PROCEEDINGS, 48th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 6-8, 2023
SGP-TR-224

# U.S. DOE Clean Energy Demonstration Program on Current and Former Mine Land – A Review of Geothermal Energy Case Studies and Opportunities

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**Keywords:** Mine land, clean energy deployment, geothermal, power production, mineral extraction, direct use

## ABSTRACT

The U.S. Department of Energy (DOE) Clean Energy Demonstration on Current and Former Mine Land (CEML) program was established to enable widespread clean energy deployment by demonstrating the technical and economic viability of clean energy projects on current and former mine land. Up to five clean energy projects will be carried out in geographically diverse regions, at least two of which shall be solar projects. These demonstration projects are expected to be replicable, with the knowledge and experience obtained from this first set of projects inspiring other CEML efforts. Geothermal energy is one of the potential technologies being considered. Geothermal systems are often spatially and genetically associated with ore deposits, and in some cases, have been discovered while in search for epithermal mineral resources. A wide range of geothermal applications have been employed at mine land around the world, including: 1) power generation; 2) mineral extraction from geothermal brines; 3) process heating; 4) direct use for other mining operations; 5) direct use for non-mining operations and subsurface energy storage, including geothermal heat pumps. Selected case studies highlighting these applications provide key lessons relating to identifying drivers and barriers to geothermal resource deployment, and can be used to create screening tools for identifying the types and locations of mine land most amenable to utilizing geothermal resources.

## 1. INTRODUCTION

The Office of Clean Energy Demonstrations (OCED) was established in December 2021 as part of the Bipartisan Infrastructure Law (BIL) to accelerate clean energy technologies from the laboratory to market and fill a critical innovation gap on the path to achieving our nation's climate goals of net zero emissions by 2050. As part of the BIL funding, a $500M program was created to demonstrate the technical and economic viability of carrying out clean energy projects on current and former mine land. The term "clean energy project" in this context means a project that demonstrates one or more of the following technologies: solar; micro-grids; geothermal; direct air capture; fossil-fueled electricity generation with carbon capture, utilization, and sequestration; energy storage, including pumped storage hydropower and compressed air storage; advanced nuclear technologies. This paper reviews the potential for deploying a range of different geothermal resource applications on current and former mine land primarily in the US.

## 2. LINK BETWEEN GEOTHERMAL SYSTEMS AND MINERAL DEPOSITS

Hydrothermal ore deposits, especially those associated with epithermal (shallow) systems, and geothermal systems are often intimately related to each other. Both types of systems (Fig. 1) require a heat source, fluids, and flow pathways. Epithermal ore deposits represent the mineralized remnants of fossil hydrothermal systems (e.g., White, 1981; Henley and Ellis, 1983; Hedenquist and Lowenstern, 1994; Bogie et al., 2005; Boden, 2017). Modern geothermal systems can serve as analogues that can be used to develop exploration models for hydrothermal ore deposits (e.g., White, 1981; Brown and Simmons, 2003). Many geothermal brines contain dissolved metals that represent an active ore fluid (e.g., Skinner et al., 1967; McKibben et al., 1988; Gallup, 1998; Brown and Simmons, 2003; Simmons and Brown, 2006; Breit et al., 2011). Thus, there is often a genetic connection between hydrothermal ore deposits and active geothermal systems. The McLaughlin gold mine in northern California was discovered using an exploration model based on the Broadlands geothermal system (e.g., Gustafson, 1991; Sherlock, 2005). It is important to note that in most cases, the hydrothermal systems associated with the ore deposits are no longer active, and that these represent fossil geothermal systems that no longer retain much heat. However, in some cases, there are instances where young ore deposits are associated with active geothermal systems.

