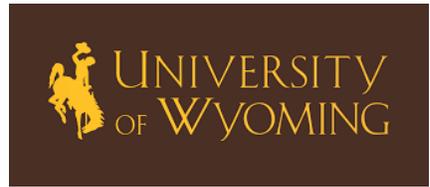


Phase One Final Report | Detailed Chapter

Case Study

Workforce Training and Opportunities in the Powder River Basin



About this report

The Intermountain West Energy Sustainability & Transitions (I-WEST) initiative is funded by the U.S. Department of Energy to develop a regional technology roadmap to transition six U.S. states to a carbon-neutral energy economy. I-WEST encompasses Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. Each state is represented in this initiative by a local college, university, or national laboratory. Additional partners from beyond the region were selected for their expertise in applicable fields. In the first phase of I-WEST, the team built the foundation for a regional roadmap that models various energy transition scenarios, including the intersections between technologies, climate, energy policy, economics, and energy, environmental, and social justice. This chapter presents work led by an I-WEST partner on one or more of these focus areas. A summary of the entire I-WEST phase one effort is published online at www.iwest.org.

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Introduction

The Powder River Basin (PRB), located in northeastern Wyoming and southeastern Montana, has the potential to develop a thriving rare earth element and critical mineral (REE/CM) extraction and processing industry. Not only does the PRB have large coal reserves (from which REE/CM can be extracted) but it also has many of the infrastructure and workforce requirements needed to support such an industry. Current research is being conducted to determine the concentrations and availability of REE/CM in coal and coal byproducts in the PRB through the DOE-funded Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) project at the University of Wyoming School of Energy Resources. This case study supplements that work by assessing the requirements and retraining opportunities to develop a trained workforce for REE/CM industries in the PRB. This is especially crucial and timely at the moment, as coal production is declining and the communities in the PRB work to diversify their economies and create new economic opportunities in the region.

Background on Wyoming and Campbell County Energy Workforce

As national demand for energy has shifted away from carbon-emitting forms of energy and towards low-carbon forms of energy, production of Wyoming's fossil resources has been declining. For example, Wyoming coal production has been steadily declining since reaching a peak of over 450 million short tons in 2008, down to just 218 million short tons in 2021.¹ Likewise, natural gas production has declined from over 2.5 billion MCFs in 2009 to less than 1.4 billion MCFs in 2021.² Oil production has been more volatile in recent years, reaching a low of 51 million barrels in 2009, but increasing up to 85 million barrels in 2021.³

These declines in fossil energy production have had a significant impact on Wyoming communities, both in terms of revenue and jobs. The state of Wyoming, and many of its counties and municipalities are highly dependent on revenue from fossil fuels. Between 2015-2020, an average of 59% of annual

¹ Wyoming Geological Survey. 'Wyoming Coal.' Accessed May 2022.

<https://www.wsgs.wyo.gov/energy/coal.aspx#:~:text=Since%201865%2C%20more%20than%2012.5,and%20Lincoln%20counties%20in%20Wyoming>

² Wyoming Oil and Gas Conservation Commission. 'Graph Gas Production.' Accessed May 2022.

<https://wogcc.wyo.gov/data>

³ Wyoming Oil and Gas Conservation Commission. 'Graph Oil Production'. Accessed May 2022.

<https://wogcc.wyo.gov/data>

state and local revenue was generated from fossil fuel production and extraction, totaling \$4,264 million annually, and over \$7,000 per resident.⁴ This revenue, which funds schools, governments, and other social services, is important for essential community functions and many communities currently do not have a plan for how to replace it as fossil energy production declines.

The loss of jobs in energy-producing communities has also been significant. In Campbell County, located in the PRB, the number of people employed in coal mining has declined from over 5,000 in 2013 to 3,500 in 2020 (Figure 1). Fewer people have been employed in oil and gas extraction in Campbell County historically, but the decline in employment has been dramatic. In 2013, there were 650 people working in oil and gas extraction and by 2020 there were fewer than 250 (Figure 2). This significant loss in jobs has created a strong impetus for new industries and economic diversification in places like Campbell County.

