowing responsible and methodologic improvements to current energy generation without compromising communities, ways of life, or energy grids. Implementation of CCUS projects can provide significant economic benefits to local communities through employment opportunities, increased capital expenditures, and increased tax revenue. An evaluation of available information on operating and actively developing projects provides insight into the benefits that CCUS has already provided or is expected to provide in the near future. Understanding the socioeconomic benefits of CCUS helps to illustrate the benefits in bringing CCUS projects to communities for project developers, government officials, and the general public.

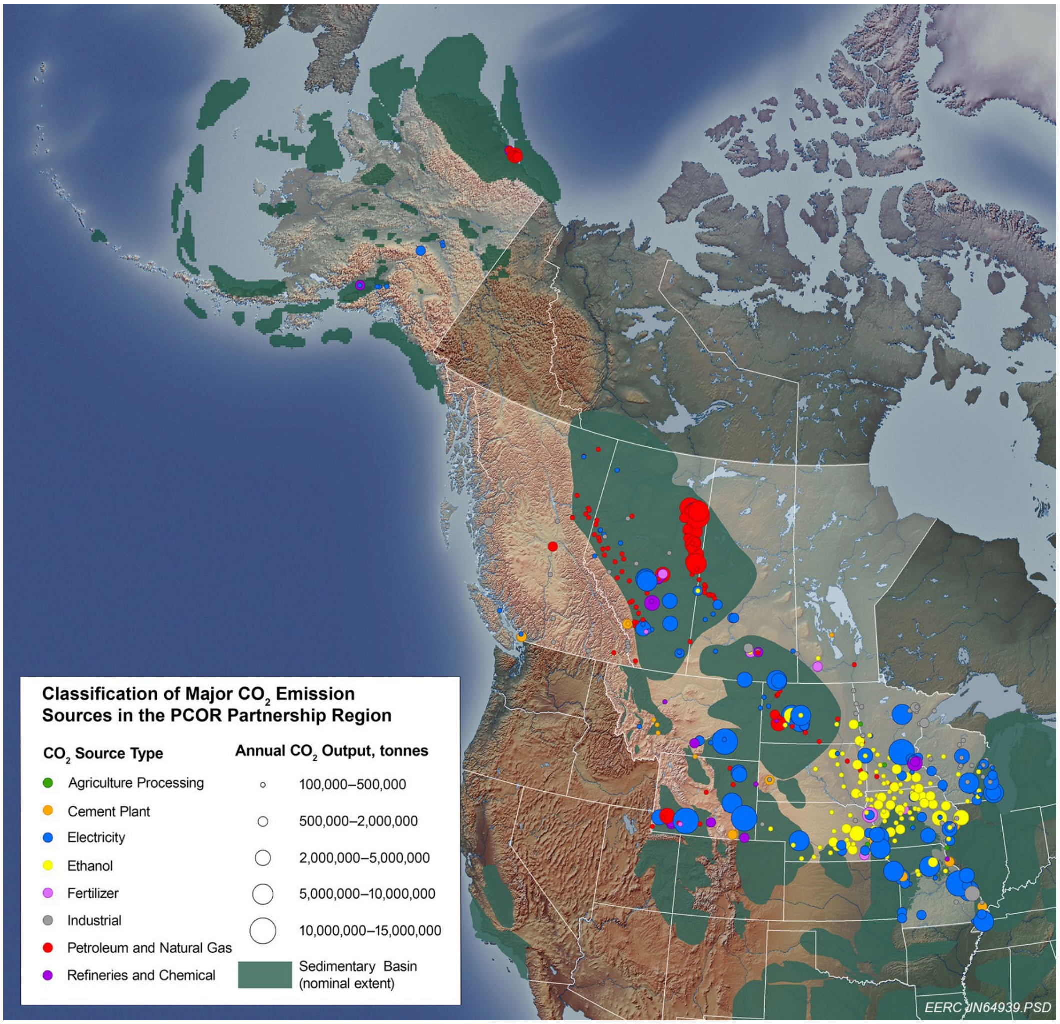

Figure 1. Classification of large stationary CO_2 emission sources in the PCOR Partnership Region.

GENERAL PROFILE OF THE PCOR PARTNERSHIP REGION

The PCOR Partnership region is located in the north-central region of North America and is home to an industrial sector that accounts for the largest proportion of energy use in nine out of the ten included states. The combination of relatively small population sizes and active industrial sectors puts many PCOR region states high among energy consumers per capita. Transportation often follows as the next most energy-intensive sector in states whose communities are more sparsely placed and populated. In the same way that fuel is required to move around within a large state, fuel is required to transport crucial resources from one state to another. The context provided by investigations into the complex and dynamic relationships between states and provinces is crucial to understanding the entire picture of energy generation and consumption. Without these pieces, it is impossible to fully understand the collaborative aspects of CCUS projects.

At the far north of the PCOR Partnership region, Alaska's economy is closely linked with the state's energy industries. This is particularly true for oil and natural gas, whose reserves rank as the fourth and fifth largest in the nation, respectively, and have generated an average of 80% of the state's revenue since 1977. While Alaska is the least densely populated state and nearly the least populated overall, its residents depend on the energy generated in the state in the face of temperatures ranging from −80°to 100°F throughout the year. Even with relatively high energy demand from the residential sector to keep homes at a reasonable temperature, the 8% of the total energy use there is exceeded by the industrial sector's claim on nearly 60% of the state's energy consumption. Extreme weather and energy-intensive industries put Alaska in the top five states with the highest energy demand per capita. However, Alaska's overall energy-related CO_2 emissions as a state rank 41st in the United States.

Wyoming serves as another example of a PCOR Partnership state with a small population that works largely in energy-intensive industries. Even as the second-highest net supplier of energy in the nation, producing 13 times more energy than it consumes, Wyoming has the title of highest total energy consumed per capita. High relative energy consumption among the state's nearly 580,000 residents is matched by a high output of fuels and foods. Wyoming has been the top coal-producing state since 1986, generating about 40% of the nation's mined coal—more than the next six highest-producing states combined. Related to agricultural production, Wyoming generated around $1.9 million in gross receipts of farms in 2020. Industries and products with roots in Wyoming have national and international impacts, and many of them would not be possible without carbon-intense industries. Fortunately, Wyoming's sources of CO_2 coexist with geology that is suitable for CCUS, which continues to be pursued in multiple projects, both in dedicated storage and CO_2-based enhanced oil recovery (EOR).

