Networked Geothermal Projects

Teacher Manual: Lesson 6

Essential Question (a.k.a. "The Big Question")
In what ways will the use of geothermal energy make our communities cleaner and healthier?

Learning objectives. Students will be able to

1. Explore the science behind networked geothermal systems and how they can contribute to clean heating
2. Identify examples of climate-critical professionals who work together to design and implement networked geothermal systems
3. Discuss the steps that communities take to explore a solution like networked geothermal systems.

Lesson Summary

This lesson explores how communities can use the Earth's natural heat for clean energy. It includes discussions of geothermal careers, the basics of geothermal system types and technologies, a Massachusetts project case study, and a closing activity focused on how to gather community support for a geothermal project.

Technology referenced in this lesson:

- Geothermal energy systems

Careers referenced in this lesson:

- Community planners
- Geothermal engineers
- Electricians

Agenda	Timing	PPT Slide
Opening Activity	5 minutes	2–4
Present agenda & learning objectives	5 minutes	5–7
Direct Instruction Video Technology introduced Careers introduced	20 minutes	8–13
Primary Learning Activity Partner or small group work Reinforce what was learned	20 minutes	14–15
Closing Review learning objectives Closing activity Reflection	5 minutes	16–17
Extension		
Handouts		
TOTAL TIME	**55 minutes**	

Pre-lesson

preparation:

- Read the student presentation deck (PPT).
- Watch the video(s) included in the student presentation deck (most are available on the MassCEC YouTube channel).
- Print worksheets and handouts prior to class.
- Verify that the computer hosting the presentation deck is connected to the internet for video and hyperlink viewing.
- Check any links in the slide deck to make sure they work as intended, and then review the content below.

Where to learn more about the lesson's content

If additional preparation time is available, these resources will provide additional background on the topics covered in this lesson.

- *Understanding Networked Geothermal Technology*
  https://www.youtube.com/watch?v=Hu3I0LfgMiM
- 4-minute video: *Eversource Networked Geothermal Neighborhood Virtual Tour*

Overview and Opening Activity (10 minutes)

Materials & Resources

- Slide deck
- Student worksheets

Opening activity: Get students thinking and talking right away.
Activity objective: To familiarize students with the core geothermal concept of underground temperature stability.
Instructions:

- Ask students to pair themselves in with someone nearby.
- Students should spend 2 minutes with a partner discussing whether they have been in a basement or cave in the summer and how they would describe it.
    - It usually feels cooler! It also tends to feel warmer in the winter.
- After a few minutes, bring students back together and ask a few people to share aloud, noting consensus or shared themes.
- The temperature, 10–15 feet below ground, stays 50–60 degrees all year long.
- Ask students for ideas as to why the temperature underground doesn't change as much as it does above ground. Answer: Earth's layers are insulating; there is no direct sunlight or wind.
- We can use this constant temperature to help heat and cool buildings, reducing our need for fossil fuels.
- Today's lesson is about geothermal systems, specifically how we may harness that energy and make the most of the underground climate solution.

Present the agenda. Students should be gaining familiarity with the format.

- After the opening activity, they will learn new information. The main activity involves groups of students analyzing a geothermal project (Lowell, MA) case study. The closing activity asks individual students to describe the need for community outreach and education to gain support for networked geothermal projects.

Present the big question and lesson objectives (see top of page 1)

- This lesson's big question focuses on the positive impact that geothermal energy could have on students' lives and communities.
- Using geothermal systems can make homes and communities cleaner and healthier.
    - Reduces greenhouse gas emissions by 60–70%
    - Lowers electricity use in hot summer months

    - Provides reliable year-round comfort
- We've already learned a bit about heat pumps, and geothermal systems are like nature's heat pumps.

Key points to emphasize:

- In the winter, when the air above ground is cooler, geothermal systems bring the heat from below ground up into buildings, raising the temperatures without the need for fossil fuels.
- In the summer, they do the same thing in reverse; because the air above ground is warmer, geothermal systems will push the warmer air back down into the ground, cooling the building.
- These systems are distinct from traditional heating or cooling systems because there's no need to burn fuel to generate heat or produce energy to create cooler air; the temperature underground remains constant.

