Geothermal Collegiate Competition

U.S. DEPARTMENT OF ENERGY

Academic Year 2021–2022 Rules

Release date: November 15, 2021

Acronyms and Abbreviations

ACH	Automated Clearing House
DOE	U.S. Department of Energy
FORGE	Frontier Observatory for Research in Geothermal Energy
GHP	geothermal heat pump
GTO	Geothermal Technologies Office
NREL	National Renewable Energy Laboratory

Summary of Changes Since the August 2021 Release

The following is a summary of changes and updates included in this Rules document since its August 2021 release:

January 2022 Update:

- Teams completing the Curriculum Elective Module are able to partner with accredited institutions of higher learning to design a geothermal supplement for an existing or planned degree or certificate program. Partnering with kindergarten through 12th grade (K-12) institutions and educational providers is also still allowed and encouraged.

November 2021 Update:

- Core Progress Submissions are optional. Teams may submit their Core Progress Submission at any time before November 18, 2021, at 5 p.m. ET. Teams may opt to submit only an Elective Modules Progress Submission. Core Progress Submissions received by November 18, 2021 will be provided feedback by December 2, 2021.

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1. COMPETITION SUMMARY

Welcome to the U.S. Department of Energy (DOE) Geothermal Collegiate Competition!

The Geothermal Collegiate Competition engages student teams to develop—and analyze—forward-thinking concepts for district energy systems using geothermal resources for a community or campus to inspire students and professionals alike.

Through the Geothermal Collegiate Competition, the DOE Geothermal Technologies Office (GTO) encourages students to develop innovative solutions for geothermal energy application challenges and build career skills for the clean energy workforce. By engaging students not traditionally involved with geothermal research, GTO aims to raise awareness of geothermal resources among communities and the public, thereby broadening the geothermal stakeholder base.

The competition engages students across geosciences, engineering, finance, regional planning, sustainability, design, communications, and other disciplines to reimagine how energy is generated and used. Students assume the role of a geothermal developer leveraging a geothermal energy resource for a district-scale direct use application. Teams describe why the district (community or campus) was selected and then analyze information including the geothermal resource as well as energy consumption and cost data. Teams also provide a preliminary economic feasibility analysis and strategy for local stakeholder engagement.

The Geothermal Collegiate Competition is designed to inspire students to consider new career opportunities, learn geothermal industry-relevant skills, engage with the community, and prepare to lead the next generation of geothermal energy development. As competitors, students:

- Gain experience with innovative renewable energy applications
- Develop real-world concepts that shape the future of geothermal energy
- Collaborate with community leaders and property owners to develop real-life geothermal applications
- Compete to earn a cash prize and national recognition.

The Geothermal Collegiate Competition invites participation by teams of at least three students enrolled in accredited U.S.-based collegiate institutions or U.S. citizens enrolled at non-U.S.-based collegiate institutions. In this case, “collegiate institution” refers to any school of postsecondary or higher education, including but not limited to community colleges, technical colleges, and traditional four-year and graduate-level universities. See “Who Can Enter” for more information on eligibility. There is no cost to register or participate.

The National Renewable Energy Laboratory (NREL) is the Geothermal Collegiate Competition administrator, and supports student team efforts through educational webinars and informational references. Learn more at https://www.energy.gov/eere/geothermal/geothermal-collegiate-competition. Questions on these rules or the program overall can be directed to Geo.Competition@nrel.gov.

Register to compete at https://www.herox.com/GeoCollegiateCompetition2022.

2. SUMMARY TIMELINE

The Geothermal Collegiate Competition spans the duration of the academic year, starting in August 2021 and culminating in May 2022.

- June 16, 2021 – 2021–2022 competition announced
- September 14, 2021, 3 p.m. ET – Informational webinar
- November 18, 2021 – Core Progress Submissions deadline (optional)
- December 2, 2021 – Feedback provided for optional Core Progress Submissions
- February 17, 2022, 5 p.m. ET – Elective Modules Progress Submission deadline (required)
- March 3, 2022 – Feedback on Elective Modules Progress Submission provided
- April 14, 2022, 5 p.m. ET – Final Submission deadline (required)
- Anticipated May 17, 2021 – Winners announced
- Summer 2022 – Winners' In-Person Stakeholder Engagement Events.

Background

Geothermal energy is a renewable energy resource derived from the Earth's heat. It is used for a wide spectrum of applications including direct use and electricity generation, spanning temperature ranges from low (e.g., 38°C/100°F) to high (e.g., 300°C/572°F and above). DOE's recent GeoVision study determined that U.S. geothermal electricity generation has the potential to increase 26-fold by 2050. The study found that "taking action consistent with the associated GeoVision Roadmap could expand the domestic geothermal industry and potentially add job opportunities in both urban and rural communities. Development of a robust residential and commercial geothermal heat pump (GHP) industry could also expand the U.S. geothermal workforce." (GeoVision: Harnessing the Heat Beneath Our Feet, 2019, p. xiii.)

DOE has a history of supporting workforce development through competitions focused on project-based learning (e.g., Solar Decathlon, Collegiate Wind Competition, EcoCAR Mobility Challenge, Cleantech University Prize). Student competitors in the Geothermal Collegiate Competition gain experience solving relevant industry challenges that prepare them for careers in geothermal and related energy fields, while benefiting from mentorship, training, and collaboration. This competition supports DOE's ongoing work to help grow the domestic geothermal industry and address employment gaps through experiential learning that inspires innovation.

3. COMPETITION PROCESS

Introduction

The Geothermal Collegiate Competition engages collegiate student teams to analyze geothermal energy (direct-use or heat pump technologies) for a district energy application. For the purposes of this competition, "districts" are defined as communities or campuses. The strongest teams are multidisciplinary, including students from geosciences; mechanical, chemical, or civil engineering; business or finance; regional planning; construction management; resource management; communications; graphic design; sustainability; education; or other degree programs. The systems proposed by students integrate a geothermal energy resource to help meet the community's energy uses and needs.

For the purposes of this competition, teams identify a community or campus use case location and propose a direct-use or heat pump application of geothermal energy.

