Michigan Tech
Michigan Technological University

Exploring the Social Feasibility of Minewater Geothermal in Calumet

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Executive summary

Exploring the Social Feasibility of Minewater Geothermal in Calumet

This report summarizes the results of a research project aimed at understanding the community development opportunities and challenges associated with tapping into minewater for geothermal energy in Calumet, Michigan. The project focuses on social feasibility, rather than technical design. The purpose is to encourage community discussion and to provide tools and strategies for community members to consider in evaluating potential minewater geothermal projects.

What is Minewater Geothermal?

Minewater geothermal involves pumping water that has been warmed by the earth out of abandoned mines. The minewater is then run through a heat exchanger in a heat pump which transfers and concentrates the heat from the minewater to other water pipes running through buildings. The minewater is returned to the mine without any outside exposure. It works similar to any other geothermal system, except that it is more efficient because you don't have to drill to access the immense amount of water stored in the mines.

The research team reviewed active minewater geothermal projects in other locations, mapped mineshafts and calculated geographic distance between shafts and key buildings, analyzed energy demand in Calumet, and used participant observation and interviews to understand the social acceptance of minewater geothermal in the Calumet community. We evaluated these data using the Community Capitals Framework for understanding and assessing community development outcomes and potential (Flora and Flora, 2013).

Results indicate that people in Calumet are generally excited about the idea of developing minewater geothermal, but there are legitimate concerns about the cost of installation and the political process of figuring out who will benefit, who will bear costs, and how the system could be managed. People generally think of minewater as a community owned resource and minewater geothermal as a way to celebrate the cultural legacy of mining in the area while promoting environmental sustainability. Additional opportunities include the potential to realize energy savings, attract businesses and create jobs, increase tourism, and strengthen social capital, community identity, and community participation.

Photo courtesy of Edward Louie

There are 37 mineshafts in the Calumet area, mostly along Mine Street and along the Osceola lode along Hwy 41. Located near shafts are multiple public institutions (i.e., CLK Schools, Calumet Township offices, Calumet Coliseum, NPS, BKG Shelter home), commercial establishments (i.e., Calumet Electronics, Calumet Industrial Park), senior housing complexes, and private residences. District geothermal systems could prove efficient for the community, but require more initial investment and political coordination than a stand-alone system for a single building or small set. The community may want to consider developing a demonstration site at a key public building, which would celebrate community ownership, as a first step toward developing minewater geothermal.

Executive Summary

Based on these findings, minewater geothermal has potential to contribute to holistic community development, but its success would depend on the degree to which a broad set of stakeholders are involved in the decision-making and planning processes.

Moving forward, our research team advises following a community planning process with broad participation to help community members and key stakeholders understand and evaluate potential alternative strategies for development (or not) and management. Along with this process, remaining technical uncertainties that could affect the cost and design of a project would be required. These issues could potentially be addressed by strengthening relationships with Michigan Technological University and partnering with local schools.

As a research group, it is not our intention to tell the community what to do. Our role is to provide an unbiased account of the potential for minewater geothermal development to enhance community development. We hope the results of this project will stimulate dialogue within the community.

Photos courtesy of Edward Louie

This project is a result of a collaborative effort between Main Street Calumet and undergraduate and graduate students at Michigan Technological University. The project was undertaken during fall semester 2013. Team members include:

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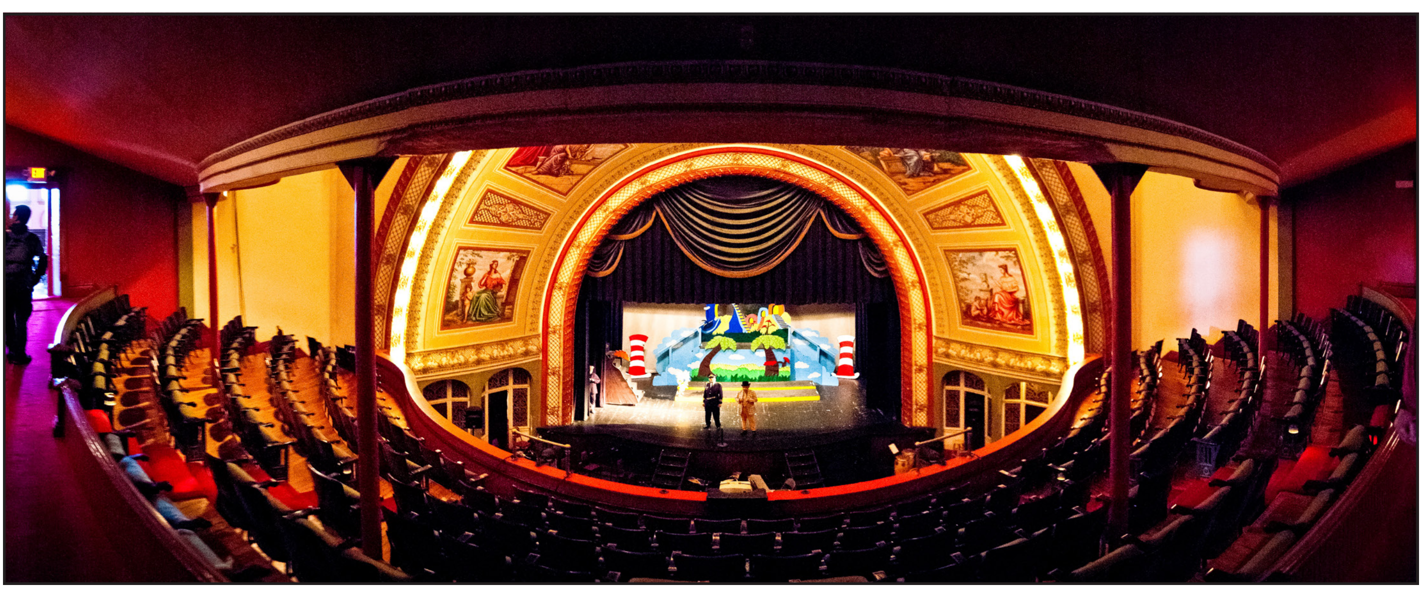
Introduction

The community of Calumet, located in Upper Michigan's Keweenaw Peninsula, once boomed as a successful mining town. When the mining operations ended, however, the population dwindled, leaving Calumet a small, remote community. The mineshafts were closed and the mines left to fill with water. The community's history of mining remains a strong legacy in the area and the abandoned mines represent an untapped source of energy.

Geothermal energy is thermal energy generated by the earth. It provides a sustainable energy source that can be used to both heat and cool buildings. Minewater geothermal involves pumping water out of abandoned mines, which has been naturally heated by the surrounding earth. The minewater can then be run through a heat exchanger in a heat pump which transfers and concentrates the heat from the minewater to other water pipes running through the buildings. Once the heat transfer has occurred, the minewater gets returned back to the mine, without any environmental exposure outside the pipes.

This report summarizes the results of a research project aimed at exploring the social feasibility of tapping into the Minewater beneath Calumet for geothermal energy.

This report summarizes the results of a research project aimed at exploring the social feasibility of tapping into the minewater beneath Calumet for geothermal energy. This project is the result of a partnership between a class at Michigan Technological University titled "Communities and Research" and Main Street Calumet. The purpose of the Communities and Research class is to learn about rural communities and how they can build upon their existing assets in order to become more sustainable. The project's goal aims to explore the potential opportunities and challenges associated with minewater geothermal energy in the Calumet area. Rather than emphasizing the technical feasibility of minewater geothermal, this project primarily investigates the social and economic aspects of how minewater geothermal may or may not benefit the Calumet community.



The Calumet Theater reminds us today of the wealth of culture brought to Calumet through the mining industry. *Photo courtesy of Edward Louie*

Minewater Geothermal: A Review of Active Cases

While seasonal temperatures can be extreme, the temperatures a few feet below ground remain nearly constant year round at approximately 45°F for the latitude of Calumet. Heat can be exchanged with this constant temperature sink and moved and concentrated by a geothermal heat pump. As with traditional air to air heat pumps, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply hot water to a home or business. The U.S. Department of Energy rates geothermal heat pumps as "one of the most efficient and durable options on the market to heat and cool" (U.S. DOE, 2011). Using mineshafts to access water heated by the earth is more efficient because you do not have to drill to reach the resource, and because the amount of water stored in the mines can be immense.