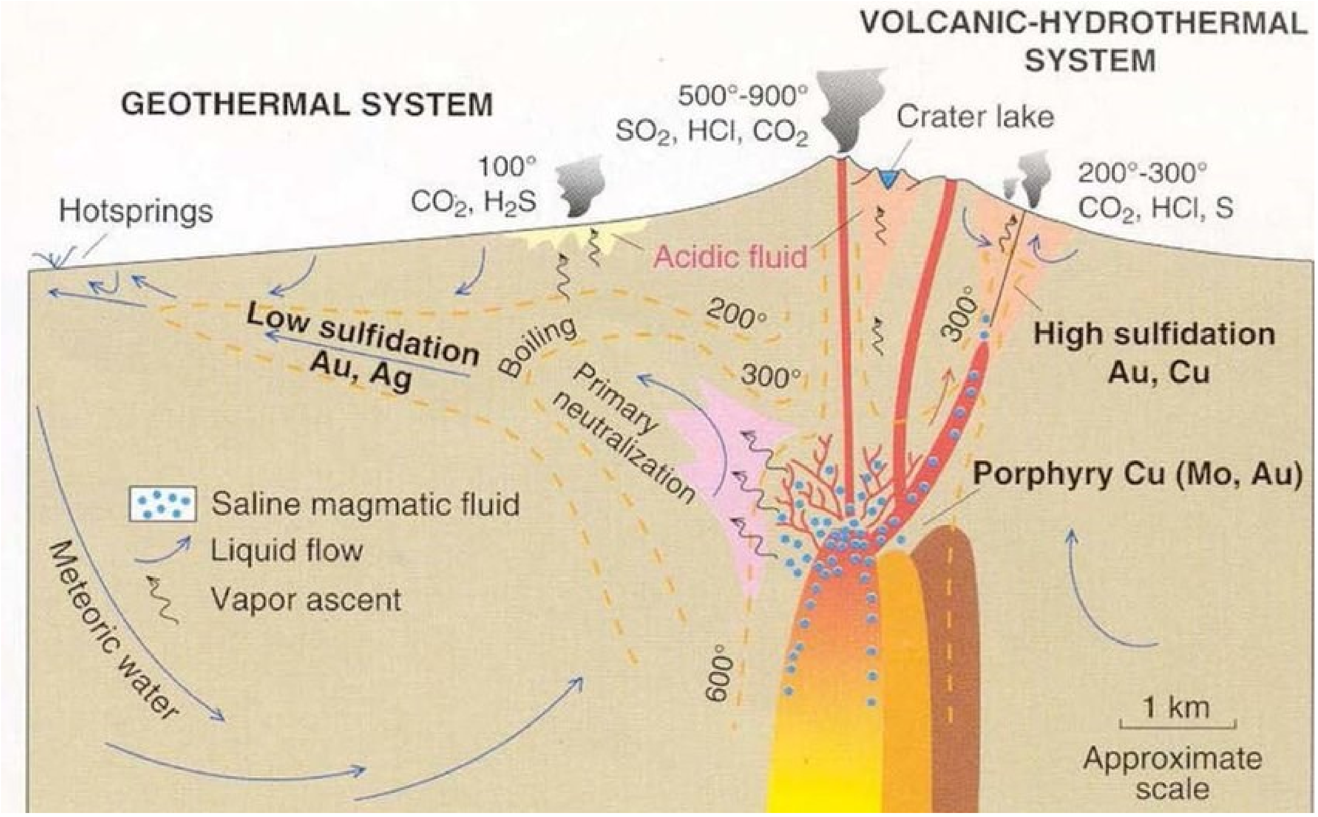


**Figure 1: Schematic cross section depicting an active geothermal system and representative geochemical processes in an arc volcanic terrane with an associated epithermal hydrothermal ore deposit (after Hedenquist & Lowenstern, 1994).**