> **Direct use,** as the name implies, involves using the heat in the water for such things as heating of districts, buildings, industrial processes, greenhouses, aquaculture (fish farming), and resorts. Direct-use projects generally use resource temperatures between 38°C (100°F) and

149°C (300°F). Current U.S. installed capacity of direct-use systems totals 470 MW, or enough energy to heat 40,000 average-sized houses (Geothermal Rising, "What is Geothermal?")

Direct, or nonelectric, use of geothermal energy refers to the use of the energy for both heating and cooling applications. Fluids with temperatures adequate for geothermal direct use are available throughout much of the United States. While accessing those fluids typically requires costly well drilling, the relatively low operations and maintenance costs (including zero fuel costs) of direct use systems means that direct use of geothermal energy in homes and commercial operations can be economically competitive under certain market conditions. Direct use of geothermal energy can help districts decarbonize their heating and cooling systems, which is of increasing value in today's energy market.

Furthermore, direct-use applications such as aquaculture, greenhouses, microbreweries, fruit and vegetable drying, spas, pulp and paper processing, and lumber drying offer attractive, low-carbon opportunities for local businesses and entrepreneurs.

Geothermal heat pumps use the natural insulating properties of the Earth to heat and cool spaces, offering a unique and highly efficient renewable energy technology for heating and cooling. Geothermal heat pumps penetrate depths from just a few feet underground to as much as several hundred feet deep, offering a unique and highly efficient renewable energy technology for heating and cooling. Most work by circulating water in a closed system through a "loop field" installed horizontally or vertically in the ground adjacent to or even beneath a building. Heat is taken from the building or district and transferred to the ground in the summer. The system is reversible, and heat is taken from the ground and used in the building in the winter. The system only moves heat, which is much more efficient than using a fuel or electricity to create heat.

Geothermal heat pumps can support space heating and cooling needs in almost any part of the country.

The district use case must be located in the United States or a U.S. territory. The use case must consist of one or more commercial or multi-family buildings, or an industrial or agricultural process use with property access rights to the geothermal resources. Each team will develop a geothermal direct-use concept for its identified use case. Students will work with real-world parameters including actual energy load, utility rates, and subsurface data while designing their district-use project. Input from community stakeholders will serve as real-world project constraints and considerations. The concepts the teams develop will provide insights that could inform community stakeholders for future development of direct-use geothermal energy resources.

Goal

Final Submissions contain three elements—a Core Submission, two Elective Modules, and a Presentation Video. For their Core Submission, each team will identify a community or campus site for a direct-use geothermal energy system and conduct an initial resource assessment, load and usage determination, and preliminary economic feasibility analysis. Teams will also develop a community engagement strategy for the local stakeholder audience at their chosen location. Each team will also prepare two (2) Elective Modules related to their project. Teams are encouraged to select Elective Modules that are relevant to team members' interests or areas of study. Teams will also include a presentation video as a part of their final submission. Final Submission elements are outlined below.

Presentation Video – Completed by all teams

1. One PowerPoint slide summarizing your project
2. 10-minute video presenting your work

Core Submission – All components are completed by all teams

3. Site Identification
4. Resource Assessment
5. Usage Assessment
6. Economic Feasibility Analysis
7. Environmental Impact Analysis
8. Stakeholder Engagement Strategy
9. Stakeholder Engagement Event Plan

Elective Modules – Each team selects two of the following to complete:

10. Curriculum Supplement

    Create an educational curriculum unit to teach local students about geothermal. Teams creating a K-12 supplement will need to align the curriculum with their applicable state standards and partner with a local school to obtain teacher input and feedback. Teams creating a supplement for an accredited institution of higher education will need to partner with a professor or administrator at the institution to ensure that the supplement aligns with the certificate/degree program. The curriculum unit should include hands-on activities as well as assessment tools to measure the effectiveness of the resources.

11. Conceptual Geologic Model

    Create a conceptual geologic model through the integration and interpretation of existing data and any additional data collected or acquired during the competition. The model should include graphical representations of key characteristics of the locality's geology and its appropriateness to host the proposed system. Key subsurface parameters could include, but are not limited to, target reservoir rock units, temperature profile, fluid content, permeability and porosity, structure and lithology, petrology, and stress regime. Supporting documentation should detail the data used with citations and interpretation methods.

12. Engineering Design

    An engineering design of your proposed system, including the location and specifications of wells, distribution networks, pumps, materials and insulation, maintenance and control points, fluid types, and points of use. Other concerns, such as the incorporation of additional energy sources to address peak demand, as well as the impacts of topography, soil quality, and other spatial concerns, should be factored into the design. Supporting documentation should detail the data used with citations and interpretation methods.

13. Project Development and Solicitation

    Create the Requests for Proposals (RFP) necessary to solicit the installation of the proposed project, including a response scoring matrix. This should be developed in partnership with the local leaders, decision makers, or utilities that would ultimately build and maintain the proposed project. This will ensure that the documents fulfill each entity's requirements for procurement and bid collection.

Diversity, Equity, and Inclusion

It is the policy of the Biden Administration that:

The Federal Government should pursue a comprehensive approach to advancing equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. Affirmatively advancing equity, civil rights, racial justice, and equal opportunity is the responsibility of the whole of our Government. Because

advancing equity requires a systematic approach to embedding fairness in decision-making processes, executive departments and agencies must recognize and work to redress inequities in their policies and programs that serve as barriers to equal opportunity. By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone.

As part of this whole-of-government approach, this competition seeks to encourage the participation of disadvantaged communities and underrepresented groups. Teams are highly encouraged to include individuals from groups historically underrepresented in science, technology, engineering, and mathematics on their project teams. Teams are highly encouraged to select sites that are located in an area that would benefit disadvantaged communities and/or underrepresented groups.

Further, Minority Serving Institutions, Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, Veteran Owned Businesses, or entities located in an underserved community that meet the eligibility requirements are encouraged to participate in this competition. The Judging Committee may consider the inclusion of these types of entities as part of the selection decision.