Minewater geothermal has been implemented at several locations around the world as a means to reduce heating and cooling costs and lower the carbon footprint. In small, remote communities, geothermal energy has also been shown to increase economic development and reduce the costs of conventional energy prices (Manson, 2009). This section briefly reviews minewater geothermal projects across the country and worldwide focusing on what we can learn about their social and economic outcomes that could inform decisions about whether or not to implement minewater geothermal projects in Calumet.

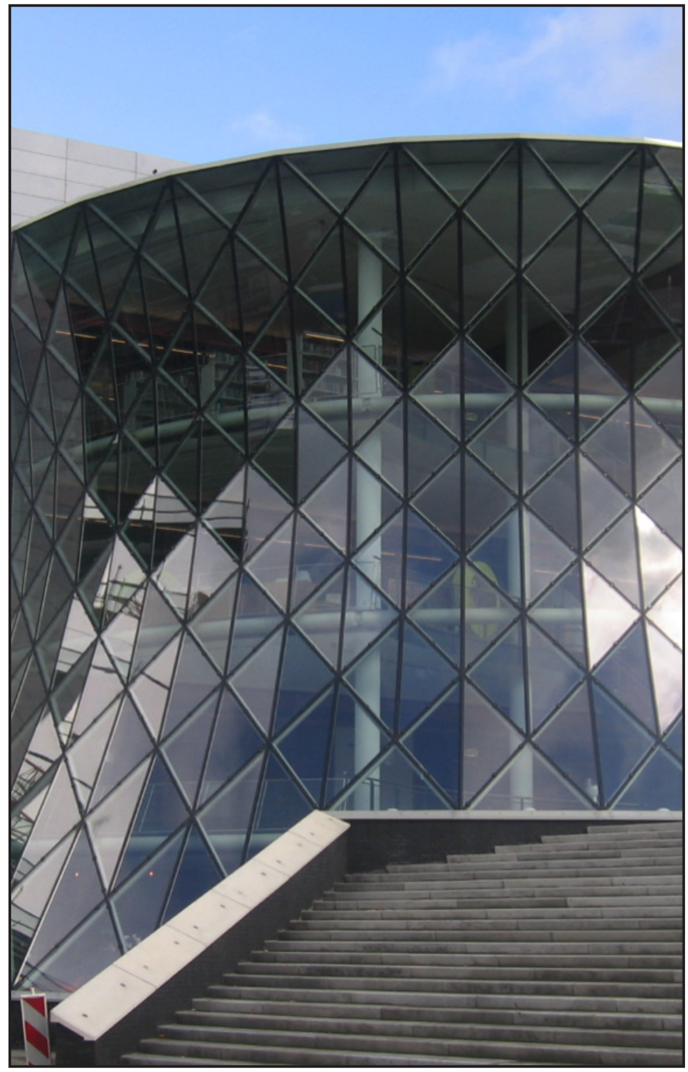
Overall, the projects reviewed show that the technical installation is feasible and that geothermal technology presents clear advantages for heating and cooling resources as opposed to other means. Investment costs can be large, but the capital return payback can be in as little as a few years (Jessop, 1995). Geothermal's high installation costs are due to the cost of the heat pump and the excavation/drilling to create the geothermal exchange field. The reuse of mineshafts eliminates the latter cost translating to significant savings (Mason, 2009). Funding may be eligible from federal and state organizations to help defray these costs (DSIRE, 2013). Also, a number of communities with a history of mining have utilized their minewater with positive results such as economic savings and increased community development (Hall, 2011).

Minewater geothermal energy in Canada started in the 1980's with a pioneering study at a plastic factory in Springhill, Nova Scotia. Ropak Packaging, a plastic container manufacturer, heats approximately 150,700 ft^2 from an old coal mine's production well 459 feet deep. The system handles 11 heat pumps used for heating and cooling. Springhill's Minewater is 64.4°F when pumped out of the mine and is returned into the mine 33 yards below the surface at 54°F (a heat load of 84 kW) during the winter and at 77°F (a

The Dr. Carson and Marion Murray Community Center houses an NHL size ice rink and saves $70,000/year in energy costs and $45,000/ year in maintenance when they switch to minewater geothermal heating and cooling. Photo courtesy of www.worldisround.com cooling load of 120 kW) during the summer. The geothermal system saves the company an estimated $160,000 per year in energy costs when compared to a typical oil furnace system, a reduction of 60% in energy costs (Jessop, 1995). Their capital was paid back in less than one year (Jessop, 1995). Since Ropak's success, outside investors entered Springhill and the Industrial Park attracted more businesses looking to benefit from geothermal energy, which has increased economic prosperity in the local community. The Springhill Geothermal Industrial Park has thus simultaneously benefited from reduced energy costs and attracted businesses looking to benefit from geothermal energy (Mason, 2009; Ewart, 2003).

In addition to the Industrial Park, Springhill's NHL sized ice rink and community center installed minewater geothermal and became the largest facility to do so in Canada. Heating and cooling with geothermal has saved the complex $70,000 per year in energy costs and $45,000 in annual maintenance cost (Gorman, 2013). Today, over a dozen local businesses either have access to or choose to use geothermal energy in Springhill (Thompson, 2013).

The largest minewater geothermal district heating project is in Herleen, Netherlands which began in October 2008. Using minewater from an abandoned coal mine, the system heats and cools 350 residences, 40,900 ft^2 of commercial space, and 174,400 ft^2 of community buildings as well as healthcare and educational buildings (Hall, 2011). The innovation was funded by Heerlen, Midlothian, Weller, BRE, WFG Kreis Aachen, BRGM, Bönen and 48% financed by the EU Interreg IIIB-programme.(Op`t Veld, 2007; Sanner, 2008). The project has reduced Carbon Dioxide (CO2) emissions by 50% and spurred development of additional buildings surrounding the geothermal energy provider (Op`t Veld, 2007). It has attracted investors, providing a new economic income for the community. Moreover, the Herleen project serves as an interpretive demonstration site and has become an attraction for tourists, engineers, and researchers from around the world.



Heerlen in the Netherlands is the largest district heating system in the world to run on mine water geothermal. Photo courtesy of www.upload.wikimedia.org

Locally, Michigan Technological University's Keweenaw Research Center (KRC) has successfully implemented a geothermal system within their 11,000 sq. foot building near the Houghton County Airport from the New Baltic No.2 Mineshaft. The supply is pumped from 300 feet below at a temperature between 55°F and 65°F year round. Their system returns water back to the mine at a depth of 60 feet. The system cost about $100,000 to install during the building's construction phase. KRC roughly estimates cost savings of about 30% over a conventional natural gas system and a payback period of three to five years (Jay Meldrum, personal communication).

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Worldwide, geothermal is a leading fuel source in renewable energy and environmental stewardship. In the United States, a total of approximately one million geothermal projects have reduced CO2 emissions by 5.8 million metric tons annually and have saved an annual 8 million kWh (Ohio Department of Natural Resources). In this context, federal and state agencies have been increasingly supportive of geothermal energy development through grants and loans. For instance, the American Recovery and Reinvestment Act of 2009 (ARRA) increased federal funding, loan guarantees, and tax credits for investment in energy efficiency and renewable energy. Moreover, efforts to utilize the untapped resource of flooded mines have been funded by the Department of Energy (DOE) with grants and funding.

Overall, our review of the literature related to active minewater geothermal cases indicates that significant carbon emission and energy cost savings can be realized. While the capital costs are higher than a natural gas or electric system, the operational savings can result in a payback period as low as a year, however, in most cases the payback period is six or more years. Payback periods are shorter if the cost of dehumidification and cooling are taken into account. While the capital cost of a district heating may be much greater than an individual system, the additional benefits provided to the community may make it worthwhile.