Similar to Wyoming, North Dakota ranks high in terms of energy use per capita yet manages to produce seven times as much energy as it consumes. While coal consumption has been on a decline in the United States, it remains an important and reliable source of electricity—especially in North Dakota, which generated 57% of its energy from coal-fired power plants in 2021. Beyond being the fifth-largest coal producer in the nation, North Dakota is home to substantial fossil fuel and renewable energy sources as the third-largest crude oil producer and tenth-highest ethanol producer. Substantial and diverse energy generation translates to numerous stationary CO_2 emission sources within the state. These varied sources, coupled with geologic potential for long-term dedicated and associated CO_2 storage, make North Dakota a crucial player in advancing the CCUS industry. Even as coal use decreases, it is important to maintain a diverse, reliable, and resilient power grid. Carbon capture offers a route for lowering the environmental impact of resources like coal and a route for prioritizing sustainable energy and industry that responsibly addresses a broad array of long-term concerns.

Montana and Alberta follow similar trends as homes to both large point sources of CO_2 and suitable geology for long-term storage. In 2020, Alberta accounted for 63% of Canada's natural gas production. The province's energy-intensive industrial sector, including a productive oil, gas, and mining industry, contributes more carbon emissions than any other PCOR state or province. Montana emits around a sixth as much CO_2 as Alberta but is home to the nation's largest recoverable coal reserves and relies on them heavily, sourcing 43% of its energy from coal-fired power plants. The proximity of carbon source to potential carbon storage makes these areas dynamic players in the application of CCUS technologies within the PCOR Partnership region.

Many clear connections between industry, energy, and neighboring states exist in the agriculture-intensive region of the North American plains. Together, the international PCOR Partnership region accounts for over 42% of the farmland, representing a larger fraction of farmland relative to the population and total land area. The vast and productive land supports national and global supplies of corn, soybeans, barley, and oats. About a third of American farmland lies within the PCOR Partnership region and routinely accounts for around the same percentage of the gross receipts of farms in the nation. Especially relevant is the corn crop that contributes to the growing production capacity and production of ethanol in the United States. Of the top ten ethanol-producing states, six (IA, NE, SD, MN, ND, WI) are in the PCOR Partnership region, producing over 64% of the nation's supply. Iowa leads the nation in corn and ethanol production, supporting the state without any crude oil, natural gas, or coal. The 10 million gallons of ethanol produced in PCOR Partnership states in 2019 contributed approximately 21.8 million dollars to the gross domestic product (GDP) of the region. Canada grows much less corn than the United States, and the acres that are planted are located almost entirely outside of the PCOR Partnership region. Still, over 30% of Canada's 1.88 billion liters of ethanol fuel nameplate capacity[1] is associated with facilities within the four PCOR Partnership provinces that rely on wheat for biofuel production more than corn. On both sides of the border, crop and subsequent ethanol production provide stationary sources of CO_2 that have the potential to incorporate CCUS into their operations.

The ties between the agriculture and energy industries are part of what defines the PCOR Partnership region. In Canada, nearly all of the nation's wheat, canola, and barley is grown within the region. In the United States, over half of corn, soybean, and oat production takes place in PCOR Partnership states. Minnesota alone grows around 10% of American soybeans, corn, and oats. While the state has no fossil fuel reserves or production, its agricultural industry relies on the production of its surrounding states. This dependence is reciprocal though, as coal- and oil-producing states like Wyoming, Montana, and North Dakota make use of Minnesota's railroad system as products are transferred to ships at its eastern border. Further, as much as 30% of all U.S. crude oil imports flow through Minnesota, making it the home to the largest refinery of crude oil in a non-oil-producing state. Wisconsin is very similar, taking advantage of its many ports to bring in fuels for its $63.1 billion manufacturing industry without in-state fossil fuel resources. These examples highlight the multifaceted relationships between states in the PCOR Partnership region and the ways that their industries support each other.

Even though the United States is home to the world's most extensive network of CO_2 pipelines, there is a need for additional CO_2 transportation infrastructure in order to fully address CO_2 emissions in the PCOR Partnership region. Trunk lines and connector pipelines are a strategic option for delivering CO_2 from states like Missouri, Nebraska, and South Dakota to desirable and established geologic storage sites. Above the 49th parallel, CO_2 pipelines like the Alberta Carbon Trunk Line (ACTL) and the Souris Valley Pipeline in Saskatchewan serve as examples of

[1] https://ethanolproducer.com/articles/report-canadian-ethanol-consumption-continues-to-grow (accessed November 2023).

supportive infrastructure to CCUS initiatives, allowing for transportation of CO_2 from source to sink.

Diverse industries and CO_2 sources are matched by diverse opportunities for long-term geologic storage in the PCOR Partnership region. Over 3.7 gigatonnes of CO_2 storage potential have been identified in oil fields in the region, in addition to over 330 gigatonnes of storage potential in saline formations. The recognized potential of CCUS in the PCOR Partnership rests steady on the framework of the region's natural resources, highly integrated industries, and productive lands. Together, these pieces make the PCOR Partnership region uniquely qualified to lead the way in investigating and implementing CCUS technologies. A contextualized, cohesive look at the region clearly indicates the immense potential that it holds. The PCOR Partnership region is positioned to contribute the necessary resources, geology, and expertise to guide the international community in commercial deployment of CCUS.

Energy-Related CO_2 Emissions Profile of the PCOR Partnership Region

As described above, the PCOR Partnership region has a diverse energy-production and consumption landscape. Similarly, a look at energy-related CO_2 emissions reveals a diverse landscape in each respective state's energy-related CO_2 profile. Many states and companies are outlining goals for net-zero carbon emissions, and an analysis of the PCOR Partnership landscape illuminates how and where CO_2 emissions are being generated.

The U.S. Energy Information Administration (EIA) provides a summarized analysis of energy-related CO_2 emissions by state.[2] For purposes of this report, relevant datasets for the states in the PCOR Partnership were extracted and analyzed to further understand the carbon and energy landscape.

Energy-related CO_2 emissions in EIA's datasets are broken into five different categories: electric power, commercial, transportation, industrial, and residential. Figure 2 shows the CO_2 emissions for the states in the PCOR Partnership as well as the carbon intensity for each state. The states with the highest carbon intensity, Wyoming, North Dakota, and Alaska, are all below the national average in energy-related CO_2 emissions (Figure 3). Similarly, these high carbon-intensity states are also the highest in CO_2 emissions per capita. Wyoming and North Dakota's carbon intensities appear to be driven by the higher relative emissions from electric power generation and industrial categories, while Alaska is driven primarily by industrial and transportation (Figure 4).