Prizes to Win

Prizes for the Geothermal Collegiate Competition are as follows:

First Place – $10,000 cash prize

Second Place – $5,000 cash prize

Third Place – $2,500 cash prize

The collegiate institutions of the first, second, and third-place teams will also receive a $10,000 University Support Cash Prize for their support of the team, specifically around planning and implementing a local stakeholder engagement event.

Honorable Mention, Curriculum Module – $1,000 cash prize

Honorable Mention, Reservoir Model Module – $1,000 cash prize

Honorable Mention, System Design Module – $1,000 cash prize

Honorable Mention, Project Development and Solicitation Module – $1,000 cash prize

The collegiate institutions of the prize- and honorable mention-winning teams will be publicly recognized.

Cash prizes are paid to the team captain upon receipt of proof of school enrollment, Internal Revenue Service Form W-9, and Automated Clearing House (ACH) banking information.

The collegiate institution of the team captain will receive the University Support Cash Prize. If team members from multiple universities are participating, only the team captain's university will receive the payment. If a team captain is enrolled at a non-U.S.-based institution, he or she must designate a U.S.-based institution to receive the University Support Cash Prize.

How to Enter

1. Go to the Challenge page at https://www.herox.com/GeoCollegiateCompetition2022.
2. Create a HeroX account if you do not already have one, or sign in and then choose "Solve this Challenge." This indicates your interest in competing; it is not yet a commitment.
3. For teams wishing to enter an optional Core Progress Submission, the team captain must click "Begin Entry" and then submit a "Core Progress Submission" entry on HeroX by the Core Progress Submission deadline. For all other teams, the team captain must click "Begin Entry" and submit an "Elective Modules Progress Submission" by February 17, 2022.

4. The competition administrator will review all entries received by February 17, 2022. All teams that meet the competition eligibility requirements and the Elective Modules Progress Submission evaluation statements are deemed eligible and may participate in the remainder of the competition.
5. Multiple teams from a single school may participate. Each student is only eligible to be a member on a single team.
6. Only the team captain may submit a Core Progress Submission entry. Other members join that captain's team via HeroX. Team members may be added or removed from a team at any time. Once you have created a team, you can invite additional members using HeroX. All participating student team members are expected to have HeroX accounts and be joined in a team.

How to Compete

The Geothermal Collegiate Competition consists of the following steps:

1. **Preparation** – Students identify their multidisciplinary team members and create their team on HeroX.
2. **Optional Core Progress Submission** – Teams can work toward their optional Core Progress Submission, identifying a site and conducting an initial resource assessment, and creating an initial stakeholder engagement strategy. Throughout the Progress Submission phase, the competition administrator hosts virtual educational opportunities and recommends resources to help teams complete their submission. These are announced through the HeroX platform. Teams submitting a Core Progress Submission must do so in HeroX by the Core Progress Submission deadline.
3. **Progress Submission Feedback** – The competition administrator evaluates each Progress Submission for eligibility and relevance. Each team that submits their Core Progress Submission by the suggested deadline of November 18, 2021 will be provided with comments to help them continue their work toward the Elective Modules Progress Submission and Final Submission deadline.
4. **Elective Modules Progress Submission** – Teams work toward their Elective Modules Progress Submission, selecting two of the four following modules that they will complete and beginning work on them.
    - Curriculum Supplement
    - Conceptual Geologic Model
    - Engineering Design
    - Project Development and Solicitation.

    Throughout the Elective Module Progress Submission phase, the competition administrator hosts virtual educational opportunities and recommends resources to help teams complete their submission. These are announced through the HeroX platform. Teams must enter their Progress Submission in HeroX by the deadline.
5. **Elective Modules Progress Submission Feedback** – The competition administrator evaluates each Elective Modules Progress Submission for eligibility and relevance. Comments are provided to each team to help them continue their work toward the Final Submission deadline.
6. **Final Submission** – Teams complete all required sections for their Final Submission and entry in HeroX by the deadline.
7. **Assessment** – The competition administrator screens all entered Final Submissions and assigns expert reviewers to independently score the content of each submission.

8. **Winner Selection** – Taking into account the expert reviewer scores, DOE makes a determination of the first, second, and third-place teams and honorable mention winners.
9. **Winner Announcements** – The competition administrator publicly announces the competition results. After the public announcement, all teams are individually notified of their status and receive the expert reviewer comments on their respective Final Submissions.
10. **Stakeholder Engagement Events** – The first, second, and third-place teams implement their plans for an in-person Stakeholder Engagement Event. It is expected that the university will support the winning teams in the local in-person Stakeholder Engagement Event.
11. **Prepare for the Next Competition** – Interested and eligible team members are encouraged to leverage lessons learned and skills developed in the next competition.

Each team designs its own solution to the challenge. A panel of expert reviewers individually scores each submission based on the evaluation statements given in this document. The reviewer scores play a key role in determining the winning teams, and a final selection is made by DOE GTO leadership.

What to Submit

Teams submit deliverables in three phases: a Core Package Progress Submission (optional), an Elective Module Progress Submission (required), and a Final Submission (required). The Final Submission is comprised of ten scored sections and two unscored sections. The Progress Submissions each contain a subset of these sections. Teams must submit an Elective Module Progress Submission in order for their Final Submission to be evaluated. Progress Submissions are evaluated by the competition administrator. Teams that submit Core Progress Submissions by November 18, 2021 will receive feedback, and the teams whose Elective Module Progress Submissions meet all requirements become finalists and are eligible to enter a Final Submission.

Table 1. Core Submission Package Summary

Section	Included in Progress Submission	Included in Final Submission
Site Identification	✓	✓
Resource Assessment	✓	✓
Usage Assessment		✓
Preliminary Economic Feasibility Analysis		✓
Environmental and Permitting Analysis	✓	✓
Stakeholder Engagement Strategy	✓	✓
Stakeholder Engagement Event Plan		✓
Presentation Video		✓
Summary Slide (unscored)		✓
Team Information (unscored)	✓	✓

Table 2. Elective Module Submission Summary

Section	Included in Progress Submission	Included in Final Submission
Module 1	✓	✓
Module 2	✓	✓

These packages are summarized in Tables 3, 4, and 5, and are described in greater detail in the appendices. These packages serve as the competition deliverables and are submitted via HeroX.