A number of studies have noted the coincidence between the location of geothermal systems and mineral deposits in Nevada (e.g., Miller and Flynn, 1992; Faulds et al., 2005; Coolbaugh et al., 2005; 2011; Hunt et al., 2011; Simmons and Allis, 2015; Boden, 2017). Many of the currently producing geothermal fields in Nevada are "hidden" systems, that is, they do not have associated thermal features present at the surface (Dobson, 2016). Many of these developed hidden geothermal systems (e.g., McGinness Hills, Blue Mountain, Don A. Campbell, and Tungsten Mountain) were discovered in part by companies exploring for mineral resources, encountering hot water instead of commercially viable mineral resources during exploration drilling operations (e.g., Casaceli et al., 1986; Parr and Percival, 1991; Fairbank and Ross, 1999; Waibel et al., 2003; Vikre and Koutz, 2013; Orenstein et al., 2015; Dobson, 2016; Levine et al., 2022). The presence of hydrothermal alteration, sinter deposits, and elevated shallow temperatures are key indicators for the presence of hidden geothermal resources at depth. While many of the commercial epithermal mineral deposits in Nevada are Tertiary in age and thus have fossil hydrothermal systems, at least one gold mine (Florida Canyon) is associated with an active hydrothermal system (Rye Patch).

## 3. GEOTHERMAL RESOURCE APPLICATIONS FOR MINE LAND

There is a wide range of potential applications of geothermal energy, mineral resources, and subsurface thermal energy storage relevant to mine land (Preene and Younger, 2014; Patsa et al., 2015), as depicted in Fig. 2. These consist of the following categories, and span a wide range of resource depths and temperatures:

1. Power generation
2. Mineral extraction from geothermal brines
3. Process heating
4. Direct use for other mining operations
5. Direct use for non-mining operations (such as geothermal heat pumps) and subsurface energy storage

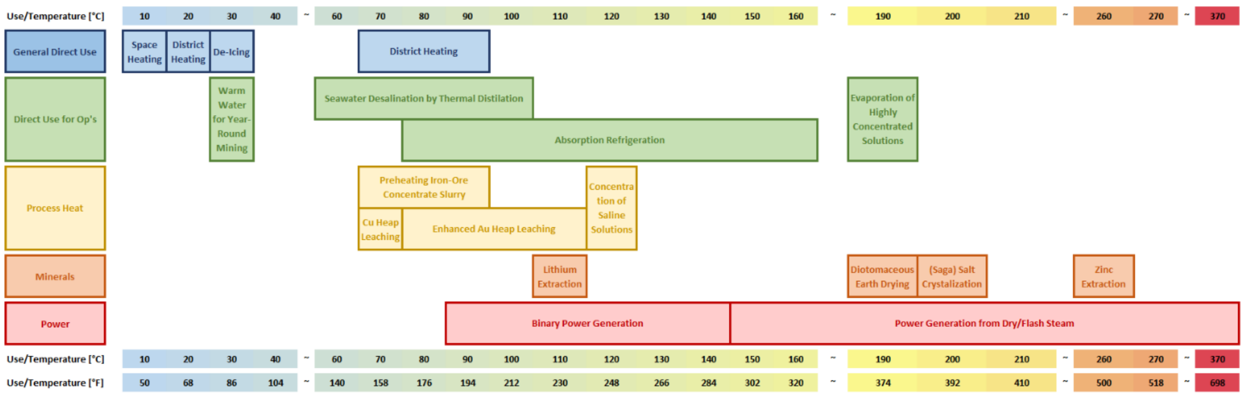


**Figure 2: Variety of uses of geothermal resource applications associated with mine land as a function of temperature (modified after Patsa et al., 2015).**

The following sections briefly describe examples of each of these geothermal resource use applications.

### 3.1 Power Generation

The best example of geothermal power generation at a mine site is the Ladolam geothermal system on Lihir Island, in Papua New Guinea (Simmons and Brown, 2006; White et al., 2010; Cooke et al., 2020). This world-class gold deposit is co-located with an active geothermal system, whose development helps depressurize the mineral deposits, thus reducing the risk of hydrothermal eruptions, and also provides electricity to power the mine's infrastructure. An initial 6 MW geothermal power plant was installed in 2003, followed by a 30 MW expansion in 2005 and an additional 20 MW of capacity was added in 2007, resulting in an overall power generation capacity of 56 MW (Maennling and Toledano, 2018).