Conversely, the higher emission states of Missouri, Wisconsin, and Minnesota offer relatively lower carbon intensities while ranking well above the national average in energy-related CO_2 emissions. The emissions for these three states have their own unique "fingerprints," as illustrated in Figure 5. While Missouri and Wisconsin lean more toward electric power and transportation as their primary emissions, Minnesota is driven more by the industrial and transportation sectors.

[2] https://www.eia.gov/environment/emissions/state/ (accessed November 2023).

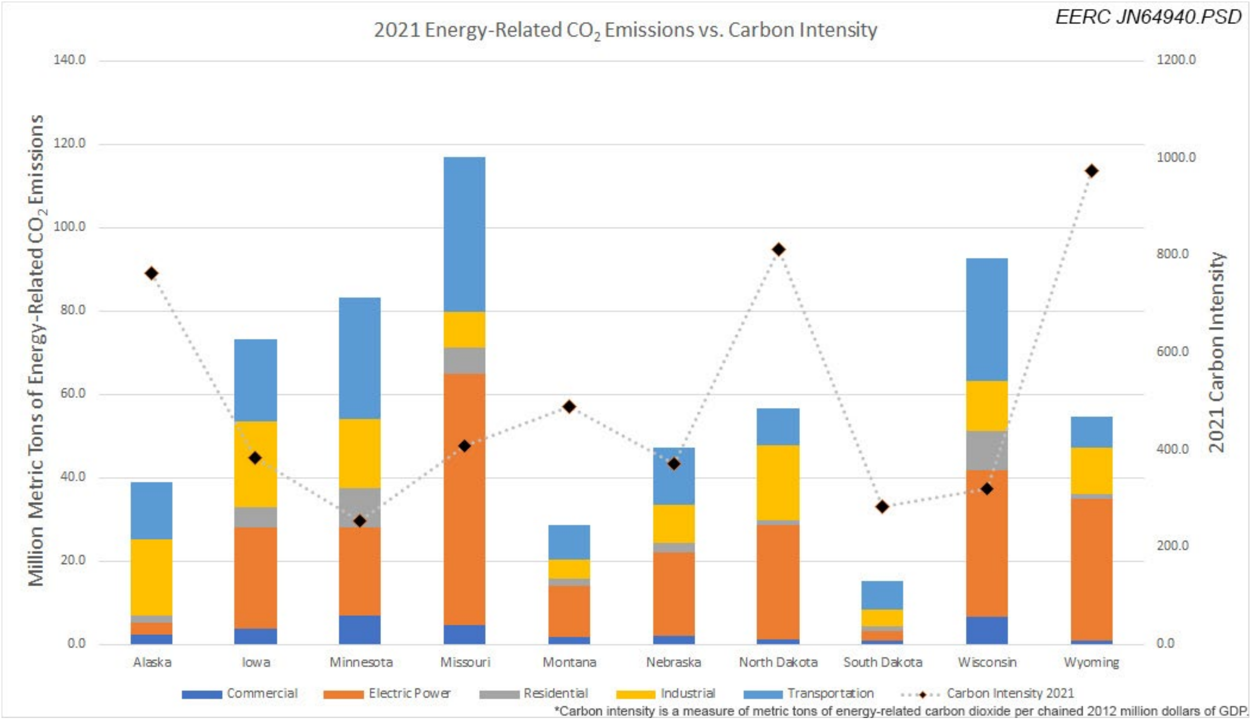

Figure 2. 2021 energy-related CO_2 emissions and carbon intensity by state.

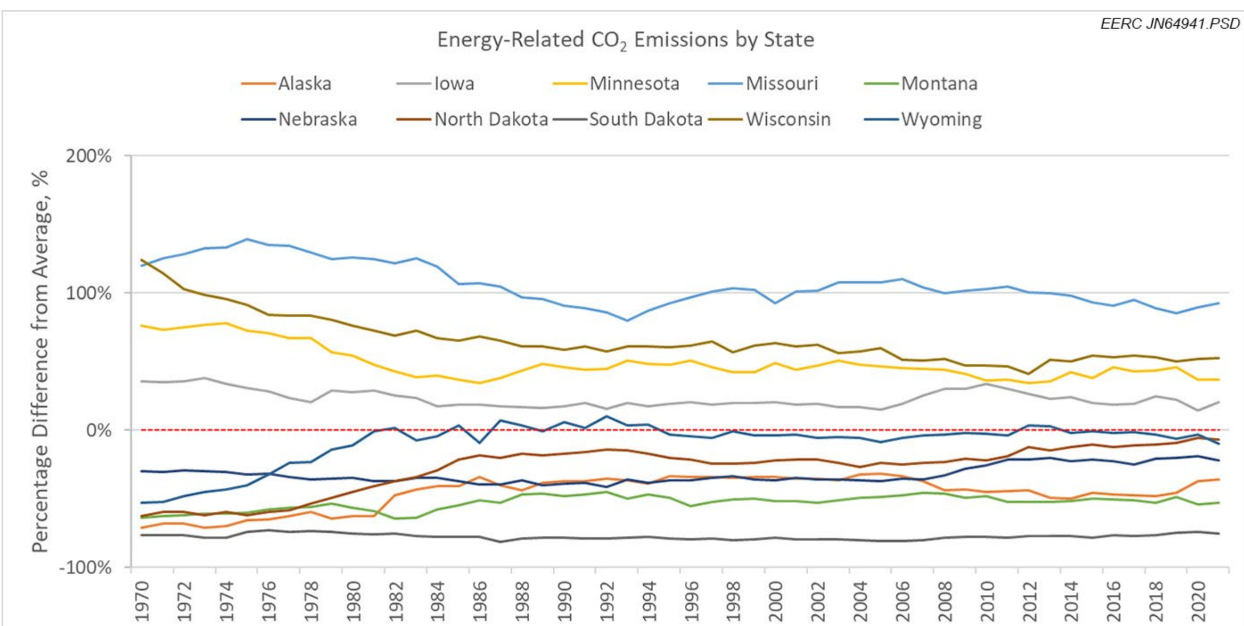

Figure 3. 2021 energy-related CO_2 emissions by state, normalized as a percentage difference from the national average.