Only one entry is accepted from each team. Competition submissions are considered to be on time if they are received by the respective due date and time as indicated on HeroX. Late submissions may be considered on a case-by-case basis but are marked as such with notice given accordingly to the competition administrator or expert reviewers.

How We Score

Core Package Progress Submission

Core Package Progress Submissions are reviewed in accordance with the evaluation statements listed in Table 3. Feedback regarding the Core Package Progress Submission is provided to all teams who submit by the November 18, 2021 deadline.

Elective Module Progress Submission

Elective Module Progress Submissions are reviewed by the competition administrator for eligibility and in accordance with the evaluation statements listed in Table 5. Teams advance as finalists if the competition administrator agrees (on average) with the evaluation statements more than they disagree with the statements. Teams do not compete against each other to become finalists, and there is no limit on the number of finalists. Feedback regarding the Elective Module Progress Submission is provided to all teams who submit.

Final Submission

Final Submissions are screened by the competition administrator for compliance and completeness. Eligible submissions are reviewed, scored, and commented on by a panel of expert reviewers in accordance with the evaluation statements listed in Table 6. The individual reviewer scores for each submission are summed, and the summed scores from each of the reviewers are averaged to determine the final score for each submission.

The rank order of the final scores is the basis for DOE to determine the winners. An overall first, second, and third-place prize will be awarded. From the remaining submissions, an Honorable Mention for each of the Elective Modules will also be awarded. Teams identified as first second, and third-place winners are not eligible to be considered for the Elective Module honorable mentions. DOE makes the final determination of all winners.

Who Can Enter

The Geothermal Collegiate Competition invites teams consisting of at least three collegiate students that meet the following criteria:

- All participating students must be enrolled in an accredited collegiate institution. Students must be enrolled in at least one class and be pursuing a degree throughout the duration of the competition.
    - For the purposes of this competition, “collegiate institution” refers to a school of post-secondary or higher education, including but not limited to community colleges, colleges, and universities. Collegiate students of any level are eligible to compete. Teams with students from multiple universities are allowed, and multiple teams from the same university are allowed. Individual students may be members of only one team.
- The team captain and HeroX account holder for the team submission must be a U.S. citizen.
    - Teams may represent U.S.-based or non-U.S.-based accredited collegiate institutions, provided the team captain is a U.S. citizen.
    - For teams representing non-U.S.-based accredited collegiate institutions, the team captain and all team members must be U.S. citizens.
- Members of the expert reviewer panels, competition administrator staff, and DOE and national laboratory employees are ineligible to compete.

- Teams are encouraged to have at least one faculty advisor, but this is not required for participation. The faculty advisor is not an official team member and does not count toward the minimum requirement of three participating students per team.
- Teams are encouraged to ensure that their team is multi-disciplinary so that the team consists of students from all disciplines needed to produce the final submission package.
- By uploading a submission package, a team self-certifies that it is in compliance with the eligibility requirements. If the competition administrator becomes aware that a team or individual is not eligible, that team may be disqualified from competition.

4. CORE PROGRESS SUBMISSION

Competing teams may opt to enter a Core Progress Submission as an opportunity to gain valuable feedback from the Competition Administrator. Core Progress Submissions must be entered in HeroX by the submission deadline in the form of a Core Progress Submission.

Table 3 contains the content requirements and corresponding evaluation statements for the Core Progress Submission. The required file format of each component of the Core Progress Submission is indicated in brackets.

Table 3. Core Progress Submission Content and Evaluation Statements

1. Site Identification	
Map showing identified site and two-page written narrative [Single PDF document] Two-page limit does not include map of site.	
Content: • Map clearly identifying location of proposed community or campus site, surface map of the area containing the geothermal resource, and end uses • Description of the community or campus site • Explanation of why the team selected this site • Explanation of why the site is appropriate for a geothermal direct-use case.	Evaluation Statements: • The community or campus site is clearly identified. • The site is appropriate for a geothermal direct-use case.
2. Resource Assessment	
Five-page document [PDF] Five pages is inclusive of all text and figures. References cited are not included in the five-page total.	
Content: • Geothermal resource characterization at the proposed location • Description of how this resource can be accessed • Description of why this resource is adequate for the selected site and end use.	Evaluation Statements: • Adequate geothermal resources are available at this site. • The team used relevant and reputable data to conduct their assessment.

3. Environmental and Permitting Analysis	
Five-page document [PDF] Five pages is inclusive of all text and figures. References cited are not included in the five-page total.	
Content: • Potential environmental impacts (e.g., biological resources, cultural resources, other environmental sensitives) applicable to the selected site • Table summarizing applicable federal, state, and local permits/approvals for the selected site.	Evaluation Statements: • The potential environmental impacts are clearly identified. • The federal, state, and local permits/approvals are clearly identified.
4. Stakeholder Engagement Strategy	
10-slide PowerPoint presentation [saved as a PDF]	
Content: • Identification and interviews of relevant stakeholder(s) for the selected site • Stakeholder interview questions • Preliminary messaging for materials to educate stakeholders about geothermal potential at the site.	Evaluation Statements: • The team identified appropriate stakeholders for the selected site. • The team's preliminary messaging educates stakeholders about the benefits of geothermal.
5. Team Information	
These questions are answered directly in the HeroX platform. They are used to determine eligibility and for reference by competition administrators. They are not scored.	
Content: • Name, collegiate affiliation, and degree program of each team member • Team photo • Feedback or questions for the competition administrator.	

Core Progress Submission Scoring

The competition administrator evaluates the Core Package Progress Submissions using the statements given in Table 3. Core Progress Submissions are scored on a scale of 1 (strongly disagree) to 6 (strongly agree) as shown in Table 4. Feedback regarding the Core Progress Submission is provided to all teams who submit.