A geothermal demonstration project was conducted at the Florida Canyon mine in Nevada (Hastings et al., 1988), where co-produced 110°C geothermal fluids were used to power a 75 kW Organic Rankine Cycle (ORC) unit (Clark, 2014). The ElectroTherm Green Machine ORC unit was in operation between 2013 and 2014, and experienced some operational issues with scaling and irregular supplies of hot water to power the system. Nevertheless, it demonstrated the feasibility of local power generation using geothermal mine water. There are two additional mining projects underway in Indonesia (the Onto porphyry Cu-Au deposit on Sumbawa and the Toka Tindung gold mine in North Sulawesi) that have associated geothermal resources with development potential.

### 3.2 Mineral Extraction from Geothermal Brines

Geothermal brines have long been recognized for containing dissolved minerals that could be extracted (e.g., McKibben et al., 1988; Gallup, 1998; Brown and Simmons, 2003; Bourcier et al., 2005; Bloomquist, 2006; Neupane and Wendt, 2017; Simmons et al., 2018). A zinc recovery plant was in operation for a short time at the Salton Sea geothermal field (Clutter, 2000). In this facility, the spent brine was flowed over an anionic exchange bed to capture the zinc, which was then recovered and purified through a variety of additional processing steps (Bourcier et al., 2005). A concerted effort focuses on directly extracting lithium (Li) from geothermal brines at the Salton Sea geothermal field and other brines that contain elevated Li concentrations (e.g., Paranthaman et al., 2017; Stringfellow and Dobson, 2021; Sanjuan et al., 2022). Berkshire Hathaway Energy Renewables commissioned in June 2022 a pilot facility to extract LiCl from their geothermal brine, and EnergySource Minerals is scheduled to start construction in 2023 on a commercial-scale $LiOH \cdot H_2O$ facility that would commence operations in 2025. Controlled Thermal Resources is also planning to develop an integrated geothermal power facility with direct Li recovery from produced geothermal brines; this facility is planned to commence operations in 2024. Lithium recovery projects are also underway at a number of geothermal fields in the Rhine Graben in Europe (e.g., Fries et al., 2022; Alms et al., 2022). Other pilot-scale mineral recovery efforts from geothermal brines involve $SiO_2$ (e.g., Lea and O'Sullivan, 2021; Climo et al., 2021).

Mineral extraction is also feasible from non-thermal mine waters. Acid mine drainage (AMD) is a major concern for many abandoned mines, where low pH waters, which commonly contain high levels of hazardous constituents, are often discharged into surface waters. However, some of these fluids contain dissolved constituents that may prove to be valuable to recover. The aqueous complexation of rare earth elements (REE) with sulfate at low pH together with the naturally extreme leaching character of acidic solutions can result in a significant enrichment of these elements in AMD, up to near ppm levels, both from sulfide ore deposits (e.g., Miekeley et al., 1992; Protano and Riccobono, 2002; Verplanck et al., 1999; 2004; Wood et al., 2005) and coal seams (e.g., Zao et al., 2009) and their associated tailings in mined areas. The precipitation of iron (oxy)hydroxides upon neutralization of these fluids and the strong surface adsorption of rare earths onto these phases at intermediate and higher pH (Verplanck et al., 2004; Tang and Johannesson, 2005) could provide a means of both mineral recovery and groundwater remediation (Ayora et al., 2015a, b). At Butte, MT, cessation of underground mining and pumping in 1982 led to the flooding of the Berkeley Pit, where almost 50 billion gallons of water have accumulated. While underground mining was suspended, copper was still being recovered from the low pH fluids from the Berkeley Pit for several decades (Duaime and McGrath, 2019). Incorporating mineral recovery into mine drainage water treatment systems may provide a source of revenue to sustain these operations and serve as an important supply to critical minerals needed for the decarbonized energy economy.

### 3.3 Process Heating

Geothermal energy can be used to supply some of a mining operation's thermal processing needs. Hot fluids can be used directly in applications such as raffinate heating in copper production and enhanced heap leaching for the extraction of gold and silver (Patsa et al., 2015). A study in Chile indicated that using 70°C geothermal water as the primary heat source in a geothermally-enhanced heap leaching alternative would increase production levels by an average of 1.2% per 1°C change in the raffinate temperature. The resulting fuel-cost savings for the proposed system upgrade corresponded to a 12-month projected payback period.