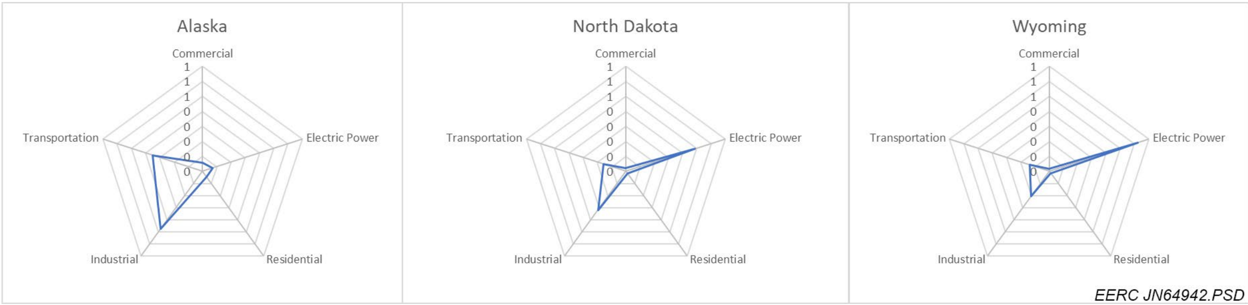

Figure 4. Emissions "fingerprint" of Alaska, North Dakota, and Wyoming.

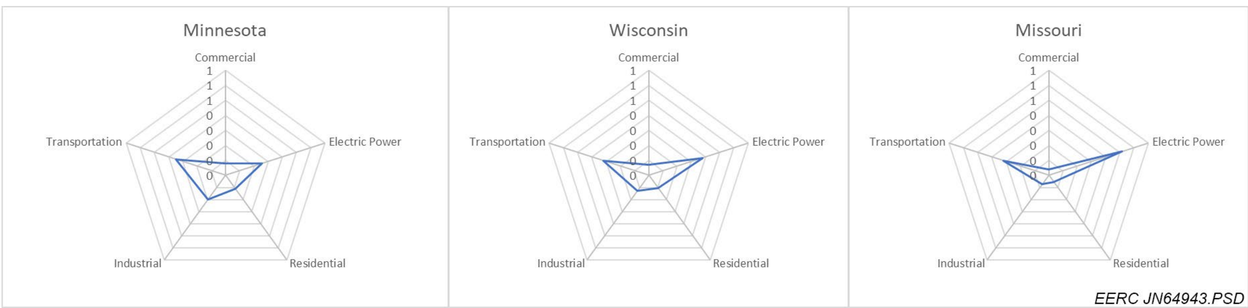

Figure 5. Emissions "fingerprint" of Minnesota, Wisconsin, and Missouri.

Fossil fuel use is intrinsically tied to CO_2 emissions, and the states producing those fossil fuels are not necessarily burning those fuels and emitting CO_2. For example, the state of Wyoming produces coal that is transported across 24 different states across the United States (Figure 6). Further, states that consume more energy than they produce (Figure 7) also contribute to greater CO_2 emissions. For example, there are states that import a significant share of their electricity when they do not have the available resources or capacity to support their populations' energy demands. One such instance would be the state of Minnesota,[3] which imports electricity generated from coal-fired power plants in North Dakota. Should North Dakota electric generating facilities implement CCUS and reduce CO_2 emissions, Minnesota's electricity would have a reduced carbon intensity. Another example that illustrates consuming energy produced from another state is in the ethanol industry. While Iowa has numerous facilities generating CO_2 emissions in the production of ethanol fuels, the demand for the ethanol often originates from other states, such as California. The ethanol facilities could also pursue CCUS and reduce the carbon intensity of the ethanol, similar to the previous example. However, Iowa geology is not conducive to large-scale CO_2 storage, and the construction of long-distance, multistate CO_2 pipeline networks would be necessary for the ethanol industry to implement CCUS. Understanding the interconnectedness of CO_2 emissions, fossil fuel supply, and energy generation and demand allows one to see the value in supporting CCUS.

[3] U.S. Energy Information Administration, Minnesota Electricity Profile 2021, Table 10, Supply and disposition of electricity, 1990 through 2021: https://www.eia.gov/electricity/state/archive/2021/minnesota/ (accessed November 2023).

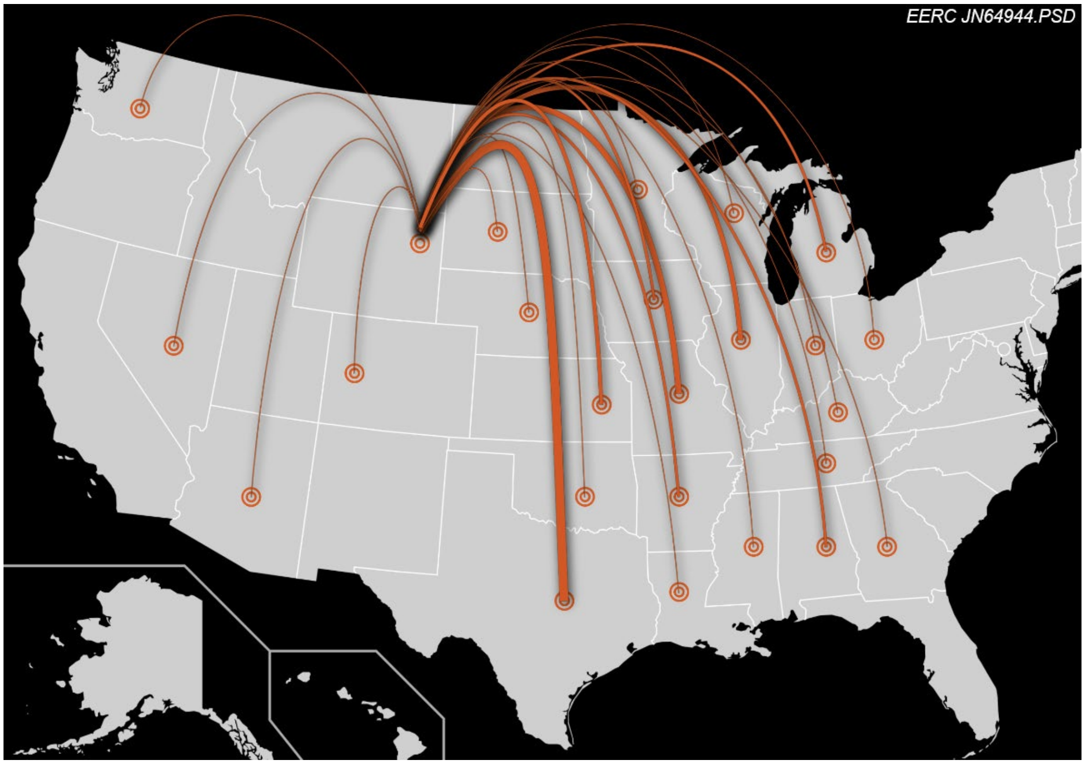

Figure 6. Distribution of coal resource from Wyoming.