Calumet Context

Calumet, originally called, "Red Jacket," was incorporated in 1875 when the Calumet and Hecla (C&H) Mining Company opened copper mining operations (National Park Service, 2008). The Keweenaw copper boom happened between 1840 and 1860 when thousands of explorers and speculators flocked to the region, riding on the so-called 'copper fever'. As an outcome of the discovery of the Calumet Conglomerate lode, the treaty of Lapointe was ratified establishing a mineral land office at the Keweenaw Point (Williams, 2012; Lankton, 1991). As the prosperities of copper mining increased, C&H was not the only mining company that took interest in the area. The Tamarack Mining Company and Osceola Mining Company also operated in this region, however, C&H remained the largest and most profitable mining company in Calumet. These mining companies created 37 shafts in the local Calumet area, with the largest concentration found along Mine Street (Johnson, 1998). Due to the availability of work, many people of differing backgrounds settled in Calumet and life was centered around the mines. According to the Keweenaw National Historical Park, "Its streets echoed with the sounds of Polish, Finish, Croatian, Norwegian, Italian, Lebanese, Syrian, Chinese, and other voices from around the world." (National Park Service, 2008, p. 13). These people and their work in the mines helped enhance the rich cultural identity that Calumet has today. The last mine to close down was Calumet and Hecla mine in 1968 and all of the area's mineshafts were thereafter abandoned and left to fill with water.

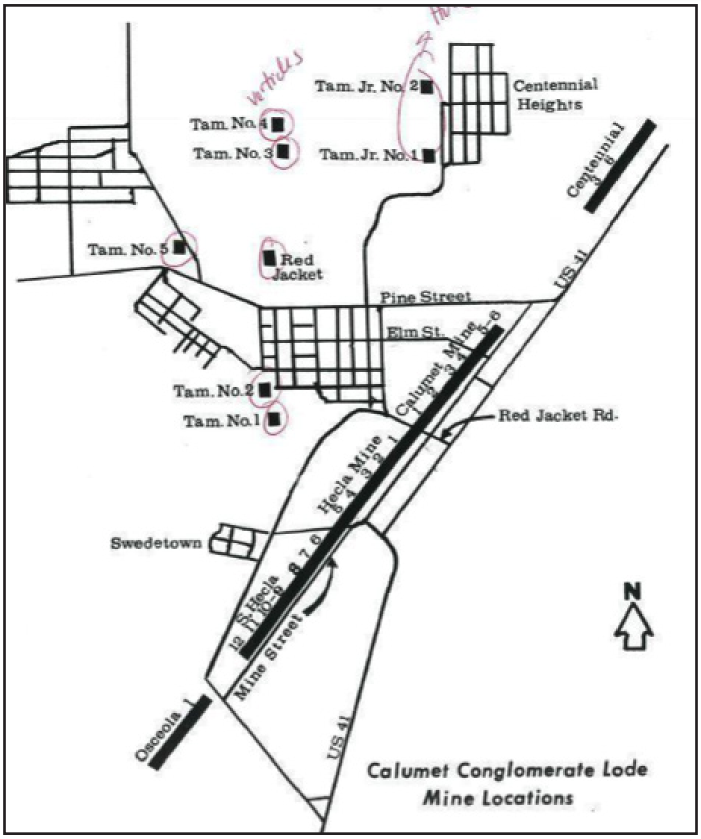


Figure 1. The Calumet area has 37 mineshafts. Those located on the Calumet Conglomerate lode are shown here. *Photo courtesy of Michigan Tech Archives*

The use of minewater for heating or cooling in Calumet is technically possible, but there are several considerations that would affect how it might be done, the upfront costs, environmental benefits, and potential cost savings. Technical considerations that affect the feasibility of minewater geothermal development include sufficient supply, demand, and favorable conditions such as temperature, location, access, and water quality (Op`t Veld, 2007; Ghoreishi, 2012). Additional money will be saved if there is easy access to the minewater and if the buildings are well insulated (Op`t Veld, 2007). Investigation about the mine's condition, the thermal dynamics of both the system and the mine, and the design stage are all critical when planning a geothermal energy system (Madiseh et al., 2012). The primary purpose of this report is not to analyze these technical considerations, but we do offer a brief summary of issues that would need to be considered and summarize what is known.

Name of Shaft	Depth (ft)	Length (ft)	Width (ft)	Number of Compartments
Calumet & Hecla Red Jacket	4900	14.5	24.5	6
Tamarack #1	3409	8	16	3
Tamarack #2	4355	8	16	3
Tamarack #3	5253	8	16	3
Tamarack #4	4450	8	16	3
Tamarack #5	5309	7	29	5
Tamarack Junior #1	Unknown			
Tamarack Junior #2	3360			

Table 1: Known Specifications of Vertical Shafts on the Calumet Conglomerate Load *(Adapted from Lane, 1909)*

At the Keweenaw Research Center (KRC), the temperature of the minewater for the first few hundred feet is 55°F, while the ground has a temperature of 45°F. Similar temperatures were found at the Hancock #2 shaft in Hancock. The temperature of the minewater in Calumet is predicted to be similarly elevated. Natural convective mixing of surface water with hotter water from depth is invaluable for replenishing the surface water with heat as it gets used in a geothermal system (Jessop, 1995).

Figure 1 shows the location of mineshafts on the Calumet Conglomerate load. Vertical shafts are circled in red, with the other shafts primarily descending at a 30° angle. The size of the shaft openings and the depths are shown in Table 1. Many of these shafts are located near businesses, community buildings, or residential homes.

The use of minewater for heating in Calumet is technically possible, but there are several considerations that would affect how it might be done and what the upfront costs, environmental benefits, and potential cost savings would be.

Some minewater projects in other regions have experienced problems with shaft stability and erosion, however, Calumet's shafts range from excellent to unknown (Johnson, 1998). The ones in excellent condition are concrete lined and still contain the skip car railings, air and water lines, and ladders. Their stability is enhanced by the fact that they are in hard basalt rock.

It is important that the intake and the return of the minewater be kept at a distance apart from one another in order to prevent the cold water return from being withdrawn prior to being reheated. Methods of accomplishing this include: pumping and returning from separate elevations, as the KRC's system does, or better yet drawing and returning from different compartments or shafts.

Tests of minewater at KRC found drinking water quality. Records of results from water samples conducted in the Calumet Conglomerate load in the early 1900s reveal the presence of sodium and chloride in the water in concentrations ranging from seawater to relatively fresh water (Lane, 1909). No published results of recent water samples could be found. Saline water and high levels of impurities will result in the corrosion of pumps, pipes and heat exchangers in an open-loop system. The purity of the water is one aspect that must be assessed to determine the suitability of an open-loop system versus a closed-loop system.

Another challenge associated with developing minewater geothermal is availability of information about the thermal behavior such as the geometry of the underground mine and the heat transfer within its rock walls. More importantly, the heat capacity for a mine is limited and the intended heat extraction should be measured. If the mine is exploited beyond capacity, its heat can be exhausted (Ghoreishi, 2012; Mason, 2009). In cases where heat demand is high (i.e. an industrial park with several high volume users), a numerical method is suggested to measure the peak demands and create heat extraction and exploitation scenarios (Ghoreishi, 2012; Michel, 2007).

Further site-specific research in Calumet is needed to resolve several technical unknowns. For instance, temperature gradients and water volumes need to be measured, water quality needs to be analyzed, heat demand requires more formal analysis, the condition of mineshafts needs to be surveyed, and the rate of heat loss in transmission pipes needs to be estimated. Fortunately given adequate surveying, exploration, data collection, and modeling, all of these unknowns are resolvable. Measurements of the temperature gradient, water sampling, and surveying of mineshafts can be accomplished with appropriate instrument probes, working together with Michigan Technological University's engineering department and/or outside firms.