### 3.4 Direct Use for Other Mining Operations

All mine sites (both open pit and underground mines) have water. In open pit mines, water can collect in the excavated pits and tailing ponds, and most underground mines require pumping to prevent the mine from being flooded by infiltrating water. Many operating mines have to manage large quantities of water, which often includes water treatment to remove harmful constituents. However, many mine operations do not take advantage of the opportunity to harness the thermal energy potential of this water. Most operating mines have on-site space heating or cooling needs (e.g., within administrative buildings, living quarters, and the mine workings); thus, the use of geothermal waters can be applied to service these requirements. Based on a study involving 12 mines in Canada, a switch from traditional heating and cooling to very low-temperature geothermal heat pumps (GHPs) could result in total annual heat savings of 20,915 kWh, equivalent to C$1.5 million/year in cost reductions and 18,850 t in $CO_2$ emission reductions (Patsa et al., 2015). Patsa et al. (2015) reported about a new geothermal fluids plant in Argentina that would cover 66%–100% of its operational heating needs of the mine, saving up to 19–30 million L of fuel and annually reducing greenhouse gas (GHG) emissions by 53,000–93,000 Mt. In Poland, geothermal mine water heating systems have been implemented for mine offices, which have an output of 135 kWt, and mine bathhouses with an output of 20 kWt (Walls et al., 2021; Chudy, 2022). These systems both have open heat pump systems with surface discharge. At the Henderson molybdenum mine in Colorado, geothermal mine waters are used to provide heating of the mining shafts (Jensen, 1983). The use of warm water in mines has also been proposed as a way to power bioreactors used for mine wastewater treatment (Dunnington et al., 2017).

### 3.5 Direct Use and Thermal Energy Storage for Non-mining Operations

Areas near abandoned mining operations may have access to low-enthalpy heating sources and water from flooded mine sites. These fluids can be used directly or in tandem with geothermal heat pumps (GHPs) to offset or replace costs from conventional heating sources. Note that this use can involve either heat extraction from the geothermal mine fluid or heat rejection/addition to the geothermal mine fluid. Motivation for installing GHPs may come from financial savings, environmental benefits, reduction in carbon footprint, and gaining economic benefits from closed mining systems. Several review papers summarize existing projects and discuss the benefits and challenges of this direct use of mining water (Peralta Ramos et al., 2015; Preene and Younger, 2014; Walls et al., 2021; Hall et al., 2011; Chu et al., 2021). These mine water geothermal (MWG) systems require an initial investment (capital costs) of designing and emplacing a geothermal system, and these costs must be offset by the long-term operational cost savings of the geothermal system. Cost savings come from the lower maintenance cost, decreased need to import fuel, and the ability to use existing infrastructure that remains from previous or existing mining operations. MWG, in comparison to other GHP systems, can benefit from constant (and sometimes elevated) temperature and the availability of water for recirculation. The use of mine water for heating can represent a sustainable use of abandoned mine land (AML) and support economic development in locations previously supported by mining activities. These systems can also be used for seasonal thermal energy storage (e.g., Bracke and Bussmann, 2015; Hahn et al., 2022; Perez Silva et al., 2022).

A number of models have been developed to predict the performance and economics of abandoned mine geothermal systems. To support the development of geothermal from AML in the UK, the Glasgow Geothermal Energy Research center has been created to collect data and supporting information (Adams et al., 2019; Monaghan, et al., 2022). The HEATSTORE project in Bochum, Germany, is under development to demonstrate the use of an abandoned mine to store heat and to provide heating and cooling to nearby buildings (e.g., Hahn et al., 2022). Efforts in modeling potential projects, including estimating energy storage and production, heat flow in subsurface mines, and specific site readiness for geothermal have been published to support the development of AML projects worldwide (Bao et al., 2019; Chudy, 2022; Rodríguez Díez and Díaz-Aguado, 2014; Díaz-Noriega et al., 2020; Farr et al., 2016; Frejowski et al., 2021; Menéndez et al., 2020; Perez Silva et al., 2022).