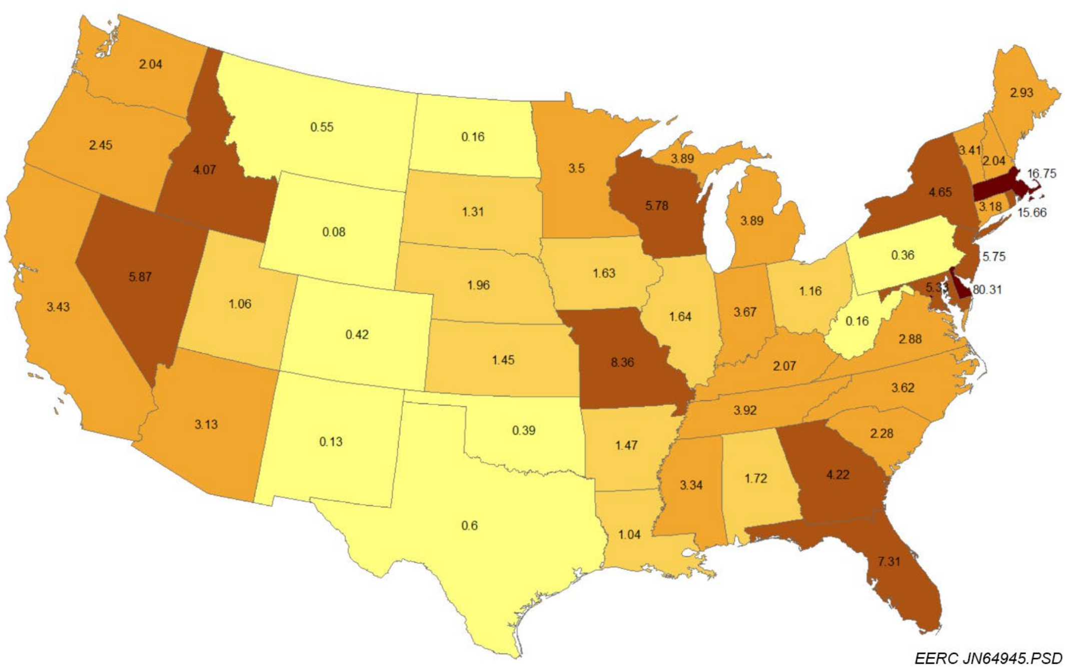

Figure 7. Energy consumption/energy production by state. Values greater than 1.0 consume more than is produced within that state.

CURRENT CCUS DEVELOPMENT IN THE PCOR PARTNERSHIP REGION

The deployment of commercial CCUS projects in the PCOR Partnership region includes geologic storage of CO_2 in saline formations (dedicated storage) and utilization of CO_2 stored in association with EOR (CO_2 EOR and associated storage). Commercialization of CCUS has led to the expansion of existing CO_2 pipeline transportation networks and construction of new CO_2 pipelines connecting major industrial CO_2 sources within the PCOR Partnership region to geologic formations best suited for permanent storage. In 2021, Denbury Resources extended the Greencore CO_2 pipeline system from its Bell Creek operation in southeastern Montana to its Cedar Hills South Unit operations bordering Montana and western North Dakota. In addition, other companies such as Summit Carbon Solutions (SCS) and Archer Daniels Midland (ADM) have announced and are actively developing new CO_2 pipelines within the PCOR Partnership region.

A number of CO_2-emitting facilities (e.g., power plants, ethanol facilities, etc.) in the PCOR Partnership region do not reside in the sedimentary basins where favorable geologic storage opportunities exist (Figure 1). Often, the most cost-effective solution for multiple facilities in areas without favorable geology is collectively creating a pipeline network that combines their CO_2 streams and transports the CO_2 stream volume to a single storage target (consisting of one or multiple injection wells in one area), referred to as CCUS hubs or hub and cluster development. The transport and storage components of the system may be owned collectively by the capture facilities or by a third party. This approach efficiently utilizes storage resources and minimizes project development and operational costs.

The PCOR Partnership region has over 500 large stationary CO_2 emission sources, defined as those facilities emitting more than 100,000 metric tons/year (Figure 1). Currently, most CCUS projects target coal-fired electric generating facilities and ethanol production plants. The PCOR Partnership region has about 150 electric-generating facilities, with many of those located in the eastern parts of the region. About 120 ethanol facilities are found primarily in Iowa, South Dakota, Minnesota, North Dakota, and Nebraska, and a number of these facilities are part of developing CCUS projects, including hub projects such as the SCS[4] project (Figure 8).

[4] https://summitcarbonsolutions.com/ (accessed November 2023).