Possible discussion questions:

- Why might a single networked geothermal system be preferable to many individual geothermal systems for a community?
- Is it possible for us to run out of geothermal energy?

Direct Instruction (20 minutes)

Provide information to help the students achieve the learning objectives and prepare them to actively engage with the activity.

- Use inquiry-based learning strategies to engage learners where possible.
- Highlight careers related to the technologies.
- Help the learners apply what they have learned to themselves and their communities.

Geothermal Heroes

Discussion guidance:

- Several different types of experts work together on geothermal energy projects, each with unique skills and training.
- Discussion must focus on three essential roles: planners, engineers, and electricians.

Key points to emphasize:

- Geothermal energy projects require diverse specialized skills, from interpersonal to highly technical.
- Three essential types of workers:
    - **Planners** are usually responsible for educating the community and ensuring everyone is on board for the project.
    - **Engineers** design, build, and maintain the system itself.
    - **Electricians** make sure that the system is correctly connected to the electric grid

and will manage any electrical repairs needed in the future.

Possible discussion questions:

- Can you think of any other job roles required to support successful geothermal projects?
- What kind of education or training might be needed to work as a geothermal planner, engineer, or electrician?

Show the video *Navigating the Future: Geothermal Networks* (3–5 minutes) and then conduct a brief check-in to hear what students took away.

Video debriefing:

- How is this project using existing infrastructure to speed up the transition to clean energy? Where else might that tactic work?
- Several professions and trades were mentioned in the video. Which ones stood out to you or interested you?
- The Framingham project relied heavily on community support. What are some ways to rally community interest and support for new clean energy projects like this geothermal project?

Suggested "Climate Watch Discussion" questions:

- Tackling climate change can feel too big to do alone. Why does a project like a networked geothermal system work well to advance climate goals?
- How would you get your community interested in a networked geothermal project where you live?
- What role does the utility company play in transitioning individual homes and communities to efficient heating and cooling?

Networked Geothermal Systems

Discussion guidance:

- How do these systems work? What advantages do they have over other energy sources for heating and cooling?
- The collector is the underground piping that transfers heat to and/or from the system. Different installation sites will require different "collector" patterns to optimize efficiency. See the illustration for examples.

Key points to emphasize:

- Geothermal systems have the most significant impact when networked to provide climate control to multiple buildings.
- These systems use a network of pipes to transfer heat, making it possible to heat and cool multiple locations efficiently.
- These systems are
    - cost-effective: Sharing infrastructure reduces costs, so installing one larger system is cheaper than installing multiple smaller ones.
    - Energy efficient: It's possible to adjust heating and cooling across multiple buildings.
    - Environmentally friendly: These systems reduce reliance on fossil fuels and cut emissions for whole neighborhoods.

Possible discussion questions:

- What's inside the geothermal collector pipes? Answer: The circulation fluid warmed/cooled by the underground loop includes a mixture of water and glycol (for freeze protection). This fluid is environmentally friendly and non-toxic.
- Why might some neighbors be hesitant to support a networked geothermal project?

Massachusetts Case Study: Framingham Pilot Project

Discussion guidance:

- MA is a leader in clean energy technology and climate goals.
- Projects in Framingham and Lowell are examples of networked geothermal systems that help reduce emissions and lower energy costs in those communities.
- These projects demonstrate how sustainable, efficient, and reliable energy sources can benefit communities.
- You will review the Framingham project together as a class, and then students will work in smaller groups to discuss the Lowell project as a case study analysis activity.

Key points to emphasize:

- Students should pay close attention to three aspects of this project:
    - **Site selection**: The location for this project was critical. Locations for geothermal systems are chosen based on factors such as soil type (rocky, soft, clay, etc.; can support the system), existing infrastructure (number of existing gas or water lines that must be moved, underground tunnels or transit lines, electricity lines, etc.), and proximity to multiple buildings that would benefit from the system. A central location can maximize the benefit of a networked system.
    - **Community engagement**: Projects like this require community education because only a few people are familiar with this technology. Others want to know how it will benefit them, how it might disrupt their lives or the risks. Community engagement includes educating the public, providing resources, addressing concerns, and ensuring that residents understand the benefits and

potential risks or disruptions. Community support is essential for success, which requires time and communication.
    - **Installation and implementation**: A geothermal system is set up by installing a series of underground pipes that link to a centralized loop. This process can involve several phases, from the first plans being made or drilling beginning to the homes and businesses being finally connected to the system.
- Successful projects require collaboration between engineers, city planners, businesses, residents, utility workers, and many more people.