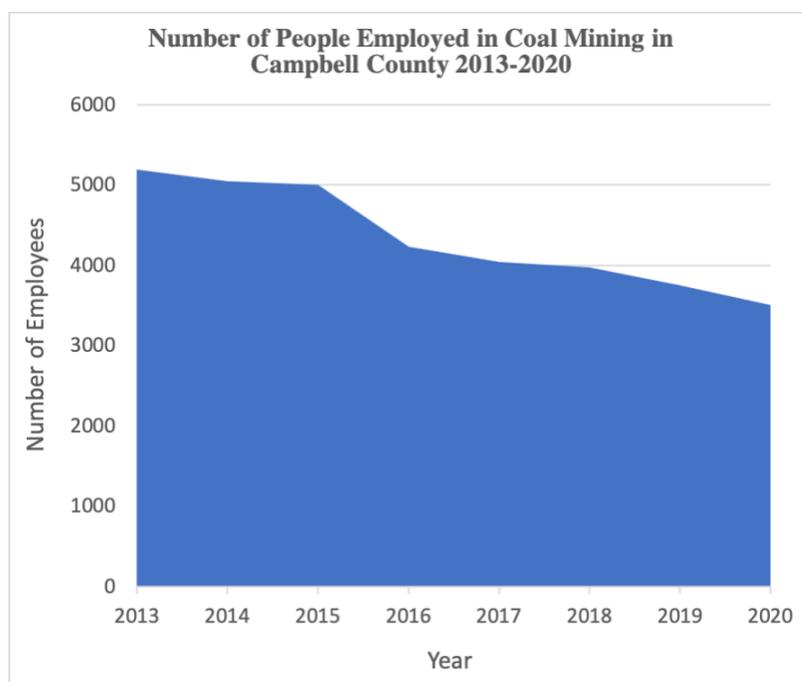


Figure 1: Number of People Employed in Coal Mining in Campbell County, 2013-2020⁵

⁴ Raimi, Daniel, Emily Grubert, Jake Higdon, Gilbert Metcalf, Sophie Pesek and Devyani Singh. 2022. “The Fiscal Implications of the US Transition away from Fossil Fuels.” Resources for the Future.

⁵ U.S. Bureau of Labor Statistics. “Databases, Tables & Calculators by Subject. Accessed May 12, 2022. <https://www.bls.gov/data/home.htm>

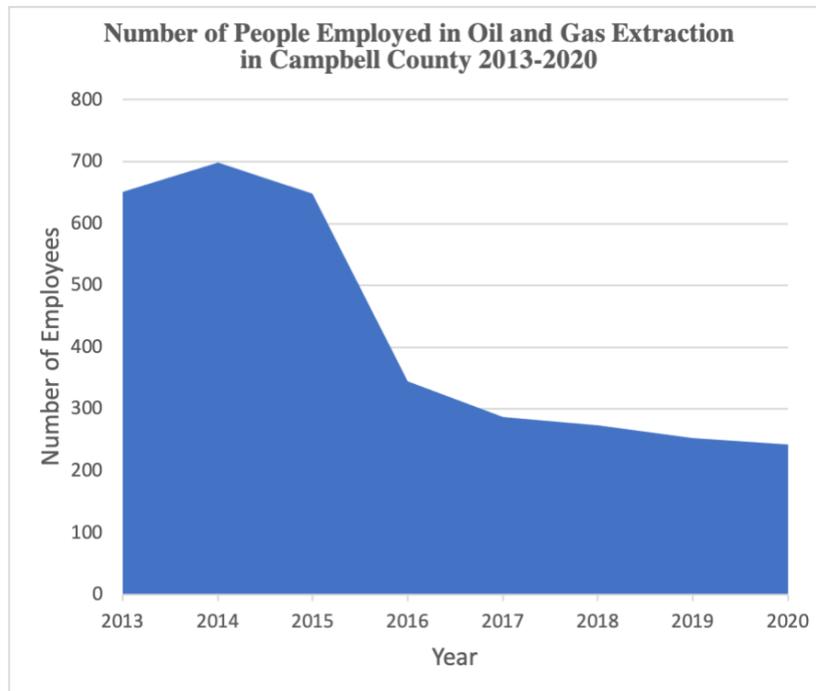


Figure 2: Number of People Employed in Oil and Gas Extraction in Campbell County, 2013-2020⁶

Opportunities for REE/CM Industries

The complete REE/CM supply chain includes exploration for identifying REE deposits, extraction, and mining of REE; processing and concentration of the REE from the feedstocks; and down-stream manufacturing using REE in products. Developing REE industries means that jobs will be created in each of these stages of the supply chain. For the purposes of this report, we will focus on the opportunities for the first three stages: exploration, extraction, processing. Below is an overview of the resources available in and around the PRB that will help to contribute to the development of REE/CM industries.