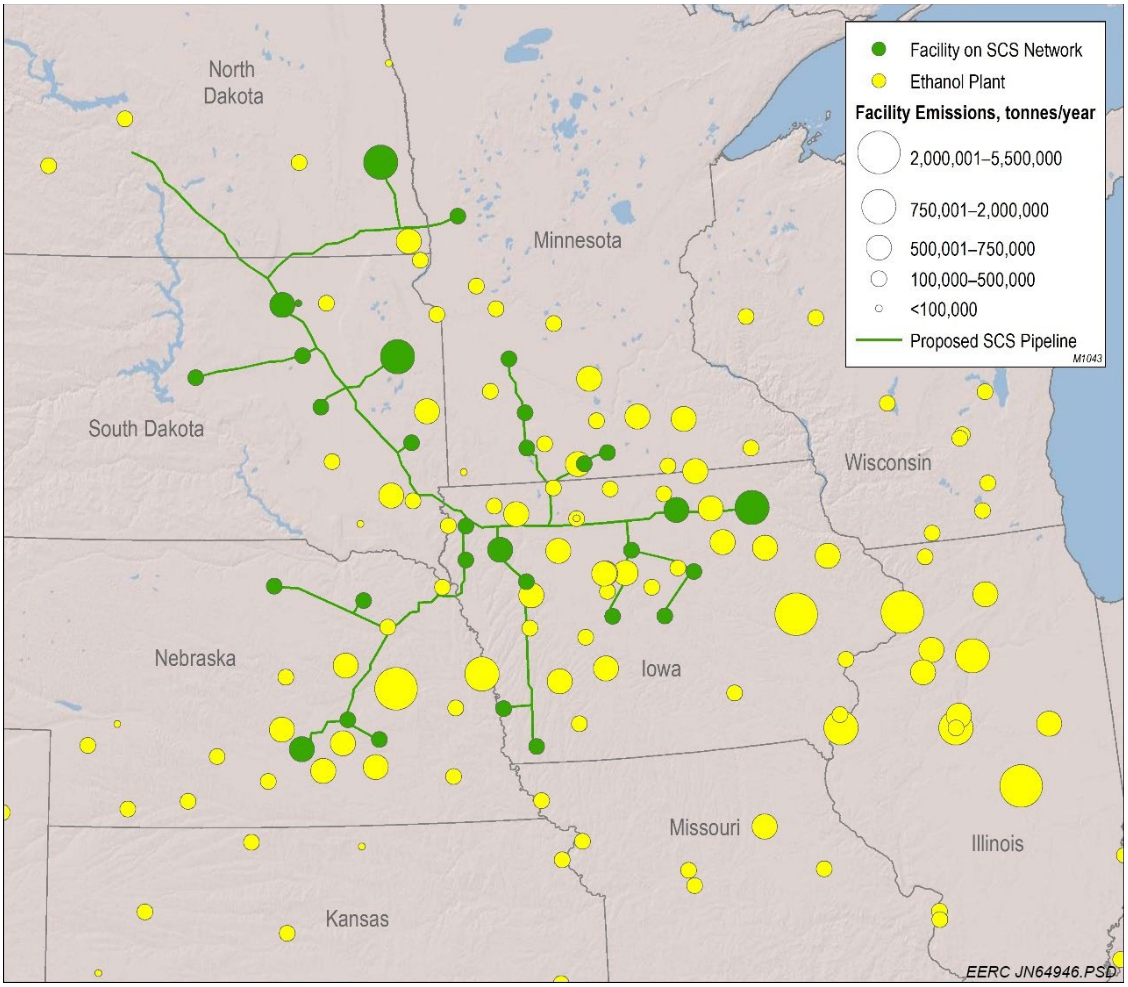

Figure 8. SCS' proposed pipeline network and ethanol plant locations (modified from Peck and others, 2022).[5]

Existing CO_2 pipelines cover about 1200 miles within the PCOR Partnership region.[6] CO_2 pipeline development in the region primarily focuses on delivering CO_2 for EOR efforts, e.g., Dakota Gasification Company's (DGC's) pipeline delivering CO_2 from North Dakota to the Weyburn/Midale oil fields in southern Saskatchewan and Salt Creek/Greencore pipelines in Wyoming to CO_2 EOR fields in Wyoming and southeastern Montana. More recent development includes the ACTL near Edmonton, Alberta, which is a CO_2 hub delivering CO_2 from multiple

[5] Peck, W.D., Nakles, D.V., Ayash, S.C., and Connors, K.C., 2022, CCUS business models in the PCOR Partnership Region: Plains CO_2 Reduction (PCOR) Partnership Initiative Task 5 Deliverable 4 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031838, EERC Publication 2022-EERC-01-05, Grand Forks, North Dakota, Energy & Environmental Research Center, p. 29.

[6] Beddow, C.J., Warmack, M.P., Swanson, M.L., Newman, T.K., Glazewski, K.A., Peck, W.D., and Connors, K.C., 2023, Simulation of CCUS hub build-out scenarios: Plains CO_2 Reduction (PCOR) Partnership Initiative Task 4 Deliverable 9 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FE0031838, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

facilities to EOR fields south of the city. Looking forward, current pipeline development efforts include not only the aforementioned SCS project but also a number of announced CCUS hub projects in the province of Alberta (Figure 9). Furthermore, the state of Wyoming has also designated CO_2 pipeline corridors under the Wyoming Pipeline Corridor Initiative that lay the groundwork for CCUS project expansion in the state.

The rapid development of CCUS projects (Figure 9) has illustrated the ideal areas for commercial deployment in the PCOR Partnership region are in the sedimentary basins (shown in Figure 1). CO_2 storage areas are targeting primarily North Dakota and Wyoming in the U.S. portion of the PCOR Partnership region and Alberta on the Canadian side. North Dakota and Wyoming also have received regulatory authority (e.g., Class VI primacy) from the U.S. Environmental