Anticipated student questions:

Can participating Framingham homes and businesses control their own heating and cooling?

- Answer: Yes. Normal thermostat controls are used like any other heating/cooling system.

What about water heating?

- Answer: While it's possible to heat water with geothermal energy, this pilot project is only designed for space heating/cooling purposes.

Primary Learning Activity (20 minutes)

Materials:

- Slide deck and slides
- Student worksheets

Activity objective: Provide a real-world example of geothermal exploration and invite students to analyze and discuss the practicalities of community engagement for large-scale geothermal projects.

Instructions:

- Divide students into groups. This activity requires them to analyze a narrative case description, which may be difficult for some students.
- Groups will review the Lowell geothermal project plan details, including project goals, National Grid's geothermal system setup, and community engagement efforts (mailings, meetings, milestones).
- In their groups, students will discuss Lowell's interest in geothermal, their preparation and community engagement efforts, and the possible impact of a geothermal system on their community.
- Following the prompts on their worksheet, each group will summarize what they think were the most critical steps in gaining community support. During the debriefing

discussion, the groups will present their findings to the class.

For the debrief discussion: Invite groups to share their insights on Lowell's most important steps to gain community support for their geothermal project.

Background on the Lowell geothermal project to help guide the discussion
Steps Lowell took to prepare the community:

1. Engaged the community:
    - Hosted public forums and informational sessions to educate residents about geothermal energy and its benefits
    - Partnered with local schools and organizations to increase awareness and understanding
2. Conducted feasibility studies:
    - Collaborated with energy experts to assess the city's geology and determine the feasibility of geothermal systems
    - Identified neighborhoods where a geothermal system could be most effectively implemented
3. Ran pilot programs:
    - Developed a pilot program to test geothermal systems in specific areas, gathering data on performance and community impact
    - Worked with utility companies to explore the integration of geothermal into existing energy systems

Potential impacts of geothermal energy on the community:

- **Environmental benefits**: Reduces reliance on fossil fuels, lowering greenhouse gas emissions; decreases air pollution, improving public health.
- **Economic benefits**: Provides stable, lower-cost heating and cooling options for residents and businesses; creates local jobs in the clean energy sector.
- **Social benefits**: Builds community resilience by providing reliable energy during extreme weather events; strengthens Lowell's role as a leader in innovative, sustainable energy solutions.

Debrief discussion:

- What were the most significant benefits of the Lowell geothermal project for the community, and why?
- What challenges did the Lowell community face in implementing the geothermal project, and how were they addressed?
- How could similar geothermal projects be used in other communities?

Key takeaways:

1. Geothermal energy is a clean and renewable solution.
2. Community engagement and education are crucial to the success of geothermal and similar projects.
3. Geothermal projects have environmental, economic, and social benefits.
4. Geothermal projects require careful planning, and conducting feasibility studies and pilots may help determine the best locations and practices for long-term success.

Differentiations & Adaptations—Learning Activity (if available)

For students who benefit from visuals: Provide a diagram or infographic
Adaptation: Supply students with a visual representation of the Lowell geothermal project, such as a simplified diagram of the geothermal network and how it was laid out in the community, demonstrating energy extraction and distribution. Include labels and key terms to help students grasp the technical details more easily.
Goal: Provide students who benefit from visual aids with a clear, tangible reference for understanding the project's components and impacts.

For students who benefit from additional activity: Create a role-playing scenario
Adaptation: Assign roles to each group member (e.g., geothermal engineer, community leader, environmental advocate), and have students discuss the case study from their assigned perspectives. They can present their findings as if they were pitching the project to the community.
Goal: Students who learn best through active participation and role-playing should be immersed in the scenario.