Coal reserves in the PRB

Wyoming has vast coal reserves from which REE/CM could be extracted. As the top coal producing state nationally since 1986, Wyoming produces 40% of the nation’s coal. And, the majority of that coal is produced in Campbell County in the PRB, which is the most prolific coal field in the world. There are currently 11 operating coal mines in Campbell County (Figure 3) and, in 2021, Campbell County produced

⁶ U.S. Bureau of Labor Statistics. “Databases, Tables & Calculators by Subject. : Accessed May 12, 2022. <https://www.bls.gov/data/home.htm>

almost 230 million short tons of the 238 million short tons of coal produced in total in Wyoming. Most of the coal mined in Wyoming is shipped via railroad throughout Wyoming and to 26 other states.⁷

The PRB is 19,500 square miles in area and has the largest resource of low-sulfur, low-ash, subbituminous coal in the nation. The United States Geological Survey (USGS) estimates there are 1.15 trillion short tons of coal resources remaining in the basin. Of this, 25 billion short tones are estimated to be economically recoverable.⁸

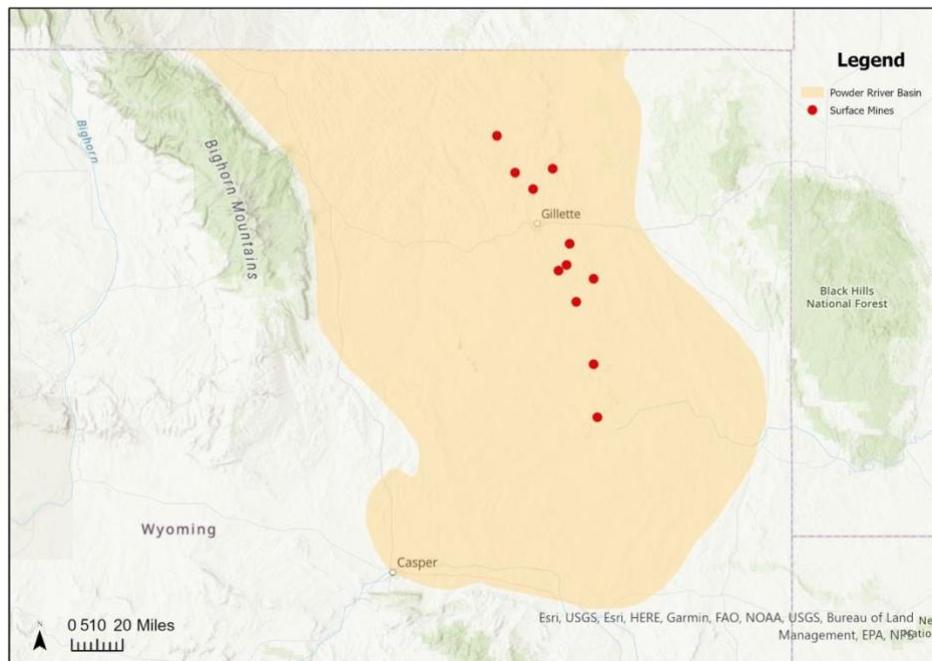


Figure 3: Coal Mines in the Powder River Basin⁹

⁷ Wyoming State Geological Survey. “Coal Production and Mining.” Accessed May 2022. <https://www.wsgs.wyo.gov/energy/coal-production-mining.aspx>

⁸ Luppens, James A., David C. Scott, Jon E. Haacke, Lee M. Osmonson, and Paul E. Pierce. “Coal Geology and Assessment of Coal Resources and Reserves in the Powder River Basin, Wyoming and Montana.” 2015. United States Geological Survey. <https://pubs.usgs.gov/pp/1809/pdf/pp1809.pdf>

⁹ Wyoming State Geologic Survey.