Researchers at Ohio University have developed a tool for identifying mines suitable for MWG in Ohio (Richardson, 2014; Richardson et al., 2016; Madera-Martorell, 2020). Using GIS software they identified flooded mines within 1.6 km of a population area. Once locations are identified, the mines are further characterized by the effective mine water volume, groundwater velocities, flow direction, and recharge rates. Using this information and temperature of the mine water they calculate the total amount of extractable heat from the mass of the water, heat capacity of the water, and the temperature change. From this analysis they identified 147 mines sites in Ohio, 129 of them already flooded, as possible sites for direct heating use, with an average heat available of between 0.55 - 2 x 109 kJ/year with a maximum value estimated at up to 45 x 109 kJ/year. Watzlaf and Ackman (2006) identified additional screening critera, including flooding mine locations, legal concerns, water quality concerns, and geology. All of these screening methods could be broadly applied to mine sites in other areas to identify candidates for development.

Several projects have been documented since the early 1980s in Europe, Canada, and the United States in which geothermal systems have been used for heating and/or cooling in buildings, homes, and pools and other recreational areas (Preene and Younger, 2014; Peralta Ramos et al., 2015; Jessop et al., 1995; Oppelt et al., 2022). A few of these projects are highlighted below.

#### 3.5.1 Asturias, Spain

A geothermal mine water district heating project is located in the Asturias coal district of NW Spain. Boreholes have been drilled into abandoned coal mine workings of the Barredo Colliery and are used for district heating system in the town of Mieres. The volume of the mine system is 11 $Mm^3$ and maintains temperatures of about 20˚C year-round. Due to the elevated hardness of the water, a closed-loop system was installed, and a heat pump was installed to allow the system to operate at optimal conditions. It has an installed capacity of 2.2 MWt, supplying heat to two public buildings and 245 dwellings, with an annual thermal energy output of 2,460 MWh (Jardón et al., 2013; HUNOSA, 2019). The mine water heat pump system provides space heat to some buildings while using heat pumps and gas-fired boilers to provide higher-temperature water for domestic hot water needs. The estimated GHG emissions reduction when compared with using just natural gas heating is 653 tons $CO_2$/year (Lara et al., 2017). Using mine water for space heating provides an economic benefit to the mining company and to the hospital and university nearby. One key aspect for successful deployment of this system was working with the mining company during closure to develop MWG potential. During one year (2015) 7,655 total MWht of both cold and heat energy was supplied, costing 1,344 MWh of electrical energy. This resulted in an 80% reduction of $CO_2$ emissions and 10% cost savings (Lara et al., 2017; Wall et al., 2021; Menéndez et al., 2020). Based on the success of this project, another district heating project that would use the nearby Fondón Colliery is currently under consideration.

3.5.2 Heerlen, The Netherlands

A well-established network in Heerlen, Netherlands (Roijen et al., 2007; Bazargan Sabet et al., 2008; Verhoeven et al., 2014; Adams et al., 2019) encompasses a system of heat pumps to extract water from an abandoned coal mine and provide space heating and cooling to several office buildings, a university, and some homes. This system may be the world's largest AML geothermal system. The system has a heating power of 700 kW and uses mine water ranging from 16°C to 28°C, which is supplied from an open-loop system with reinjection into a deeper portion of the mine (Verhoeven et al., 2014). The heating area is reported to be 123,000 $m^3$. A hybrid network has been developed in the last stage of the project, in which the residual (unused) heating and cooling capacity from one customer is used for other customers. A thermal smart grid is planned to recognize patterns of demand over time, making the system more efficient.