If Calumet decides to implement a minewater geothermal system, we recommend that the construction design include the ability to monitor the performance of the system. The performance of a geothermal system is highly location dependent. Due to the limited number of systems in place globally, there is insufficient operational performance data. The generation of this data in Calumet would provide valuable insight for further development of minewater utilization projects in the Keweenaw and around the world.

Research Methods

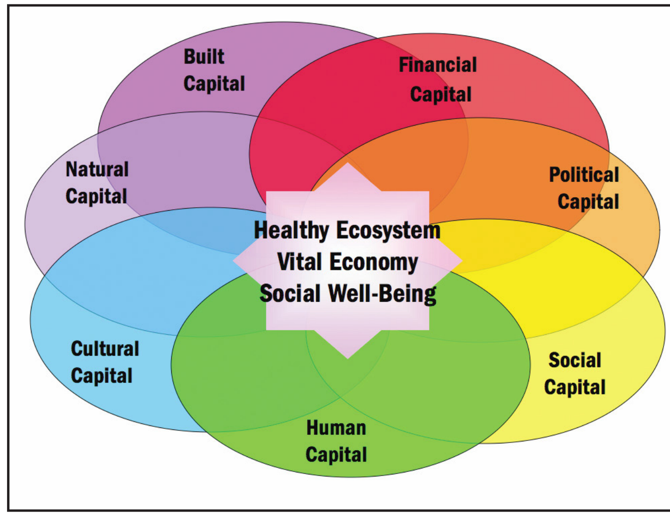
Our research team employed a variety of data collection and analysis methods, including: literature review of existing cases of minewater geothermal, energy demand analysis, geographic analysis of shaft locations, interviews, and participant observation. In addition, we collaborated with a class of engineering students at Michigan Technological University (the Alternative Energies Enterprise Team) who studied technical design options for minewater geothermal in Calumet. We gained further expertise by consulting regularly with Jay

Meldrum, a mechanical engineer and Executive Director of the Keweenaw Research Center which runs an active minewater geothermal system for heating and cooling.

Case studies of other minewater geothermal energy projects were reviewed with the purpose of finding the benefits and challenges other projects experienced and thus insight into the potential for tapping minewater geothermal energy in the Calumet area. We estimated potential demand for geothermal energy and current heating costs in the Calumet area by analyzing natural gas usage data from SEMCO Energy gas company, which provides natural gas to the Calumet area. Geographic analysis of mineshaft locations was performed by taking GPS readings of various mineshafts. We then used Google Earth to map these locations and analyze the distances between the mineshafts and several key buildings for which community members expressed interest.

The class conducted a total of 16 interviews with Calumet community leaders, volunteers, business owners, and residents. Most participants were selected using a snowball sampling process, beginning with community leaders. Three interviews were randomly drawn from addresses in the Village of Calumet. Questions asked about Calumet community vision, social acceptance of minewater geothermal, and opportunities for community change (refer to Appendix to see list of interview questions). Interviews were audio-recorded, summarized, transcribed, and coded for key themes related to community development and related opportunities and challenges associated with minewater geothermal.

Finally, students engaged in participant observation during three full day field trips to Calumet where students took tours of local buildings, including the NPS Visitors Center, the Coliseum, and the Calumet Theater; walked the downtown; explored mineshaft locations; driving tours of the Calumet and Laurium areas; and



Above is an image referencing to the integration of the capitals used in the research methods.
Photo courtesy of www.bushfoundation.org

spent time in local coffee shops, restaurants, and bars. Students recorded field notes from these experiences and shared with one another for analysis.

In order to make sense of the data we collected and determine how minewater geothermal could impact community development, we analyzed all of the data following the Community Capitals Framework. The Community Capitals Framework is a well respected community development strategy and tool for analyzing community development made popular by Cornelia and Jan Flora (Flora and Flora 2013). The framework provides an effective way to analyze community structures and develop ways to invest in existing assets in order to ensure a healthy ecosystem, strong economy, and the social well-being of communities. This approach focuses on seven different assets that communities hold and that can be developed and balanced in an effort to contribute to a broad “spiraling up” process whereby investment in one capital fuels positive outcomes across the community. The capitals a community has include: natural, cultural, human, social, political, financial, and built.

Natural capital includes the natural resources and environmental aspects of a community. Cultural capital symbolizes the way people ‘know the world' and how to act within it. Human capital consists of the skills and abilities of the people in a community. Social capital represents the connections among people and organizations of a community. Political capital corresponds to the ability to influence standards, rules, regulations and their enforcement. Financial capital consists of the financial resources available in a community. Built capital is the infrastructure that supports the community. Each capital represents different aspects of the community, but are all interconnected. Good spiraling up of a community's capitals is cumulative so that investing in one community asset encourages investment in other related assets and contributes to a holistic type of community development that benefits a broad cross-section of community members.

By carefully analyzing our interviews, field notes, and other data sources according to the Community Capitals Framework, we summarized how the community feels about the idea of using minewater geothermal energy and synthesized key opportunities and challenges associated with developing minewater geothermal. The class analyzed data by considering what it meant for each of the seven different community assets (or community capitals). In this process, we concentrated on data indicating potential positive or negative relationships between minewater geothermal and the community capitals. This line of thinking was used to determine the potential effects, both positive and negative, that may occur from investing in minewater geothermal energy.

By carefully analyzing our interviews, field notes, and other data sources according to the Community Capitals Framework, we summarized how the community feels about the idea of using minewater geothermal energy and synthesized key opportunities and challenges associated with developing minewater geothermal.

Findings

Geographic Analysis of Mineshafts

Mineshafts are scattered amongst the Calumet area, with the largest concentration being found along Mine Street. In order to evaluate geothermal possibilities for Calumet, we assessed the distances from the shafts to the buildings. In order to do this, the class took GPS readings of numerous shafts in the area and uploaded them to Google Earth. Google Earth was then used as a tool for calculating the distance between key buildings that community members determined to be of interest and the nearest mineshaft (see Table 2).

Because of the concentrations of shafts and the number of public and commercial buildings in the Mine Street area, Mine Street is arguably the most desirable location for geothermal development. Alternatively, several shafts along the Oseola lode are located along Highway 41 in primarily a residential area. These are the closest shafts to Laurium.

In addition to existing buildings near shafts on Mine Street, several open areas could offer opportunities for constructing new buildings designed for minewater geothermal use. For example, the open area behind the Calumet Fire Department is near Hecla 2 and the area behind the National Parks Library is near Hecla 1, both of these areas are roughly 200-300 feet away from the shafts mentioned. Some shafts are also sitting on open acres, such as Calumet 4 and Osceola 15. The Calumet 1 shaft is located in an empty parking lot near CLK Schools, Calumet Township offices, and the Coliseum. The empty areas mentioned could be utilized to make a new building, such as a recreation center with a pool,