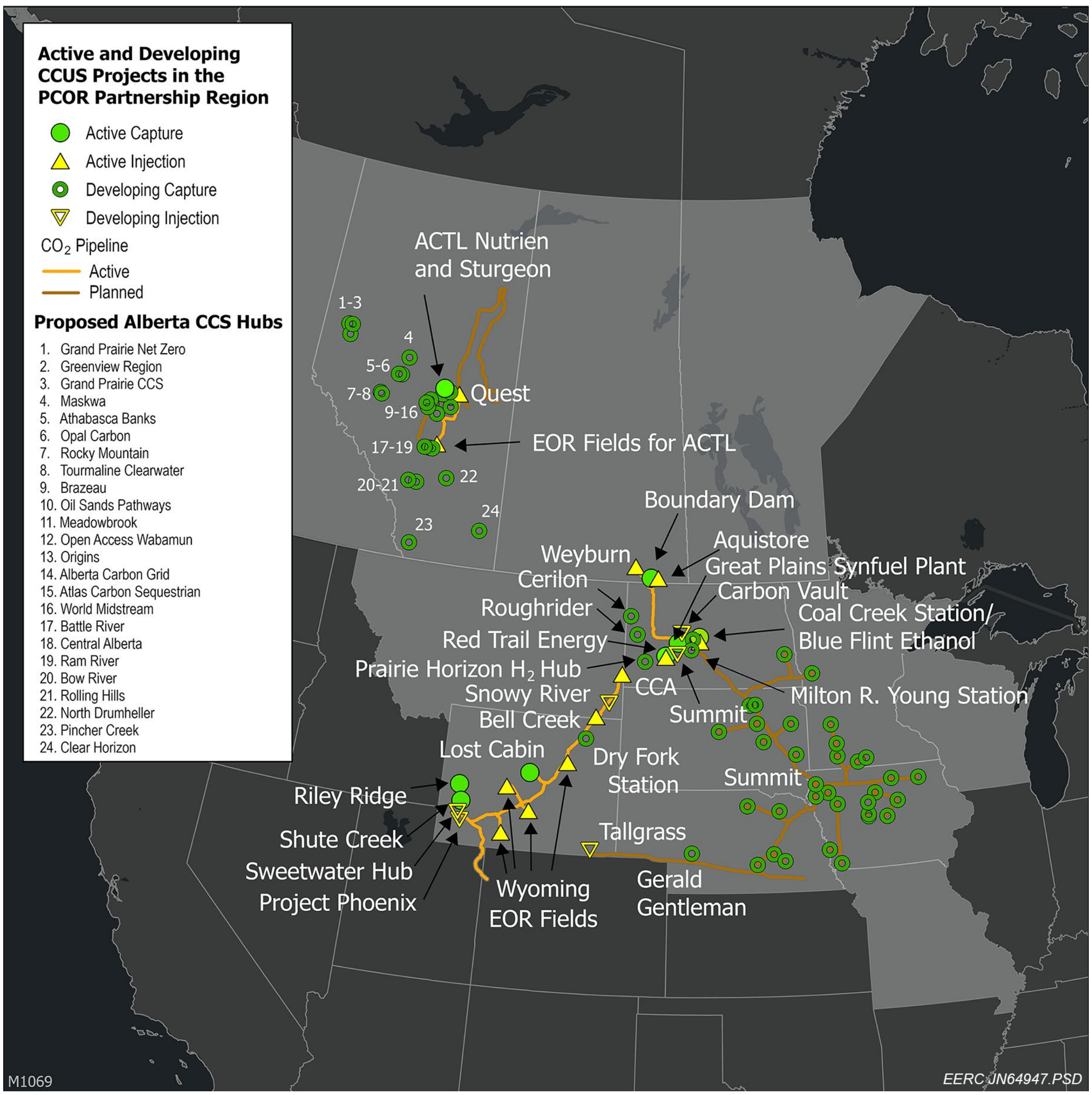

Figure 9. Current and developing CCUS projects in the PCOR Partnership region.

Protection Agency (EPA), which allows project developers of dedicated storage projects in these states to work through the regulatory and permitting process at the state level. In contrast, currently EPA is the Class VI regulatory and permitting authority in all states other than North Dakota and Wyoming. For the near future, dedicated geologic CO_2 storage project development on the U.S. side will likely be the primary target in North Dakota and Wyoming until surrounding states with the ideal geology (e.g., adequate storage resource) can obtain primacy, such as Illinois or Kansas. At that point, more CO_2 emission sources in the eastern portions of the PCOR Partnership (e.g., Missouri, Wisconsin, Minnesota, Iowa) may accelerate deployment of CCUS as the storage targets will be closer. One would expect significant hub development as multiple emission sources would likely look to pool their resources together to develop pipeline networks and storage targets. On the Canadian side, most of the development has been and will likely continue to be focused on the province of Alberta. Most of the CO_2 emission sources are located within the Alberta Basin, and most existing and future CCUS development will likely stay in this region, with the exception of some activity in the Williston Basin in southern Saskatchewan.

CCUS projects continue to face challenges in their development. Two significant challenges are related to the regulatory environment and in societal pushback. While some aspects of CCUS-related regulations have certainty (e.g., Class VI primacy in North Dakota and Wyoming), there is some uncertainty surrounding the regulations around CO_2 pipelines. New CO_2 pipeline regulations are expected to be released by the Pipeline and Hazardous Materials Safety Administration (PHMSA) that will provide assurance for many communities to help understand the risks around CO_2 pipelines and what safety measures will be in place to ensure CO_2 pipelines are operated safely. Another challenge in CCUS project development is in society's understanding of CCUS in general. There can be misconceptions or lack of understanding of CCUS technologies, and if the local population does not have the opportunity to rely on an expert opinion, it will turn to the Internet where information can be inconsistent and unreliable,[7] which can inhibit public acceptance. For example, some may claim that CCUS is an unproven technology at the commercial scale.[8] However, several commercial-scale projects are already in operation (e.g., Boundary Dam, Red Trail Energy, etc.) within the PCOR Partnership area. Further, CO_2 EOR has been occurring since the 1970s, with several EOR fields in operation in the PCOR Partnership region that have been safely operating for decades (e.g., Weyburn, Bell Creek, Salt Creek, etc.). There is significant misunderstanding around CO_2 EOR in that CO_2 is not only permanently stored but nearly all of the purchased CO_2 remains in the subsurface at the conclusion of the EOR operation.[9]

Economic Impacts and Workforce Development in the PCOR Partnership Region

Economic impacts from CCUS development can be described in three ways, namely direct impacts, indirect impacts, and induced impacts. Direct impacts involve the initial value of wages from CCUS project-related jobs; project capital expenditures such as infrastructure (e.g., roads)

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[7] Public perception of carbon capture and storage: a state-of-the-art overview: www.sciencedirect.com/science/article/pii/S2405844019365041 (accessed November 2023).

[8] www.reuters.com/business/environment/why-carbon-capture-is-no-easy-solution-climate-change-2023-11-22/ (accessed November 2023).

[9] https://www.en-standard.eu/bs-iso-27916-2019-carbon-dioxide-capture-transportation-and-geological-storage-carbon-dioxide-storage-using-enhanced-oil-recovery-co2-eor/?msclkid=a1aaac59ce0d14231c0cc93e603d2d8b (accessed November 2023).

development, facility and pipeline construction, well drilling and completion, project operations (e.g., start of capture and storage operations), and direct sale of captured CO_2 (in EOR). Indirect impacts include the increase in output, employment, and labor earnings in industries supporting CCUS project investments. Indirect impacts include money spent on goods and services, equipment, utilities, fuel, and insurance purchased by companies that support the project. Lastly, induced impacts include economic benefits from jobs involving businesses that support the local workforce.

Economic impacts and workforce development (e.g., job creation/retention) in the CCUS industry are often discussed as a benefit of deploying projects. Studies that attempt to forecast the economic potential of CCUS deployments often make projections based on economic models such as IMPLAN, which calculates direct, indirect, and induced impacts arising from an event or policy change. These models and forecasts may be useful and illustrate great potential for CCUS across the PCOR Partnership region. For example, the Rhodium Group[10] forecasts that the states in the PCOR Partnership region over the next 15 years could add approximately 25,000 direct jobs with over $49 billion in private investment. While the Rhodium Group and similar studies attempt to make projections, the ongoing efforts within the PCOR Partnership offer insight into the impacts of operating projects and near-term developing projects that have forecast their expected workforce needs and financial expenditures. Both the existing and actively developing projects offer a guide as to what can be expected at the project level for future project developers.