For students who benefit from pre-group work individual reflection: Provide a guided reflection worksheet
Adaptation: Before group discussions, give students a short worksheet to complete individually. The worksheet could include a space where they could jot down their thoughts on the Lowell geothermal project's key challenges, benefits, and questions.
Goal: Allow students to process the information independently first, which will boost their confidence in contributing to the group discussion.

Closing Activity (5 minutes)

Materials

- Presentation/slide deck, slides
- Reflection journal or student worksheets

Activity objective: Students will translate the activity and the concepts of the lesson into their own community. They will be encouraged to think about the long-term community engagement and education efforts required for climate projects.

Discussion notes:

- To close out the class, invite students to respond to this prompt: *what kinds of community outreach or education do students believe would help gain support for a project like this in their own community?*

Instructional Steps:

1. Review the learning objectives so that learners can summarize what they have learned.
2. Present closing activity.
3. Allow time for reflection in the career journal.

Extensions–If Learners Love This Topic and Want More

Research a geothermal project near you

Prompt: Investigate a geothermal energy project in your region or anywhere in the world. Create a short report, model, or presentation outlining how the project works, its benefits, and any challenges faced during implementation. If no projects are nearby, research a notable example, such as Iceland's geothermal energy system.

Goal: Encourage students to explore real-world applications of geothermal technology and understand its global relevance.

Design a geothermal system for your community

Prompt: Imagine you are planning a geothermal energy system for your community. Consider local conditions (e.g., climate, population density) and design a basic plan for how the system would work. Include where the energy would be sourced, who it would serve, and what challenges might arise. Present your ideas as a diagram, map, or written proposal.

Goal: Help students apply their knowledge to a creative, community-focused project that deepens their understanding of geothermal systems.

Handouts–Group Activity

Case Study: Lowell, MA Geothermal Project

Instructions

Read the information below about the geothermal project in Lowell, MA. Work with your group to analyze this information and answer the questions provided. Identify the primary reasons for exploring geothermal energy, the preparations made by the city, and the potential effects on the community. Be prepared to present your findings to the class.

The Lowell, MA Geothermal Project

Lowell is a historic city in Massachusetts with a population eager to embrace clean energy technologies. Faced with rising energy costs and a need to reduce greenhouse gas emissions, Lowell has turned its attention to geothermal energy. Unlike traditional energy sources, geothermal energy uses the earth's natural heat to provide efficient heating and cooling, making it a renewable and sustainable option.

The city has taken several steps to explore and implement geothermal energy. First, Lowell worked with experts to study the local geology and assess whether geothermal systems would be effective in the area. These studies helped identify specific neighborhoods where a geothermal system could have the greatest impact. To build support, Lowell hosted community forums where residents could learn about geothermal energy and ask questions. These events also allowed the city to gather input from the community about their energy needs and concerns.

In addition to public engagement, Lowell launched a pilot program to test geothermal systems in select locations. Data from this pilot will help determine the feasibility of expanding geothermal energy systems to more areas of the city. Lowell also partnered with utility companies to explore how geothermal energy could be integrated into the existing energy infrastructure.

Lowell sees geothermal energy as an opportunity to address both environmental and economic challenges. By reducing reliance on fossil fuels, the city can cut emissions and improve air quality. Geothermal systems also offer long-term cost savings for residents and businesses by stabilizing heating and cooling expenses. Additionally, Lowell hopes the project will create new job opportunities in the clean energy sector and position the city as a leader in innovative energy solutions.

Geothermal energy could benefit the community significantly, but the city recognizes the importance of ongoing dialogue and flexibility as the project evolves. The pilot program results and community feedback will guide Lowell's next steps in its transition to a cleaner, more sustainable energy future.

Discussion Prompts

Why is Lowell interested in geothermal energy more than other energy sources?

What steps did Lowell take to prepare their community for geothermal energy?

What are some of the possible impacts of geothermal energy on this community?

What other questions do you have about the Lowell, MA geothermal project?

Be prepared to share your findings with the rest of the class by giving a short presentation with your group. Highlight the key points about Lowell's geothermal project and explain why it's an essential step toward clean energy. Note what Lowell did well that could be used as a model for other communities, and share questions you may still have about the project or similar community energy projects.