Workforce and infrastructure availability

Transportation and other infrastructure

The mines in the PRB are already within close proximity to all the necessary infrastructure for extraction—roads and railroads for transportation, transmission lines, etc. They are also already equipped with all the necessary mining equipment and have developed supply chains to obtain new equipment as needed.

REE/CM processing plants will need to be permitted and constructed, as well, to build out a REE/CM processing industry. There are currently no similar facilities (e.g., chemical manufacturing) in the PRB. However, all necessary materials to construct and operate such as facility should be readily available in the Gillette area or could be transported to the PRB.

The Bear Lodge Project

The Bear Lodge Project, operated by Rare Element Resources, is an REE mining and processing project that is located just east of the PRB, near Sundance, Wyoming. It includes one of the largest conventional REE deposits in the US and is expected to be a dependable, long-term source of REEs domestically. Currently, Rare Element Resources is completing economic analyses and working with regulatory agencies on permitting. Once it is operational, it could contribute to a basin-wide REE industry in the PRB.¹⁰

The Wyoming Innovation Center

The recently completed Wyoming Innovation Center is a facility designed to encourage innovative alternative uses of coal. Located in the PRB, near the Dry Fork Power Station, the Innovation Center provides the necessary infrastructure, including lap space, water, and testing sites located within close proximity to nearby mines. It is a public-private partnership that will give companies and organizations an opportunity to research and develop processes for making products from coal or extracting REE/CM from coal and coal byproducts.

Community College and Makers' Space

The City of Gillette in the PRB has well-established and state-of-the-art educational facilities. Gillette College, the local community college, offers degrees and certifications that already directly train the energy workforce. For example, they offer a Mine Safety and Health Administration training program

¹⁰ Rare Element Resources. "Bear Lodge Project Overview". Accessed May 17, 2022. <https://www.rareelementresources.com/bear-lodge-project/overview#.YoQIZ5PMLtU>

(which notably features virtual reality training which shows miners hazards that cannot be seen from the cab of heavy equipment), a Mining Technology program, and a Mine Management Certificate.^{11,12,13}

Additionally, Gillette has a well-equipped Maker's Space that provides the community with access to cutting-edge equipment such as robotics, 3-D printers, welders, etc. Called *Area 59*, this space gives people in the community an opportunity to learn to use this equipment and to make/manufacture products.¹⁴ The skill-development and ability to develop product prototypes could be valuable for a variety of applications in developing new industries.

Trained workforce and social license

As the home of the most prolific coal mine in the world, the PRB already has an extensive trained workforce for mineral extraction. Coal mining has been a major industry in the region for decades and many of the skills needed will be similar to the skills needed for REE/CM industries. Additionally, Campbell County is strongly supportive of new energy industries. Wyoming as a state has strong social license for energy development, in general¹⁵. And, Campbell County is particularly encouraging and inviting of new innovative industries. They are a partner on the CORE-CM project through the University of Wyoming School of Energy Resources which is exploring the potential for REE/CM industries. Additionally, the economic development organization in Campbell County, Energy Capital Economic Development, is also strongly supportive of and partnering with the CORE-CM project.

Training Opportunities

Skills needed

Exploration

Exploration of REE/CM (to determine where REE/CM are located) is one of the industries that will need a trained workforce. This will mostly be done by geologists, and Wyoming already has a well-

¹¹ United States Department of Labor. "Wyoming: State of Wyoming Program Summary". Accessed May 9, 2022. <https://www.msha.gov/wyoming>

¹² Gillette College. "Mining Technology AAS". Accessed May 9, 2022. http://catalog.sheridan.edu/preview_program.php?catoid=13&poid=1681&returnto=400

¹³ Gillette College. "Mine Management Certificate". Accessed May 9, 2022. http://catalog.sheridan.edu/preview_program.php?catoid=14&poid=1822&returnto=430

¹⁴ Area 59. "Equipment". Accessed May 9, 2022. <https://area-59.com/equipment>

¹⁵ University of Wyoming School of Energy Resources. "Social License for Wyoming's Energy Future". Accessed May 10, 2022. http://www.uwyo.edu/haub/_files/_docs/ruckelshaus/pubs/2020-wyomings-energy-social-license-report.pdf

developed geology workforce. However, as REE/CM industries develop, there will be need for more geologists, including field geologists, geochemists, geophysics, and mineralogists.^{16,17}