Existing and Planned Projects

Construction of CCUS facilities requires a large workforce, and while the numbers will vary by project, typical construction of a CCUS project (e.g., capture equipment, transport, injection well, etc.) can require several hundred to thousands of workers. When looking at existing projects in the PCOR Partnership region, the Boundary Dam CCUS[11] project peaked at about 1700 jobs during construction, while Alberta's Quest[12] and the ACTL[13] employed about 2000 people each during their respective construction periods. North Dakota's Project Tundra, which is pursuing CCUS on a coal-fired power plant (Milton R. Young Station) in the western part of the state, expects to employ about 1000 workers during construction on its capture system and injection wells that are located next to the power plant.[14]

Conversely, during the operation of CCUS facilities, the workforce is significantly reduced from the construction phase, but operating the CCUS system employs a stable, permanent workforce of managers, operators, technicians, and maintenance workers. Capture facilities typically have a rotating staff in place, and currently, operating facilities suggest around 20 people

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[10] Larsen, J., Herndon, W., Hiltbrand, G., and King, B., 2020, The economic benefits of carbon capture—investment and employment estimates for regional carbon capture deployment initiative states: Rhodium Group, October.
[11] www.globalccsinstitute.com/wp-content/uploads/2020/05/Thought-Leadership-The-Value-of-CCS-2.pdf (accessed November 2023).
[12] https://open.alberta.ca/publications/quest-carbon-capture-and-storage-project-annual-report-2022 (accessed November 2023).
[13] https://open.alberta.ca/publications/alberta-carbon-trunk-line-project-knowledge-sharing-report-2022 (accessed November 2023).
[14] www.projecttundrand.com/faq (accessed November 2023).

are employed in the operation of a capture plant.[15] Quest provides permanent employment for 25 full-time equivalent (FTE) positions during operations.[16] The ACTL has resulted in permanent employment for approximately 75 positions, with more expected as additional EOR fields are developed.[17] Beyond employment, the project is expected to enable 1 billion barrels of oil to be produced, which is estimated to generate more than $15 billion in royalties for Alberta.[9] Similarly, the Weyburn oil field, which has been conducting CO_2 EOR operations since 2000, is expected to produce an additional 130 million barrels of oil over the lifetime of the project. While oil prices do fluctuate, even at a modest $30/bbl, the revenue generated would be $3.9 billion. A study by Cook[18] evaluated economic impacts of CO_2 EOR activity in Wyoming during 2010–2013. During this time, CO_2 EOR activities resulted in employment for over 1900 jobs annually, adding a total of about $325 million in labor income and adding $1.65 billion to Wyoming's gross state product (GSP).

The economic benefits of CCUS can extend beyond increased employment, project expenditures, or tax revenue. For example, the local farmers that sell corn to the Blue Flint Ethanol facility are expected to be able to receive $0.40 more per bushel of corn sold.[19] The Blue Flint Ethanol facility currently uses about 25 million bushels per year, which would equate to an additional $10 million for the local economy, simply as a result of the increased value of the ethanol from CCUS.

Large CO_2 hub development projects can potentially have a greater impact on the local workforce and economy as a larger network of pipelines and capture facilities are involved. The most visible example in the PCOR Partnership region that is in development right now is the SCS project. This project proposes capturing CO_2 from over 30 ethanol facilities across Iowa, Nebraska, Minnesota, and the Dakotas and transporting the CO_2 via nearly 2000 miles of pipeline to storage facilities in western North Dakota. SCS has compiled its expected economic impacts into its developing CCUS hub project.[20] Assuming the project moves forward into construction, SCS expects to generate $4.6 billion in capital expenditures and about $494 million in federal, state, and local taxes during the construction phase. SCS also anticipates 11,000 annual jobs to support capture facility, transport, and injection well development over a 3-year construction period. The first operational year for the SCS project is expected to contribute a combined $97 million in federal, state, and local taxes. While the SCS project is pressing forward, a similar, recently cancelled Heartland Greenway project had been pursuing capturing CO_2 from a similar network of ethanol facilities across Iowa, Nebraska, South Dakota, and Illinois, although the project was targeting fewer ethanol facilities (~20). Despite this cancellation, there still is interest in the ethanol

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[15] www.globalccsinstitute.com/wp-content/uploads/2020/05/Thought-Leadership-The-Value-of-CCS-2.pdf (accessed November 2023).

[16] https://open.alberta.ca/publications/quest-carbon-capture-and-storage-project-annual-report-2022 (accessed November 2023).

[17] https://open.alberta.ca/publications/alberta-carbon-trunk-line-project-knowledge-sharing-report-2022 (accessed November 2023).

[18] Cook, B.R., 2013, The economic contribution of CO_2 enhanced oil recovery in Wyoming 2010–2012: USAEE Working Paper No. 14-159, https://dx.doi.org/10.2139/ssrn.2411868 (accessed November 2023).

[19] North Dakota Department of Mineral Resources, 2023, 3/21/2023 hearing: www.youtube.com/watch?v=NfEF6FkaBqg&list=PLm38gQ8XLiJ7sIfsE11m0FrgekM6nuCUs&index=37 (accessed November 2023).

[20] https://summitcarbonsolutions.com/driving-economic-growth/ (accessed November 2023).

industry in lowering its carbon intensities via CCUS, and the potential still exists for future efforts to develop CCUS hubs in the region. In addition to these ethanol facilities, there is currently CCUS hub development in Alberta (Figure 9). These projects are still in the early planning phases, and should some of them come to fruition, they could have significant economic benefits to the province.

SUMMARY

CCUS deployment provides an avenue for reducing energy-related CO_2 emissions. The CO_2 profile across the PCOR Partnership region is more complex than simply where the fossil fuels are being produced or the CO_2 is being emitted. The supply and demand for energy varies across the region. Some states may transport fossil fuels (i.e., coal) to nearby states for energy generation (e.g., electricity), while other states may produce the energy (e.g., electricity, ethanol) in-state and transport the energy product to another jurisdiction.

Support for CCUS project development varies across any given segment of the population. While reducing CO_2 emissions is one benefit, understanding the economic benefits to local and regional residents is important to communicate as people formulate their opinions regarding potential developing projects in their communities. Economic studies have projected the possible economic benefits should CCUS be deployed in given geographic areas. One such study from the Rhodium Group[10] forecasts CCUS development over the next 15 years in PCOR Partnership states could add approximately 25,000 direct jobs with over $49 billion in private investment. While this is promising, the PCOR Partnership region has multiple active projects, with many more in various stages of planning, that offer project-based examples in terms of number of people employed or capital investment. Developing projects offer a project-specific forecast for the expected economic impacts at the local level. These active and developing projects have or expect to employ hundreds to thousands during the construction phase. During the operational phase of these projects, a longer-term, stable employment of dozens of employees is expected. Additionally, CCUS deployment can extend the lifespan and keep certain facilities open, thereby providing continuing employment. For example, a coal-fired power plant with CCUS may remain open if CO_2 emissions can be reduced, thereby extending the available employment for those at the plant and the supporting coal mine, meaning that a full-scale CCUS power plant can provide and sustain hundreds of employees at that one given facility.