Table 4. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

5. ELECTIVE MODULE PROGRESS SUBMISSION

Competing teams must enter an Elective Module Progress Submission. Teams with successful Elective Module Progress Submissions are considered finalists in the Geothermal Collegiate Competition and are eligible to submit a Final Submission Package. Elective Module Progress

Submissions must be entered in HeroX by the submission deadline in the form of an Elective Module Progress Deliverable Package.

Table 5 contains the content requirements and corresponding evaluation statements for the Elective Module Progress Submission. The required file format of each component of the Elective Module Progress Submission is indicated in brackets.

Table 5. Elective Module Progress Submission Content and Evaluation Statements

1. Curriculum Supplement	
Five-page document [PDF] Five pages is inclusive of all text, tables, and figures. References cited are not included in five-page total.	
Content: • Description of grade level that curriculum will be designed for, along with name of school and teacher/administrator that team will be partnering with • Draft Standards Document (for K-12) • Draft Program Alignment Document (for post-secondary) • Outline of curriculum unit.	Evaluation Statements: • The learning objectives of the instructional materials are aligned with state curriculum standards or the certificate/degree program. • The curriculum unit is designed and organized in a manner that facilitates teacher use.
2. Reservoir Modeling	
Five-page document including map showing well locations at surface and geologic cross-sections illustrating well completions. References cited are not included in the five-page total.	
Content: • Relevant well and reservoir characterization parameters are provided and referenced; discussion and quantification of key subsurface uncertainties impacting performance predictions • Description of software application(s) selected for modeling well and reservoir performance.	Evaluation Statements: • Sources providing well and reservoir characterization parameters are referenced and subsurface uncertainties for key parameters are quantified. • The software application(s) selected for reservoir modeling is/are considered appropriate and fit for purpose given quantification of subsurface uncertainties.
3. Engineering Design	
Five-page document [PDF] Five pages is inclusive of all text and figures. References cited are not included in five-page total.	
Content: • Qualitative description of direct-use system design, including details on selected technology and necessary components/equipment.	Evaluation Statements: • The project identifies the necessary components and equipment. • The proposed system is sized appropriately for the identified resource.

4. Project Development and Solicitation	
Five-page document [PDF] Five pages is inclusive of all text and figures.	
Content: • Draft RFP Overview Document including project overview, proposal guidelines, and project description and requirements.	Evaluation Statements: • The project overview briefly and succinctly states what is being procured and why. • The proposal guidelines clearly explain to potential suppliers what you are looking for in their response.

6. FINAL SUBMISSION

The Final Submission includes a proposed community or campus site, subsurface resource characterization, energy load or usage assessment, preliminary economic feasibility analysis, environmental and permitting analysis, stakeholder engagement strategy, stakeholder engagement event plan, presentation video, and summary slide.

Final Submissions must be entered in HeroX by the submission deadline.

Table 6 contains the content requirements and corresponding evaluation statements for the Final Submission. The required file format of each component of the Final Submission is indicated in brackets. Additional details on the required content and formatting of the deliverable package sections are provided in Appendices A through E.

Table 6. Final Submission Content and Evaluation Statements

1. Submission Summary Slide (may be made public, not scored)	
Applicants are required to provide a single slide summarizing the proposed project. [Single PowerPoint slide; template available on HeroX]	
Content: • A project summary • A description of the proposed project's impact • Proposed project goals • Any key graphics (illustrations, charts, and/or tables) • The proposed project's key idea/takeaway • Project title, team name, names and email addresses of all team members and faculty advisor (if applicable).	
2. Presentation Video	
Online public video (up to 10 minutes). Ensure that your video is posted publicly online (YouTube, Vimeo, etc.)	
Content: • The real-world problem you are solving • Your solution and why it is transformational • Who you are and why you have a competitive edge.	Evaluation Statements: • The video explains a compelling real-world problem. • The video describes a unique innovation that will benefit the proposed community. • The video shows a knowledgeable and skillful team.

3. Site Identification	
Map showing identified site and two-page written narrative [Single PDF] Two-page limit does not include map of site.	
Content: • Map clearly identifying location of proposed community or campus site, surface map of the area containing the geothermal resource, and end uses • Description of the community or campus site • Description of why the team selected this site • Description of why the site is appropriate for a geothermal direct use case.	Evaluation Statements: • The community or campus site is clearly identified. • The site is appropriate for a geothermal direct use case.
4. Resource Assessment	
Five-page document [PDF] Five pages is inclusive of all text and figures. References cited are not included in five-page total.	
Content: • Geothermal resource characterization at the proposed location • Description of how this resource will be accessed • Description of why this resource is adequate for the selected site.	Evaluation Statements: • Adequate geothermal resources are available at the site. • The team used relevant and reputable data to conduct their assessment.
5. Usage Assessment	
Visual (graph or chart) and four-page written narrative [PDF] Four-page limit does not include visual (graph or chart) or references cited.	
Content: • Visual aid (chart or graph) showing annual energy end usage for the community or campus • Description of how the usage matches the available geothermal resources • Conclusions drawn from available data.	Evaluation Statements: • The chart or graph clearly demonstrates the community or campus energy usage. • The team clearly articulates accurate conclusions from the available data.
6. Preliminary Economic Feasibility Analysis	
Three-page document [PDF] References cited are not included in the three-page total.	
Content: • Identified life cycle cost and required payback period.	Evaluation Statements: • The team has used appropriate methodology and calculations to determine economic feasibility. • The payback period (return on investment) has been calculated, as well as potential future monetary savings.