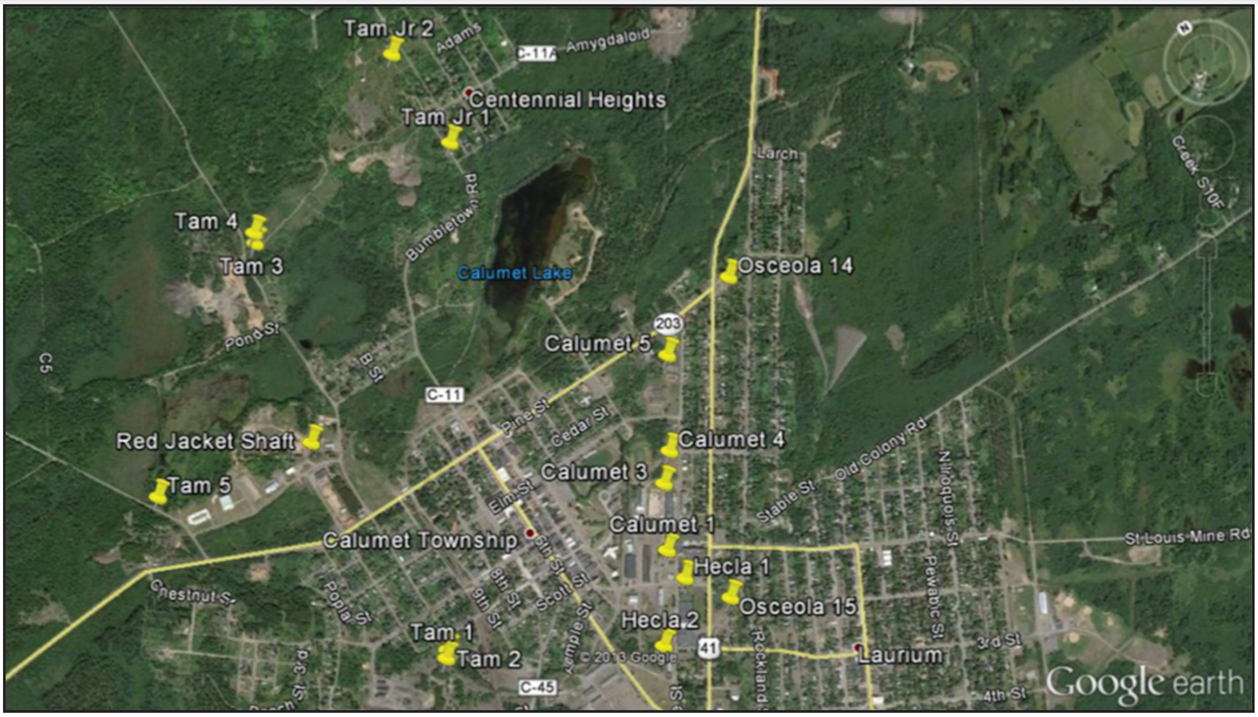


Figure 2: Shaft locations along Mine Street and surrounding areas

which could be entirely heated using geothermal energy. Alternatively, a demonstration center showcasing how minewater geothermal works, its environmental impacts, and celebrating its relationship to the cultural legacy of mining dedicated to geothermal energy could be constructed at one of these sites to draw in tourism and to serve as an educational facility.

The Red Jacket Shaft could also be used to increase development in the area, as it is located in the Industrial Park. As Table 2 notes, the shaft is roughly 230 feet away from the REL Building, and 65-300 feet away from the other industrial buildings in the area. Bare space also exists in this area, so if more buildings were to be put in they could utilize the geothermal energy which the Red Jacket Shaft could offer, similar to the Springhill Geothermal Industrial Park in Nova Scotia. Figure 2 shows a map of the shafts we considered in this analysis. This map is publically accessible at *http://tinyurl.com/n6c9zgw*, where one can see and calculate distances from these shafts to any address.

Table 2: Distances of shafts from community buildings

Shaft	Building	Distance (FT)
Calumet 1	Township Office Building	106
	CLK Schools	210
	Mishawaubik Club	250
	NPS Warehouse	280
	Coliseum	330
	NPS Headquarters	400
	NPS Visitor Center	790
Calumet 3	CLK School	80
	Michigan House Cafe	1,530
Calumet 5	Golden Horizon Apartments	50
	GardenView Assisted Living	215
Hecla 1	NPS Library	30
	Calumet Electronics -Business center	95
	Barbara Kettle Gundlach Shelter	165
	NPS Warehouse	205
	NPS Visitor Center	1,000
Hecla 2	Calumet Fire Department	175
	Calumet Electronics-Roundhouse	310
Osceola 15	Aspirus Keweenaw Hospital	1,250
	Vertin Gallery	1,850
Red Jacket Shaft	REL Building	230
	Other Industrial Buildings	65-300

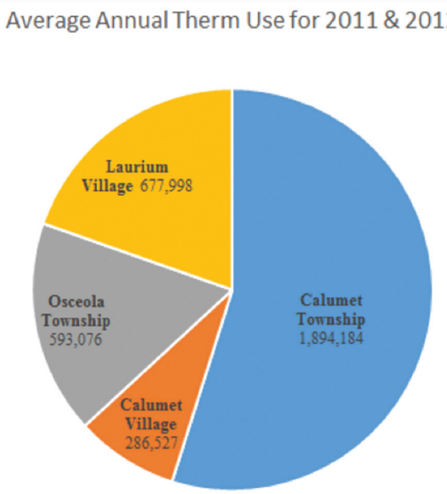


Figure 3: Average annual therm use by location

Building	Square Footage (approx)	Average Annual Therm Use	Annual Heating Cost
Calumet Township Clerk Office	2,960	2,736	$1,086
National Park Warehouse #1	4,000	4,068	$1,614
National Park History Center	10,430	4,380	$1,738
Calumet Township Fire Hall	4,500	4,524	$1,795
Calumet Electronics -Business center	15,000	9,240	$3,667
National Park Headquarters	11,500	10,500	$4,167
National Park Union Building	13,200	14,100	$5,595
Michigan House	7,500	17,328	$6,876

Table 3: Buildings assessed for heating use

Energy Demand Analysis

In order to evaluate the advantages of installing a geothermal system, it is critical to first understand the demand for energy in the area. The Calumet area (including Calumet Township, Calumet Village, Laurium Village and Osceola Township) used an average of 3,642,099 therms worth of natural gas each year over the last two years (2011 and 2012). The cost of paying for this energy at current natural gas rates is roughly $1,456,840 per year. Natural gas, provided by SEMCO, currently meets most heating needs in the local area, but some people burn wood or rely on propane or fuel oil. The therm use, broken down by location, is shown in Figure 3 below (one therm equals 100,000 Btu). The method for gathering this data can be found in the Appendix.

Data was also obtained on monthly natural gas use for eleven buildings in the Calumet area through collecting and evaluating SEMCO bills. These buildings, along with their square footage, average annual therm use, and average annual heating cost, are shown in Table 3. Average annual heating costs were calculated using natural gas rates from 2012. It should be noted that additional heating using electric or other sources are not captured in the table, so this is a conservative estimate for heating demand.

Results from interviews with business and residence owners revealed the significance of energy costs on operating expenses and family budgets. To better understand this, we estimated the average monthly heat demand and cost for a typical commercial or public building and for a typical residence in Calumet (see Figures 4 & 5). Please refer to the Appendix to find more information about how we gathered and calculated the monthly therm use for these buildings.

Photo Credit: coppercountryexplorer.com

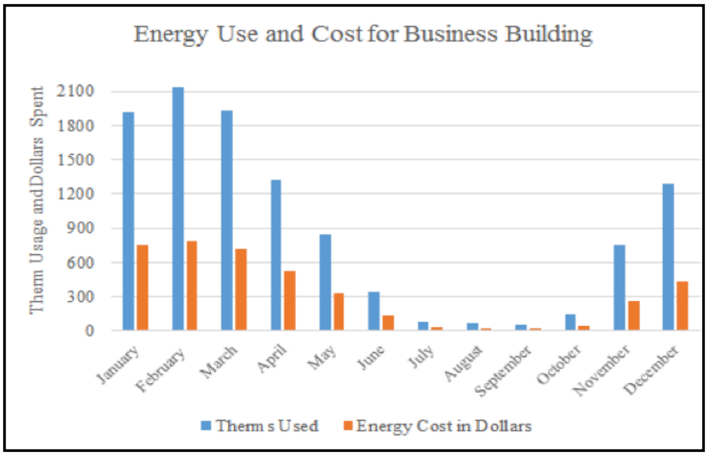


Figure 4: Average monthly heat usage and cost of an 11,000 ft² public building for the year 2012.