3.5.3 Springhill, Nova Scotia, Canada

In Canada, a successful and long-term active system in Springhill, Nova Scotia has been operating since late 1980 (Jessop et al., 1995). This site is located over an abandoned coal mine with water temperatures averaging 18°C and generates up to 111 kW heating and 160 kW of cooling power. It is an open system with reinjection into a groundwater well. The users are several industrial buildings with a total area of 14,000 $m^3$. The data from the first year shows that the heating cost of the system was approximately C$18 thousand per year, which is less than the annual heating cost of the original building (Jessop et al., 1995). In addition to economic benefits, Jessop et al. (1995) also calculated the avoided $CO_2$ emissions to be about 370 t/year compared with a conventional geothermal heat pump system, and 780 t/year compared with oil heating and conventional air conditioning.

3.5.4 Butte, Montana, USA

At Montana Tech University in Butte, Montana, an AML geothermal system was designed to heat and cool Montana Tech's Natural Resources Building (Blackketter, 2015; Hagan, 2015; Malhotra et al., 2014; Liu et al., 2016). This closed loop GHP system was designed to supply space heating and cooling needs for a 5,200 $m^2$ building, reducing their reliance on natural gas heating and lowering the building's carbon footprint. This system was designed as a pilot program and funded by the American Recovery and Reinvestment Act, which included extensive student projects and monitoring, generating usable information on design and performance for future studies. A performance analysis based on half a year's operation (January to July 2014) indicated the system was able to deliver 88% of the building's heating and cooling needs. The system demonstrated a reduction in $CO_2$ emissions of 39% and annual savings of $17,000 in utility costs when compared with a baseline natural gas system (Blackketter, 2015). However, because of some leaking in piping, personnel turnover, and loss of institutional knowledge, the system has been nonfunctional for several years.

3.5.5 Calumet, Michigan, USA

A demonstration project using the abandoned Quincy copper mine in Calumet, Michigan, installed a geothermal mine system to provide space heating to a 1,400 $m^2$ building (Bao et al., 2019). The project provided information on the actual use and economic value of this energy source. It was reported that the system would produce 10.26 MW of thermal energy for the Keweenaw Research Center using 12.8 °C mine water from a depth of 91 m; the actual amount of thermal energy being used depends on the mine water temperature and the pumped flow rate, which can vary seasonally as heating needs change (Bao et al., 2019). Bao et al. (2019) compared the heating cost when using this system to other heating methods for the Upper Peninsula of Michigan and concluded the cost is slightly higher than from burning natural gas but much lower than using an electric resistance heater or heating oil or propane (note that these cost estimates can change due to the volatility of fossil fuel prices). The estimated installation cost of this system was $100,000 with a payback period of 3–5 years, and the system has an estimated lifetime of 20–25 years (Bao et al. 2019).

## 4. BARRIERS TO DEPLOYMENT

While the utilization of geothermal resources associated with mine land is attractive for several reasons, there are a number of challenges that need to be addressed when designing, permitting, building, and operating these systems. Challenges may include finding funding, obtaining permissions from applicable regulatory agencies, the need for extensive site-specific engineering design, economic modeling of potential benefits, management of water chemistry, licensing and permitting, and the long-term sustainability of the system. Maennling and Toledano (2018) categorized roadblocks to success into five categories: technical, available expertise, financing, regulatory, and local interest. Walls et al. (2021) used similar criteria when summarizing some of the challenges with implementing MWG systems into four categories: planning, construction, operational, and economic. Additionally, Farr and Busby (2021) indicated that two barriers to consider are ownership of the site and water rights, which may be difficult to define in terms of AML and geothermal.

A number of key lessons have been identified from based on the review of these projects. These include the following:

- Characterization of mine water chemistry is critical to ensure that problems such as scaling, clogging, and corrosion do not occur (e.g., Banks et al., 2022).
- It is important to understand the hydrology of the mine and surrounding area, and to conduct thermal-hydrologic-chemical modeling studies to identify potential technical issues to properly evaluate the resource and reduce operational risks (e.g., Preene and Younger, 2014).
- The condition of the underground workings of abandoned mines may be uncertain, as these features may undergo structural changes after closure (Banks et al., 2022).
- Meeting permitting and regulatory requirements on mine land may take significant time and effort, given the complex legal and environmental issues associated with mine land (e.g., Banks et al., 2022).
- The economics of direct use projects will depend not only on the quality and size of the geothermal resource, but also on the proximity and need for heating, cooling, and/or thermal energy storage near the mine land site (e.g., Menéndez et al., 2020).