<table>
<tr><th colspan="2">6. Environmental Impact Analysis</th></tr>
<tr><td colspan="2">Five-page document [PDF]
Five pages is inclusive of all text and figures. References cited are not included in five-page total.</td></tr>
<tr><td>Content:
Potential environmental impacts (e.g., biological resources, cultural resources, other environmental sensitives) applicable to the selected site
Proposed mitigation measures to address potential environmental impacts
Table summarizing applicable federal, state, and local permits/approvals for the selected site.</td><td>Evaluation Statements:
The potential environmental impacts are clearly identified and appropriate mitigation efforts are proposed.
The federal, state, and local permits/approvals are clearly identified.</td></tr>
<tr><th colspan="2">7. Stakeholder Engagement Strategy</th></tr>
<tr><td colspan="2">Visual tool or link upload [PDF or URL] and 10-page PowerPoint presentation [Saved as a PDF]</td></tr>
<tr><td>Content:
Identification and interviews of relevant stakeholder(s) for selected site
Presentation of key findings from interviews
Messaging for materials to educate stakeholders about geothermal potential at the site
A visual aid/tool (e.g., video, presentation, model, interactive website) to engage and educate local stakeholders about the geothermal potential of the community or campus geothermal direct use case
Description of how and with whom this tool was shared
A plan for sharing the tool more broadly.</td><td>Evaluation Statements:
The visual tool is innovative, with a unique and compelling story.
The visual tool is creative and clearly conveys a relevant message.
The visual tool is relevant and of high quality (increases public interest or assists decision makers).
The plan clearly defines how the team would engage appropriate stakeholders to inform them about this process, as well as possible objections and how those would be handled.</td></tr>
<tr><th colspan="2">8. Stakeholder Engagement Event Plan</th></tr>
<tr><td colspan="2">Four-page document, including letter of support from university [PDF]</td></tr>
<tr><td>Content:
A description of an in-person stakeholder engagement event that you would hold, should you win first, second, or third place
Letter from appropriate official at the team captain’s university agreeing to host a local stakeholder engagement event if the team is awarded first, second, or third place in the competition.</td><td>The in-person stakeholder event is well-thought out and will engage the correct audience.
The university is committed to hosting a stakeholder engagement event, should the team win first, second, or third place.</td></tr>
</table>

8. Team Information	
These questions are answered directly in the HeroX platform. They are used to determine eligibility and for the competition administrator's reference. They are not scored.	
Content: • Name, collegiate affiliation, and degree program of each team member • Team Photo • Feedback for the competition administrator • Favorite aspects of the competition experience.	

Elective Modules

Submit two of the four modules described in Table 7.

Table 7. Elective Modules Submission Content and Evaluation Statements

1. Curriculum Supplement	
Maximum 20-page document [saved as a PDF]. Link to visual tool or website if created. The 20-page limit is inclusive of all student handouts/worksheets and other related documents.	
Content: • An interdisciplinary curriculum unit to teach students about geothermal energy and heating, including appropriate lesson plans, handouts, assessment tools, etc. • A Standards Document aligning the unit with the appropriate state and local standards (for K-12 curriculum supplements). • A Program Alignment Document showing how the unit will fit into an existing or planned certificate or degree program.	Evaluation Statements: • The unit is aligned with appropriate state and district standards, objectives, and guidelines (K-12). The unit is aligned with the certificate/degree program (post-secondary). • There is a balance of teaching strategies, learning strategies, and authentic tasks that engage and meet the needs of diverse learners. • The formative and summative assessments measure the knowledge and skills identified in the objectives. • The unit is multidisciplinary and includes connected lessons/activities in multiple subject areas.
2. Reservoir Modeling	
Five-page document including map showing well locations at surface and geologic cross-sections illustrating well completions. References cited are not included in the five-page total.	
Content: • Relevant well and reservoir characterization parameters are provided and referenced; discussion and quantification of key subsurface uncertainties impacting performance predictions • Description of software application(s) selected for modeling well and reservoir performance • Modeled rates, pressures, and temperatures in plots of low, mid, and high case scenarios	Evaluation Statements: • Sources providing well and reservoir characterization parameters are referenced and subsurface uncertainties for key parameters are quantified. • The software application(s) selected for reservoir modeling is/are considered appropriate and fit for purpose given quantification of subsurface uncertainties.

• Description of data gathering programs needed to reduce uncertainties and improve performance predictions.	• Low, mid, and high case modeling results are presented. • Data needs to reduce subsurface uncertainties are described.
3. Direct/District Use System Design	
Five-page document [PDF] Five pages is inclusive of all text and figures. References cited are not included in five-page total.	
Content: • Qualitative description of direct-use system design, including details on selected technology and necessary components/equipment • Quantitative analysis of system design, including, but not limited to, discussion of required system size (e.g., MWth), required temperatures and flowrates, well design (e.g., depth, diameter, count), required distribution network, and any other design components specific to the proposed project • Discussion of how the system design component integrates with the usage assessment component.	Evaluation Statements: • The project identifies the necessary components and equipment. • The direct-use system is properly sized, evidenced by quantitative analysis. • The system design and usage assessment are well integrated. • Calculations and/or simulations to assess techno-economic performance of the direct-use system are included and discussed.
4. Project Development and Solicitation	
10-page document [PDF] 10 pages is inclusive of all text, tables, and figures.	
Content: • RFP document for services required for the proposed project • Potential RFP distribution list • RFP scoring matrix.	Evaluation Statements: • The RFP document clearly explains to potential suppliers the proposed project, as well as what is desired in their response. • The distribution list includes key vendors from the area of the proposed project. • The scoring matrix has clearly identified appropriate evaluation factors. • The weighting of sections and/or individual questions is reasonable and in line with industry standards.

Final Submission Scoring

Final Submissions are screened by the competition administrator for compliance and completeness. Eligible submissions will be reviewed, scored, and commented on by a panel of expert reviewers in accordance with the evaluation statements listed in Table 7.

Submissions will be scored on a scale of 1 (strongly disagree) to 6 (strongly agree). Each evaluation statement is equal weight and receives a score as shown in Table 8.

Table 8. Scoring Scale

1	2	3	4	5	6

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

The individual reviewer scores for each submission will be averaged for a total score for each submission. An additional score for each Elective Module will also be given for each submission.

The final scores for each submission will provide the basis for DOE to determine the winners. An overall first, second, and third-place prize will be awarded. From the remaining submissions, an Honorable Mention for each Elective Module will also be awarded. Teams identified as first, second, and third-place winners are not eligible to be considered for honorable mentions. DOE makes the final determination of the winners.

7. WINNING THE COMPETITION

Teams that win first, second, or third place in the competition are expected to implement their local stakeholder engagement event in the three months following the winners' announcement. The team captain's university will receive a cash prize to support the implementation of this event. It is expected that this event will take place in the United States, at or near the selected direct-use site.