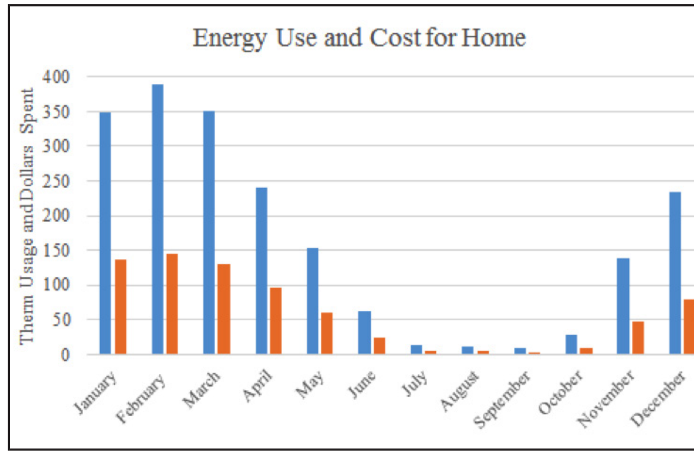


Figure 5: Average monthly heat usage and cost of a 2,000 h home for the year 2012.

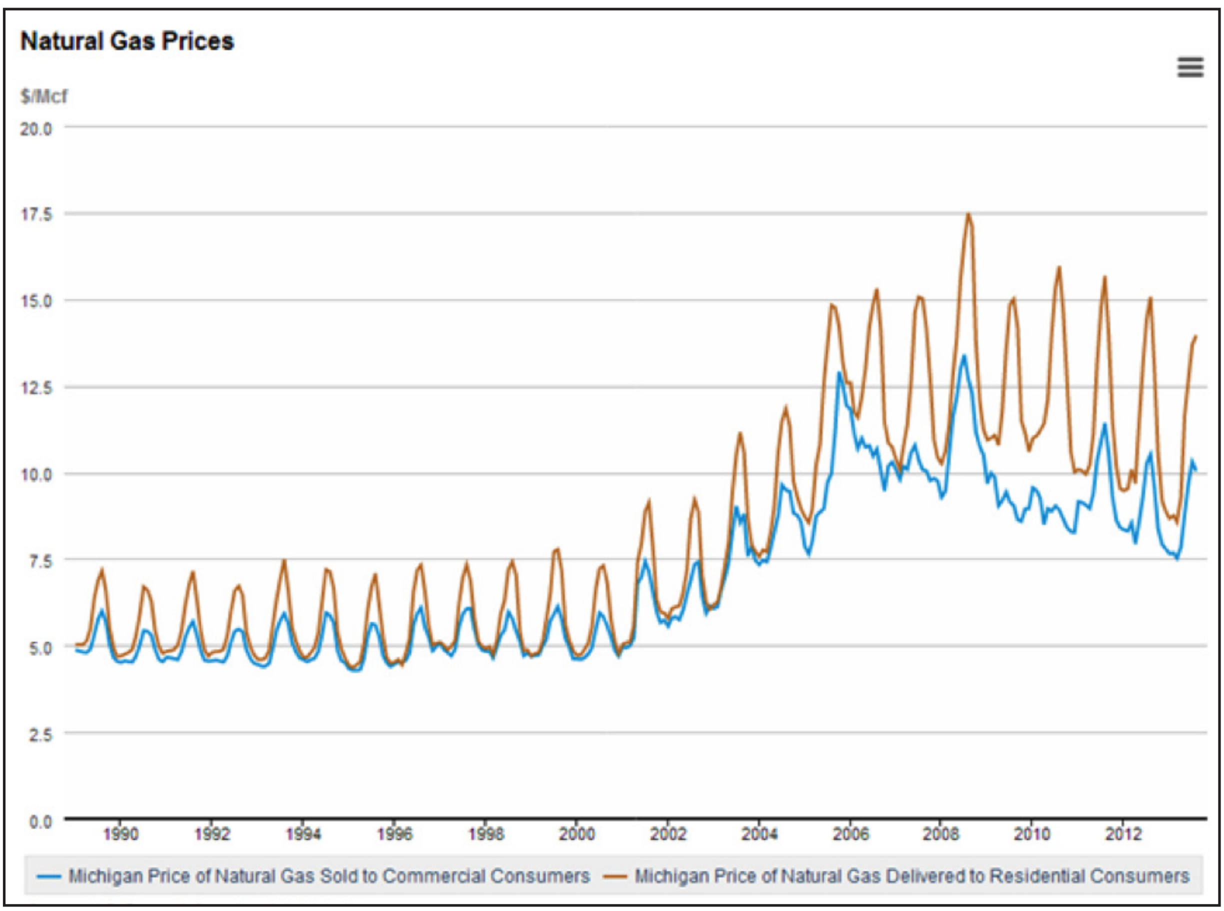


Figure 6: Michigan natural gas prices from 1990 - 2012. Photo courtesy of www.eia.gov

Community Opportunities and Challenges

Tapping into the billions of gallons of minewater beneath the Calumet area presents several key opportunities and challenges for community and economic development. The following sections summarize the opportunities and challenges our research team uncovered. The potential opportunities include: (1) strengthen social capital, community identity, and participation (2) a way to celebrate the cultural legacy of mining while promoting environmental sustainability; (3) increase economic development by attracting businesses and realizing energy savings; (4) increase tourism to the area; and (5) offer synergistic opportunities for related community development. The key potential challenges include: (1) resolving some remaining technical questions that could affect the cost and design of a project; (2) financing the installation costs; and (3) negotiating political decisions around where and how a minewater geothermal system should be installed, how it would be managed, who would benefit and who would bear the costs.

Miners for Calumet and Hecla Mining Company
Photo Courtesy of Keweenaw Archives

Opportunities

We found a general sense of excitement about the potential for developing minewater geothermal in Calumet. The key opportunities discussed below, represent the key themes that the interviewees saw as the potential opportunities that minewater geothermal could bring to Calumet.

Strengthen social capital, community identity, and participation

The people we spoke to in Calumet spoke about the minewater underneath the community as a common pool resource that their ancestors toiled to create. It belongs to "the community." As a community resource, it is something that requires careful management. Community members will need to work together to make decisions about how best to use it, or not. Developing a minewater geothermal system would require significant community effort and involvement. Calumet residents have a strong community identity and a commitment to improving the community, described as "real passionate people to carry out to make things happen" by one Calumet resident. The community already works together in running successful large-scale events like the CopperDog 150 and PastyFest.

In order to implement a minewater geothermal system in Calumet, not only would the community need to collaborate together, but it would need to partner with external agencies (such as Michigan Technological University, engineering firms, and/or state agencies) to help design the system as well. The process of engaging in practical work both within the local community and partnering

1. Resource belongs to community and community must manage
2. Community works through visioning process with partners from external agencies with technical expertise
3. Create new educational and work opportunities
4. Energy savings and tourism earnings re-invested into community projects
5. Political action to further develop and sustain the community

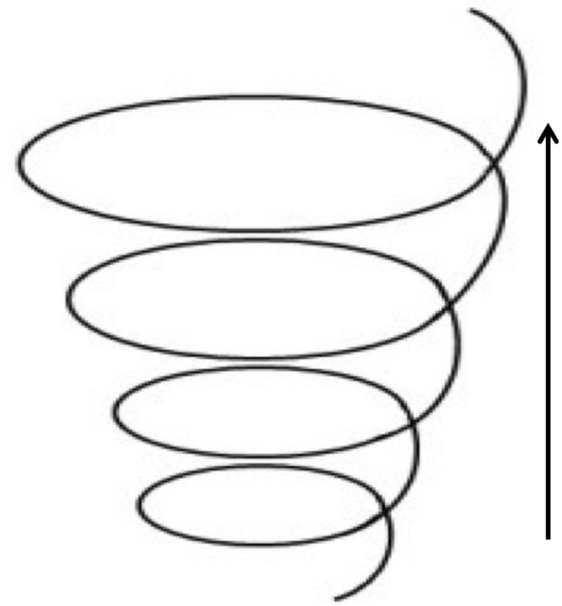


Figure 7: Spiraling up in Calumet could result in community revitalization

with external agencies has the potential to build and strengthen relationship and to create bridging relationships between communities and agencies. Investments in social capital are one of the most important ways to spur widespread community development. Working together on a key project like a minewater geothermal energy system can strengthen social capital and in turn begin a "spiraling up" process of community revitalization.