## 5. DRIVERS FOR DEPLOYMENT

There are numerous incentives for developing geothermal resources at mine land sites. These include: 1) the reduction of GHG emissions by using geothermal energy instead of fossil fuel energy sources, which will help address the climate crisis; 2) the transformation of abandoned (and underutilized) mine land into productive green energy geothermal systems; 3) the transitioning of the mining workforce to conduct geothermal resource development and operations activities; 4) providing economic activities that will sustain mining communities that are often subject to boom and bust cycles; and 5) providing operational mines with reliable, local and sustainable clean energy resources. In addition, if mine waters contain useful thermal energy, these fluids could be harnessed in a beneficial way to support mining operations (e.g., Breunig et al., 2013). For geothermal projects to be successful, it is important that these projects be conducted in an environmentally responsible and sustainable manner, that benefits are received by the local community, and that stakeholder engagement is conducted throughout the life of the project.

## 6. THE DOE CLEAN ENERGY FOR MINE LAND PROGRAM

As part of the transition to a clean energy economy, there is an opportunity to redevelop the thousands of active and abandoned mine land sites across the United States with clean energy technologies, helping to revitalize local communities that will be impacted by the closure of coal mines as fossil energy is phased out. The Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL), includes a $500M program to demonstrate the technical and economic viability of carrying out clean energy projects on current and former mine land under section 40342 of the IIJA. The BIL also includes relevant programs to update abandoned mine land inventories, to support reclamation and remediation of abandoned mine land, as well as to promote economic development in communities where coal mines have closed. The clean energy projects under consideration under the BIL include the following technologies: solar; micro-grids; geothermal; direct air capture; fossil-fueled electricity generation with carbon capture, utilization, and sequestration; energy storage, including pumped storage hydro-power and compressed air storage; advanced nuclear technologies.

The Office of Clean Energy Demonstrations (OCED) was established in December 2021 as part of the Bipartisan Infrastructure Law (BIL) to accelerate clean energy technologies from the lab to market and fill a critical innovation gap on the path to achieving our nation's climate goals of net zero emissions by 2050. OCED issued a request for information (RFI) in 2022 to solicit input on how to best implement the CEML program. Two in-person workshops and one virtual workshop were held in the fall of 2022 by OCED, Oak Ridge National Laboratory, National Renewable Energy Laboratory, and Lawrence Berkeley National Laboratory to engage stakeholders, obtain community feedback, and spread the word about this exciting program. A Funding Opportunity Announcement (FOA) is expected to be issued by OCED in 2023 to solicit proposals from developers, mining companies, and other groups, with the goal of funding up to five demonstration projects that will develop clean energy technologies on mine land in the US. The expectation is that this initiative will spur the development of similar clean energy projects at many other mine sites across the country as the economic, environmental, and social benefits of such projects are demonstrated through this program.

It is hoped that this summary of the potential applications of geothermal resources on mine land will encourage and advance the sustainable and environmentally responsible utilization of geothermal resources on mine land sites, either through this initiative, or through related efforts. Such efforts can be made on mine land sites across the globe, and help reduce GHG emissions.

## ACKNOWLEDGMENTS

Funding for this work was provided by U.S. Department of Energy, Office of Clean Energy Demonstrations, to Lawrence Berkeley National Laboratory under Award Number DE-AC02-05CH11231, to the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DEAC36-08GO28308, and to Oak Ridge National Laboratory under Award Number DE-AC05-00OR22725. We thank Hanna Breunig (LBNL) for helpful comments. The CEML program is being managed by Regina Galer, Chris Haas, Jillian Romsdahl, and Sheela Rao from the DOE Office of Clean Energy Demonstrations (OCED), with engagement coordinated by Courtney Haynes, also from OCED.

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