Mining

Many of these necessary jobs will require the same skills that the workforce in the Powder River Basin already has, since the extractive process is expected to be basically the same. The only difference may be in the quantity of the skilled labor needed. For example, if they were to start mining a new coal bench, they may need additionally trained labor.¹⁸ There may also be a need for more mining engineers as REE/CM mining expands, since it is a field that has seen many retirements in recent years and a shortage of students applying for mining engineering degree programs. To ensure an adequate workforce, it will be important to encourage education for a new generation to do this work.¹⁹ Table 1 provides an example of the types of jobs required to operate a REE/CM mine from the Bear Lodge Project operated by Rare Elements Resources in northeastern Wyoming.

Title
Operations Hourly Workforce
Shovel/Loader Operators
Truck Drivers
Drillers
Dozer/Grader Operators
Maintenance Hourly Workforce
Heavy Equipment Mechanics
Fuel/Lube—Light Vehicle
Electrician
Salaried Personnel
Mine Superintendent
Maintenance Foreman
Shift Boss
Maintenance Planner
Sr. Mine Engineer
Ore Control/Geology
Surveyor
Clerk
Security

Table 1: Example of mining labor requirement for REE/CM mining based on Rare Element Resources’ Bear Lodge Project.²⁰

Processing

¹⁶ Miskovic, Eli: Assistant Professor, University of British Columbia. Interviewed. Conducted by Selena Gerace. May 2, 2022.

¹⁷ Sauer, Kirsten: Research Scientist, Los Alamos National Lab. Interviewed. Conducted by Selena Gerace. April 25, 2022.

¹⁸ Green, Dave. Project Manager, Dry Fork, Mine. Interviewed. Conducted by Selena Gerace. May 3, 2022.

¹⁹ Miskovic, Eli: Assistant Professor, University of British Columbia. Interviewed. Conducted by Selena Gerace. May 2, 2022.

²⁰ Roche Engineering. “[Bear Lodge Project: Pre-Feasibility Study Report.](#)” 2014. Rare Element Resources.

The processing of REE/CM from the raw material (e.g. coal or coal byproducts) can be divided into two categories: 1) development of processing procedures and, 2) operation of processing facilities.

The development of the procedures for REE/CM processing is the research phase of developing the industry. It will rely mainly on chemical engineers, chemists, geochemists, and metallurgy engineers. These unique and technical skillsets will be necessary for figuring out how to extract REE/CM from coal and coal by-products and how to get the REE/CM to the level of concentrations needed.^{21,22}

For the daily operations of the processing facilities, trained operators, laboratory technicians, and maintenance personnel will be essential.^{23,24,25} Table 2 and Table 3 show examples of labor requirements at two types of processing facilities: 1) a Physical Upgrade Plant (PUG), where the barren rock will be removed from the ore to increase the concentration of REE, and 2) a Hydrometallurgical Plant, where chemical processing will remove impurities and recover the REE²⁶. Both of these plants require skilled labor in Operation/Operational Support, Maintenance, and Laboratory. Within these categories, the specialties range from metallurgists, operators of specific machinery, safety engineers, mechanists, electricians, and lab technicians.

²¹ Miskovic, Eli: Assistant Professor, University of British Columbia NBK Mining Institute. Interviewed. Conducted by Selena Gerace. May 2, 2022.

²² LiOakey, Katie. Associate Professor, University of Wyoming Department of Chemical Engineering. Interviewed. Conducted by Selena Gerace. May 9, 2022.

²³ Miskovic, Eli: Assistant Professor, University of British Columbia. Interviewed. Conducted by Selena Gerace. May 2, 2022.

²⁴ LiOakey, Katie. Associate Professor, University of Wyoming Department of Chemical Engineering. Interviewed. Conducted by Selena Gerace. May 9, 2022.

²⁵ Heinrichs, Mike. Program Manager, Battelle. Interviewed. Conducted by Selena Gerace. May 29, 2022.

²⁶ Rare Element Resources. "Proposed Operations". Accessed May 17, 2022.