Celebrating mining's legacy while promoting environmental sustainability

Calumet's rich cultural heritage, derived in part from the copper mining industry, is highly valued and is a source of pride in the community. This is clearly demonstrated through several local events including: the 100th Anniversary of the 1913 Copper Mine Strike, PastyFest, and Heritage Days. The legacy of the copper mining industry is also reflected within the community's infrastructure. The mineshafts that once spurred expansive development in the area could now be reused to extract a sustainable energy source through geothermal energy. One interviewee commented, "…we are sitting here with this unused resource, let's find a way to use it."

Minewater geothermal presents an opportunity to celebrate the legacy of mining as a present day environmental asset that can be used to increase sustainability. One interviewee made the remark that geothermal energy represents "a nice way to try to use something that you've already got that's a natural resource that they are getting some benefit from after the mines are gone and not just have to look at slate piles or abandoned buildings." Mining used to be the primary use of natural capital and the marks of the industry still remain noticeable today. The abundant supply of minewater under Calumet represents another natural resource. The minewater could be transformed into geothermal energy to stimulate economic growth, similarly to how mining did in its past.

Geothermal is a sustainable source of energy that could reduce the community's reliance on outside sources and fossil fuels, reduce the local carbon footprint, and contribute to self-sufficiency and the preservation of the natural environment of the area. If designed correctly, this system could be sustained indefinitely, because the minewater is recycled and reused. Some research and exploration of the mines have been conducted to look into the possibilities of opening up the area to mining again. Should mining come back to the Keweenaw area, it would not be utilizing the shafts, and thus minewater geothermal and mining can coexist.

Potential for Economic Development

Minewater geothermal could potentially expand employment in the Calumet area. The construction, maintenance and management of the system would generate new jobs. Outmigration of young people to other areas in search for jobs is a concern for the community as one interviewees said: “I wish young people stay in town and do not have to leave because of lack of jobs.” The implementation of a geothermal energy system could attract locals (especially youth) to remain within in the community and entrepreneurs seeking exciting new opportunities in the Calumet community.

The 37 mineshafts in Calumet could serve as easy access points to pump the warm water to the surface, as one interviewee pointed out: “There was some type of a heat system that ran for the mining company homes. So it sounds like this was in place during those days. So if it could happen 100 years ago, it could certainly be even better today.” Indeed, reusing the mineshafts would significantly reduce the initial cost required to install a geothermal system. Minewater geothermal holds the potential to reduce the cost of heating and cooling for public facilities (such as the National Park Service, Calumet-Laurium-Keweenaw Schools, and Township and Village owned properties), which could ultimately reduce tax burden. It could also reduce heating and cooling costs for residents and for businesses located in the downtown and industrial district as previously mentioned. These savings could then be reinvested back into the community. It could reduce heating and cooling costs for potential new community projects, such as the development of a community greenhouse that could grow local produce year round, a recreation center, or for the development of the Red Jacket Educational Institute.

Increasing Tourism

Calumet’s cultural legacy, beautiful scenery, wildlife, and the nearby Lake Superior make it a popular tourist destination. Calumet offers thousands of acres of recreational areas for tourists to mountain bike, hike, ski, snowshoe, skate, dog sled, and snowmobile to name a few. Minewater geothermal holds the potential to increase tourism because the facilities using minewater geothermal could be promoted as a touristic attraction that would draw people interested in alternative energies, sustainable development, technical engineering, and mining legacies at the same time that it would reinforce current heritage tourism efforts by contributing to Calumet’s mining legacy.

Overall, this project could strengthen political action to promote community independence through local ownership and reduced reliance on outside companies to provide heating and cooling services. One of the benefits of geothermal energy compared to fossil fuel based sources such as natural gas or oil, is its low variable and operating cost, thus creating a more secure economic solution. The increased partnerships within and outside of the community, jobs, education, sustainability, and financial savings could all be opportunities gained from geothermal heating. Although there are many opportunities connected with minewater geothermal, there are challenges that must be considered as well.

CHALLENGES

A main concern related to minewater geothermal is the cost of the implementation. The Village, Township, local business, and residents of Calumet have questions such as: “How would it cost to people?”, “Who is going to pay for it?”, “How are you going to get the funding?” High poverty rates and a low tax base does not provide Calumet with many funds for such a project. Depending on the system configuration that gets implemented, different financial options are available including grants, loans, bonds, tax credits. The Database of State Incentives for Renewable Energy (DSIRE) catalogs a comprehensive source of information on state, local, utility, and selected federal incentives. Interviewees mentioned that money is more easily spent when from outside sources, but that spending can be misused, unorganized, and unreliable when working with private investors or using government grants.

Some community members may be hesitant or opposed to this change because of Calumet's current financial distress and the requirement to make a financial investment. The idea of tapping the minewater for geothermal has come up before in the past, but due to real and perceived financial issues, lack of a wider community support and outside expertise, and lack of broad community participation in discussion and planning the idea has never been fully explored.

A number of technical unknowns still exist regarding water quality, water temperature, and depth to water surface, and the maximum sustainable heat extraction rates. Some of these parameters have been ascertained at a few shafts but most have not been assessed.

The key challenges of implementing this system in Calumet include: resolving the technical aspects and remaining unknowns, addressing how to pay for the initial costs of installing the system, climate, and need to increase community involvement in decision making processes.

Cultural celebration in Agassiz Park
Photo Courtesy of Main Street Calumet

These specifics are needed in order to carry out a detailed technical and economic feasibility analysis. For an example, a high concentration of minerals may limit the design to a closed loop system to prevent clogs or corrosion of pipes.

A few community members had questions about who owns the mineral and water rights of the mines as well as who owns the mineshafts. However, the minewater geothermal system does not permanently extract minerals or water from the mines, so these concerns are most likely not applicable, though because this is a relatively rare situation there is little legal precedence on the matter. The Michigan Department of Environmental Quality has established a system for determining when and what permits are required. This system is outlined in the flowchart seen in Figure 8.

Calumet's cold weather and high amounts of snowfall may make this project challenging. A number of community members brought up concerns over the possibility of pipes freezing during the winter. This concern can be alleviated by burying the pipes below the frost line, but the cold weather may still lead to some reductions in the maximum distance a demand source can be located from a shaft opening due to greater heat loss from the water. A few community members raised concerns that using the minewater for geothermal heating might de-water the mines or cause water contamination. Neither would occur, as the water would be recycled back into the mine to be reused again, with no outside exposure to the minewater.

An important challenge to the implementation of minewater geothermal in Calumet is the concentration of power in some local institutions. Calumet Township, Mainstreet Calumet and the Village of Calumet are institutions residents perceive as key power holders. Many people believe they make final decisions about whether and what things will happened or not in the town. For instance, a resident made the comment,“if they don’t have that (good opinion of using minewater geothermal) or if the council or the… village leaders aren’t behind it, it’s not going to happen”. There is some concern about whether or not these leaders fully consider the variety of resident opinions, allow broad participation in decision making, or treat different stakeholder groups fairly so that potential benefits of minewater geothermal would be open to all.

Although using minewater geothermal in Calumet presents many exciting possibilities, the potential challenges presented above need to be considered and resolved prior to final decision making. The key challenges of implementing this system in Calumet include: resolving the technical aspects and remaining unknowns, addressing how to pay for the initial costs of installing the system, climate, and need to increase community involvement in decision making processes. If desired and willing, the community can pursue solutions to these challenges and decide whether or not implementing minewater geothermal would be practical and desired.

Summary

The Village of Calumet and surrounding areas contain 37 mineshafts, which are filled with billions of gallons of water. This minewater has the potential to offer Calumet with a new energy source. SEMCO bills of buildings in Calumet revealed the lofty financial burden many community members face during the winter months. Implementing geothermal energy could reduce heating costs while celebrating the cultural legacy of mining and community identity, promoting environmental sustainability, and strengthening social relations within the community and with key external partners.

We found general excitement in the Calumet community about the idea of tapping into the minewater for geothermal energy, though certain hesitancy remains. Challenges include the need to resolve some remaining uncertain technical aspects, funding the installation costs, and improved community involvement in the decision making processes. The community could apply for grants, form a cooperative, or sell bonds to help pay for the initial start up costs.