Winning teams will coordinate with the competition administrator on the timing of their in-person event to ensure that a representative from NREL and/or DOE can attend. The NREL and/or DOE representative will be available to participate in the event as the team sees fit (i.e., can speak, answer questions, etc.).

8. ADDITIONAL TERMS AND CONDITIONS

Universal Contest Requirements

Your submission for the Geothermal Collegiate Competition is subject to the following terms and conditions:

- You agree to release your stakeholder engagement tool under a Creative Commons Attribution 4.0 International License (see https://creativecommons.org/licenses/by/4.0/).
- You must include all the required submission elements. The competition administrator may disqualify your submission after an initial screening if you fail to provide all required submission elements. Competitors may be given an opportunity to rectify submission errors due to technical challenges.
- Your submission must be in English and in a format readable by Adobe Acrobat Reader. Scanned hand-written submissions will be disqualified.
- Submissions and competitors will be disqualified if any engagement with the Geothermal Collegiate Competition—including but not limited to the submission, the HeroX forum, or emails to the competition administrator—contains any matter that, in the sole discretion of DOE or NREL, is indecent, obscene, defamatory, libelous, lacking in professionalism, or demonstrates a lack of respect for people or life on this planet.
- If you click "Accept" on the HeroX platform and proceed to register for the competition described in this document, these rules will form a valid and binding agreement between you and DOE and are in addition to the existing HeroX Terms of Use for all purposes relating to this contest. You should print and keep a copy of these rules. These provisions only apply to the contests described here and no other contests on the HeroX platform or anywhere else. To the extent that these rules conflict with the HeroX Terms of Use, these rules shall govern.
- The competition administrator, when feasible, may give competitors an opportunity to fix nonsubstantive mistakes or errors in their submission packages.

Verification for Payments

The competition administrator will verify the identity and the role of a participant potentially qualified to receive the prizes. Receipt of a prize payment is contingent upon fulfilling all requirements contained herein. The competition administrator will notify winning competitors using provided email contact information after the date that results are announced. Each competitor (or parent/guardian if under 18 years of age), will be required to sign and return to the competition administrator, within 30 days of the date the notice is sent, a completed NREL Request for ACH Banking Information form and a completed W-9 form (https://www.irs.gov/pub/irs-pdf/fw9.pdf). In the sole discretion of the competition administrator, a winning competitor will be disqualified from the competition and receive no prize funds if: (i) the person/entity cannot be contacted; (ii) the person/entity fails to sign and return the required documentation within the required time period; (iii) the notification is returned as undeliverable; (iv) the submission or person/entity is disqualified for any other reason.

Teams and Single-Entity Awards

The competition administrator will award a single dollar amount to the designated primary submitter, whether consisting of a single entity or multiple entities. The primary submitter is solely responsible for allocating any prize funds among its member competitors as they deem appropriate. The competition administrator will not arbitrate, intervene, advise on, or resolve any matters between team members or between teams.

Submission Rights

By making a submission, and thereby consenting to the rules of the contest as described in this document, a competitor is granting to DOE, the competition administrator, and any other third parties supporting DOE in the contest a license to display publicly and use all parts of any submission for any other government purpose. This license includes posting or linking to the portions of the submission on the competition administrator or HeroX applications, including the contest website, DOE websites, and partner websites, and the inclusion of the submission in any other media, worldwide. The submission may be viewed by the DOE, competition administrator, and reviewers for purposes of the contests, including but not limited to screening and evaluation purposes. The competition administrator and any third parties acting on their behalf will also have the right to publicize the competitor's name and, as applicable, the names of the competitor's team members and organizations which participated in the submission on the contest website indefinitely.

By entering, the competitor represents and warrants that:

1. Competitor's entire submission is an original work by competitor and competitor has not included third-party content (such as writing, text, graphics, artwork, logos, photographs, dialogue from plays, likeness of any third party, musical recordings, clips of videos, television programs or motion pictures) in or in connection with the submission, unless (i) otherwise requested by the competition administrator and/or disclosed by competitor in the submission, and (ii) competitor has either obtained the rights to use such third-party content or the content of the submission is considered to be in the public domain without any limitations on use;

2. Unless otherwise disclosed in the submission, the use thereof by competition administrator, or the exercise by competition administrator of any of the rights granted by competitor under these rules, does not and will not infringe or violate any rights of any third party or entity, including without limitation patent, copyright, trademark, trade secret, defamation, privacy, publicity, false light, misappropriation, intentional or negligent infliction of emotional distress, confidentiality, or any contractual or other rights;

3. All persons who were engaged by the competitor to work on the submission or who appear in the submission in any manner have:

a. Given competitor their express written consent to submit the submission for exhibition and other exploitation in any manner and in any and all media, whether now existing or hereafter discovered, throughout the world;

b. Provided written permission to include their name, image, or pictures in or with the submission (or if a minor who is not competitor's child, competitor must have the permission of their parent or legal guardian) and competitor may be asked by competition administrator to provide permission in writing;

c. Not been and are not currently under any union or guild agreement that results in any ongoing obligations resulting from the use, exhibition, or other exploitation of the submission.

Copyright

Each competitor represents and warrants that the competitor is the sole author and copyright owner of the submission; that the submission is an original work of the applicant or that the applicant has acquired sufficient rights to use and to authorize others, including DOE, to use the submission, as specified throughout the rules; that the submission does not infringe upon any copyright or upon any other third party rights of which the applicant is aware; and that the submission is free of malware.

Contest Subject to Applicable Law

All contests are subject to all applicable federal laws and regulations. Participation constitutes each participant's full and unconditional agreement to these contest rules and administrative decisions, which are final and binding in all matters related to the contest. This notice is not an obligation of funds; the final awards are contingent upon the availability of appropriations.

Resolution of Disputes

DOE is solely responsible for administrative decisions, which are final and binding in all matters related to the contest.

Neither DOE nor the prize administrator will arbitrate, intervene, advise on, or resolve any matters between team members or among competitors.

Publicity

The winners of these prizes (collectively, "winners") will be featured on the DOE and NREL websites.