<https://www.rareelementresources.com/bear-lodge-project/proposed-operations#.YoPyZPMLtU>

Title
Operation
Metallurgist
General Foreman
Operation Team Leader
Ore Handling Operator
Crusher Operator
Classification Operator
Dewatering Operator
Magnetic Separation Operator
Operation support
Safety Engineer / Trainer
Secretary/Process Clerk
Accounting Clerk
Warehouse Personnel
Maintenance
Superintendent - Mech Eng. - Planner
Mechanical Clerk
Mechanical Foreman
Mechanical
Maintenance Helper
Electrical Engineer - Planner
Electrical Clerk
Electrical Foreman
Electrician
Intrumentation Tech.
Assay Laboratory
Chief Analyst
Assay Lab Technician
Laborer

Title
Operation
Operation Team Leader
Production materials receiving
Pre-Concentrate handling Operator
Leaching Operator
Precipitation Operator
Oxidation/HCl recovery operator
Ammonium Nitrate Operator
Operation Support
Area Manager -Chemical Engineer
Process engineer (Chemical)/Env.
Geologist
Technician-Env
Secretary/process clerk
Accounting clerk
Warehouse personnel
Security Guards
Maintenance
Superintendent-Eng.-Planner
Mechanical Planner
Mechanical Clerk
Mechanical foreman
Mechanic
Maintenance Helper
Electrical Engineer-Planner
Electrical Planner
Electrical Clerk
Electrical Foreman
Electrician
Instrumentation Tech.
Assay Laboratory
Chief Analyst-Environment
Assay lab technician
Laborer

Table 2 (left): Example of labor requirement for Physical Upgrade Plant based on Rare Element Resources’ Bear Lodge Project²⁷. Table 3 (right): Example of labor requirement for Hydrometallurgical Plant based on Rare Element Resources’ Bear Lodge Project²⁸.

²⁷ Roche Engineering. “[Bear Lodge Project: Pre-Feasibility Study Report.](#)” 2014. Rare Element Resources.

²⁸ Roche Engineering. “[Bear Lodge Project: Pre-Feasibility Study Report.](#)” 2014. Rare Element Resources.

Potential new skills needed

Depending on how technologies change, the skills and jobs required for REE/CM industries could change as well. For example, advances in automation could disrupt the industry greatly. If most of the processes could be automated, many jobs could be eliminated. However, it is estimated that this is still 10-15 years away. If automation is widely adopted, it will not eliminate the need for many of the more highly skilled jobs, such as metallurgy engineers.²⁹

Biologically enabled solutions could be another disruptive technology. Microbes could be used to separate and process the REE/CM. If this does develop, the jobs and skills needed would be more biology-based.³⁰

In current mining techniques, there is already some use of autonomous vehicles, diesel/electric hybrids, electric vehicles, and drones. But the use of all of these could be expanded in the future, requiring additional need for expertise in the specialized skills for operating and maintaining the technology and equipment.³¹ Robotics is another technology that could be widely adopted in mining, sampling, and loading/unloading processes.³²

Training opportunities

Universities

Some of the necessary education and training to develop the workforce for REE/CM industries will need to happen at the university level. For example, there will be a need for chemical engineers, metallurgy engineers, mining engineers, and geologists who have bachelor's degrees, Master's degrees, and Doctorates.^{33,34} This is especially true of the jobs necessary for doing research and development of REE/CM extraction processes, as well as jobs for processing of REE/CM that are further downstream,

²⁹ Miskovic, Eli: Assistant Professor, University of British Columbia. Interviewed. Conducted by Selena Gerace. May 2, 2022.

³⁰ Heinrichs, Mike. Program Manager, Battelle. Interviewed. Conducted by Selena Gerace. May 29, 2022.

³¹ Grubb, Travis. Dean of Career & Technical Education, Gillette College. Interviewed. Conducted by Selena Gerace. April 5, 2022.

³² Grubb, Travis. Dean of Career & Technical Education, Gillette College. Interviewed. Conducted by Selena Gerace. April 5, 2022.

³³ Miskovic, Eli: Assistant Professor, University of British Columbia. Interviewed. Conducted by Selena Gerace. May 2, 2022.