If these challenges could be resolved, the opportunities minewater geothermal could bring to Calumet are great. It could provide energy savings, sustainability, self-sufficient energy production, celebrate a cultural legacy, and strengthen social capital, a known way to improve community development. The success of such a project would, however, depend in part on the degree to which a broad set of stakeholders are involved in the decision-making and planning for minewater geothermal development.

This class hopes to spur discussion within the community about the utilization of minewater geothermal energy in Calumet. Working together on a project like this would build upon the social capital, spurring the “spiraling up” process, which can stimulate positive community development. The community must carefully review the opportunities and challenges and thus determine whether or not they think utilizing minewater for geothermal energy is a desirable option for Calumet and then initiate a visioning and planning process through which community members work together to determine the goals of the community.

Michigan House Cafe & Red Jacket Brewing Co.
Photo Courtesy of Edward Louie

Moving forward from this study, we recommend a broad community discussion in the form of a planning workshop to decide whether or not to further pursue the idea of minewater geothermal. If decided to pursue, we advise the creation of a committee to further evaluate issues including the locations that would participate, technical design issues, economic analysis, funding and management structures. These issues could potentially be addressed by strengthening relationships with Michigan Technological University and partnering with local schools.

Located near mineshafts are multiple public institutions (i.e., CLK Schools, Calumet Township offices, Calumet Coliseum, NPS, BKG Shelter home), commercial establishments (i.e., Calumet Electronics, Calumet Industrial Park), senior housing complexes, and private residences. There are many different ways a minewater geothermal system could be setup, such as whether to setup a district system of a single building system. A district heating system may be more capital intensive and complicated to implement, however it may have additional social benefits that may make it worthwhile. The community may want to consider developing a demonstration site at a key public building, which would celebrate community ownership, as a first step toward developing minewater geothermal.

As a research group, it is not our intention to tell the community what to do. Our role is to provide an unbiased account of the potential for minewater geothermal development as a way to enhance community development. We hope the results of this project will stimulate dialogue within the community.

Acknowledgements

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ESTIMATING COST AND ANALYZING THERMS

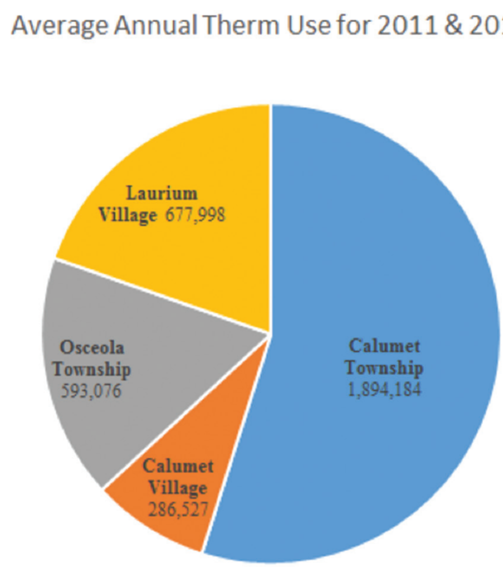

Figure 3: Average annual therm use by location

In order to break down the therm use per location census data was retrieved for each area. The number of households of each location were divided by the total number of households for the entire Calumet area, to give a percentage of how many houses they contribute to the area. The percentage of households per location was then multiplied by the monthly gas use for the Calumet area, to give the total amount of gas used per month and per location. The monthly totals were then added together to give the total amount of natural gas use per location, per year, for the years 2011 and 2012.

FLOW CHART OF PERMITS

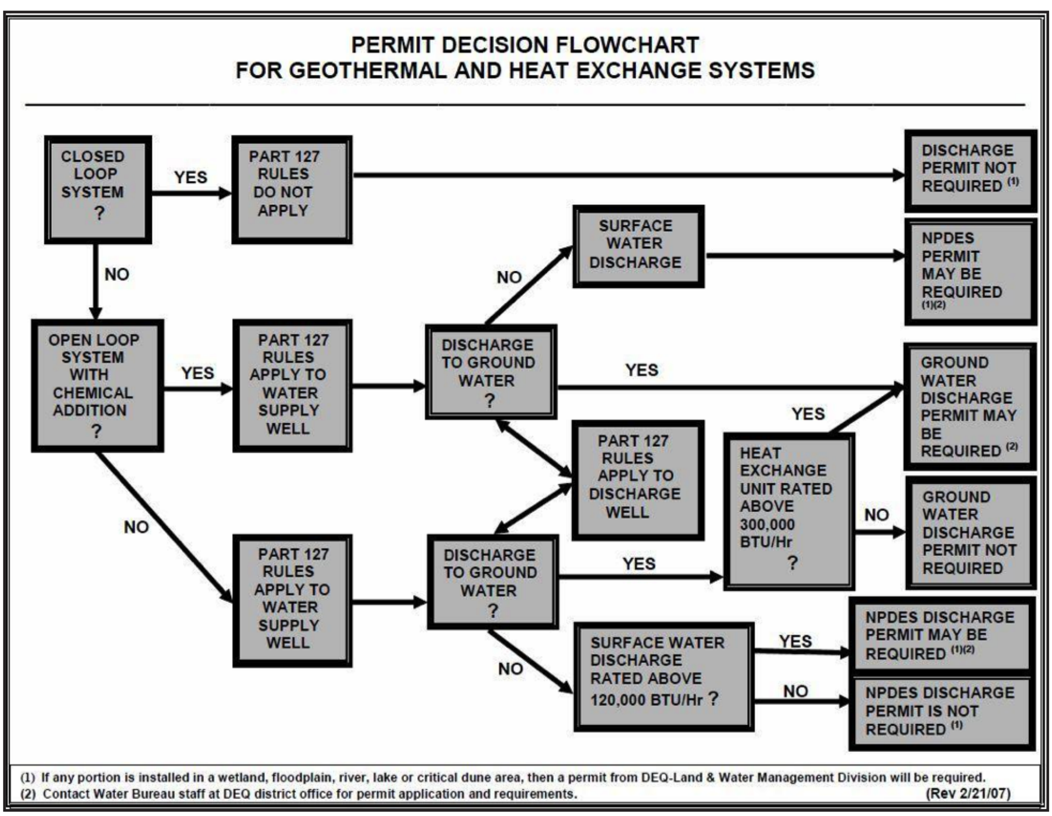

Figure 8: The Michigan Department of Environmental Quality has established a system for determining when and what permits are required. *Photo courtesy of* Michigan DEQ, 2007)

Interview Protocol

1. How long have you lived in Calumet?
    a. If always, why did you stay here?
    b. If moved in, why did you move here?
    c. If grew up here then left and came back, why did you come back?

2. I don't know much about this community. What can you tell me about Calumet? What kind of place is it?

3. What do you like most about Calumet (or this area more broadly)?

4. What are some things that you would like to see different about Calumet?

5. When good things happen in Calumet, how do they get done? Who or what makes things happen?
    a. Can you tell me about any other innovative projects that the Calumet community has been engaged in? How did this happen? How has it worked out?

6. What kind of future do you see for Calumet?

7. You may have heard that some people in the Calumet community (and around the Keweenaw Peninsula more broadly) are interested in exploring the idea of tapping into the minewater under the village for geothermal energy. This energy could be used for heating or cooling buildings or greenhouses, or possibly for converting to electricity. What do you think about this idea? [is it worthwhile to look into it? Why or why not?]

8. If the Calumet area were to tap into the minewater for geothermal energy, how would you like to see it get done? What would be important things to consider?

9. What do you see as the primary opportunities that minewater geothermal could potentially bring to Calumet?

10. What do you see as the major challenges that would make minewater geothermal difficult or problematic?

11. Do you believe that Calumet (or maybe the Keweenaw Peninsula more broadly) is capable and ready to be an innovator or leading community for sustainable energy sources? Why or why not?

12. Is there anything else that you think I should know?

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