³⁴ LiOakey, Katie. Associate Professor, University of Wyoming Department of Chemical Engineering. Interviewed. Conducted by Selena Gerace. May 9, 2022.

including final purification. These jobs will involve methodologies for more advanced chemical processes, so advanced degrees will be needed.³⁵

Community Colleges

Jobs in more upstream parts of REE/CM processing, which involve less material and less complex chemical processes, will require considerable workforce with Associates degrees and technical training. For example, there will be a need for far more trained laboratory technicians and operators, positions that will be essential for ensuring that plants run safely, efficiently, and continuously. This type of training is one that community colleges are well equipped to provide³⁶ And, of course, much of the training needed to develop the workforce for the mining industry is already done at the community college level and it will be important that workforce training continues.

Gillette College Current Programs

Gillette College already provides Associate degrees and technical training in many of the fields that are important in mining and will be important in developing a workforce for REE/CM processing. For example, programs include:

- Diesel Technology
- Electrical Apprenticeship
- Industrial Electricity
- Industrial Technology
- Welding
- Engineering
- Mine Safety and Health Administration
- Mining Technology
- Mine Management Certificate

Future Program/Training Potential

Gillette College is poised to develop future programs to train the workforce for new skills and jobs that will be needed for future energy jobs, as well. For example, they are developing an Operator Program

³⁵ Heinrichs, Mike. Program Manager, Battelle. Interviewed. Conducted by Selena Gerace. May 29, 2022.

³⁶ LiOakey, Katie. Associate Professor, University of Wyoming Department of Chemical Engineering. Interviewed. Conducted by Selena Gerace. May 9, 2022.

that would include training in operating dozers, excavators, blades, forklifts, and skid steers. (They have applied for a grant to fund this program and are waiting on approval.)³⁷

Additionally, Gillette College is partnering with the University of Wyoming Maker's Space and the University of Wyoming School of Energy Resources to develop training modules that will be available through University of Wyoming's Maker's Space. These trainings will be available as part of the Maker's Space 'Badge' program in which 'badges' are issued to indicate completion of a specific training. Some of the trainings are completely virtual, while others involve a combination of virtual and hands-on training.³⁸

UW Maker's Space already offers a wide variety of badges in topics ranging from safety to modeling and design to 3D printing. Participants sign up for badge trainings online and, once the trainings are completed, badges are issued and operate like a certificate from an issuing authority. Badges also provide a way for employers to find trained personnel with specific skillsets. If participants give approval, they will be added to a database that employers can search and send job postings to.³⁹

Gillette College and the UW School of Energy Resources 3D Visualization Center are planning to work together to develop a series of badges specific to REE/CM industry skills and information as part of the CORE-CM Initiative.⁴⁰ Gillette College will provide the raw material/information for the trainings and the 3D Visualization Center will adapt this information into educational modules.

These badges will provide a convenient and adaptable way to offer trainings in specialty skills and knowledge that will help to prepare the workforce for jobs in REE/CM industries. Potential topics for REE/CM badges include:

- Foundational information about rare earth elements and critical minerals (e.g., how they are extracted, what products they are used for, etc.)
- Information about career opportunities in mining, energy, and other regionally relevant industries
- General information about energy and other infrastructure that will be relevant for REE/CM industries.

³⁷ Grubb, Travis. Dean of Career & Technical Education, Gillette College. Interviewed. Conducted by Selena Gerace. April 5, 2022.

³⁸ Wyrkshop Maker's Space. "Badges". Accessed May 13, 2022. <https://www.wyrkshop.org/badges>

³⁹ Wyrkshop Maker's Space. "Badges". Accessed May 13, 2022. <https://www.wyrkshop.org/badges>

⁴⁰ University of Wyoming School of Energy Resources. "Powder River Basin CORE-CM". Accessed May 13, 2022. <https://www.uwyo.edu/cegr/research-projects/core-cm-prb.html>

Badges could also be issues for current programs that Gillette College offers that will be necessary for REE/CM industries. For example, equipment operator programs (dozer/excavator/forklift/skid-steer) or commercial driver's license (CDL) programs.

Conclusion

Community colleges, such as Gillette College, are poised to play an important role in providing trainings that will develop the necessary workforce for REE/CM extraction and processing. While training at the university level will also be important, people with Associates degrees and technical training will likely make up the majority of the industry. This type of workforce training will be essential as states and communities that are currently dependent on revenue from fossil energy industries seek economic development opportunities in new low-carbon energy industries. It will be important for communities to ensure they have a well-trained and prepared workforce to meet the needs of these industries.