Except where prohibited, participation in the contest constitutes each winner's consent to DOE's and its agents' use of each winner's name, likeness, photograph, voice, opinions, and/or hometown and state information for promotional purposes through any form of media, worldwide, without further permission, payment, or consideration.

Liability

Upon registration, all participants agree to assume and, thereby, have assumed any and all risks of injury or loss in connection with or in any way arising from participation in this contest, or development of any submission. Upon registration, except in the case of willful misconduct, all participants agree to and, thereby, do waive and release any and all claims or causes of action against the federal government and its officers, employees, and agents for any and all injury and damage of any nature whatsoever (whether existing or thereafter arising, whether direct, indirect, or consequential and whether foreseeable or not), arising from their participation in the contest, whether the claim or cause of action arises under contract or tort.

Records Retention and the Freedom of Information Act

All materials submitted to DOE as part of a submission become DOE records and are subject to the Freedom of Information Act. The following applies only to portions of the submission not designated as public information in the instructions for submission. If a submission includes trade secrets or information that is commercial or financial, or information that is confidential or privileged, it is furnished to the Government in confidence with the understanding that the information shall be used or disclosed only for evaluation of the application. Such information will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act. Without assuming any liability for inadvertent disclosure, DOE will seek to limit disclosure of such information to its employees and to outside reviewers when necessary for review of the application or as otherwise authorized by law. This restriction does not limit the Government's right to use the information if it is obtained from another source.

Submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

The submission must be marked as follows and identify the specific pages containing trade secrets, confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:

Pages [list applicable pages] of this document may contain trade secrets, confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes. [End of Notice]

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Trade Secrets, Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, each line or paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets.

Competitors will be notified of any Freedom of Information Act requests for their submissions in accordance with 29 C.F.R. § 70.26. Competitors may then have the opportunity to review materials and work with a Freedom of Information Act representative prior to the release of materials.

Privacy

If you choose to provide HeroX with personal information by registering or completing the submission package through the contest website, you understand that such information will be transmitted to DOE and may be kept in a system of records. Such information will be used only to respond to you in matters regarding your submission and/or the contest unless you choose to receive updates or notifications about other contests or programs from DOE on an opt-in basis. DOE and NREL are not collecting any information for commercial marketing.

General Conditions

DOE reserves the right to cancel, suspend, and/or modify the contest, or any part of it, at any time. If any fraud, technical failures, or any other factor beyond DOE's reasonable control impairs the integrity or proper functioning of the contests, as determined by DOE in its sole discretion, DOE may cancel the contest.

Although DOE indicates that it will select up to several winners for each contest, DOE reserves the right to only select competitors that are likely to achieve the goals of the program. If, in DOE's determination, no competitors are likely to achieve the goals of the program, DOE will select no competitors to be winners and will award no prize money.

ALL DECISIONS BY DOE ARE FINAL AND BINDING IN ALL MATTERS RELATED TO THE CONTEST.

9. COMPETITION AUTHORITY AND ADMINISTRATION

The Geothermal Collegiate Competition is organized by DOE and NREL, which is managed and operated by the Alliance for Sustainable Energy, LLC, for DOE. Funding is provided by DOE GTO. The views expressed herein do not necessarily represent the views of DOE or the U.S. government.

The Spring 2021 Geothermal Collegiate Competition is governed and adjudicated by this rules document, which is intended to establish fair contest rules and requirements. The competition is designed and administered by a team consisting primarily of DOE and NREL staff. In the case of a discrepancy with other competition materials or communication, this document takes precedence. The latest release of these rules takes precedence over any prior release. The competition administrator reserves the right to change contest criteria, rules, and outcomes as needed. Additionally, competitors are encouraged to bring to the organizers' attention rules that are unclear, misguided, or in need of improvement. For the purposes of competition evaluation, a violation of the intent of a rule will be considered a violation of the rule itself. Questions on these rules or the program overall can be directed to Geo.Competition@nrel.gov.

Expert reviewers may not have personal or financial interests in; be an employee, officer, coordinator, or agent of any entity that is a registered participant in; or have a familial or financial relationship with an individual who is a registered competitor in this contest.

By making a submission and consenting to the rules of this competition, each team member grants to the Government permission to use and make publicly available any entry provided or disclosed to DOE in connection with the competition. In addition, each team grants to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the U.S. Government, for any and all copyrighted works that are or make up any submission.

Geothermal Collegiate Competition and any associated nicknames and logos ("Competition Marks") are trademarks owned by DOE. The trademark license granted to contestants is below. Non-contestants can request individualized trademark licenses (for the purpose of engaging with contestants and/or expressing interest in the competition); the decision to grant such licenses is under the sole discretion of DOE.

1. Contestants are granted, for the duration of the competition, a revocable, non-exclusive, royalty-free license to use the Competition Marks for the purposes of producing materials for the competition and other approved competition-related activities as long as the use does not suggest or imply endorsement of the contestant by DOE, and the use of the Competition Marks by a contestant does not imply the endorsement, recommendation, or favoring of the contestant by DOE.
2. Contestants may not use the Competition Marks for any other purpose. Contestants may not sublicense the Competition Marks.
3. All contestants can request individualized trademark licenses; the decision to grant such requests is under the sole discretion of DOE.

Further, from the Competes Act:

(j) Intellectual property

(1) Prohibition on the government acquiring intellectual property rights

The Federal Government may not gain an interest in intellectual property developed by a participant in a prize competition without the written consent of the participant.

(2) Licenses

As appropriate and to further the goals of a prize competition, the Federal Government may negotiate a license for the use of intellectual property developed by a registered participant in a prize competition.

Appendix A. Site Identification

Description of Task:

- Map clearly identifying location of proposed community or campus site, surface area containing the geothermal resource, and end uses
- Description of the community or campus site
- Description of why the team selected this site
- Description of why the site is appropriate for a geothermal direct use case.

Guidance: The selected site must be within the United States or within U.S. territories. The site must be clearly identified and appropriate for the selected use case. The use case must consist of one or more commercial or multi-family buildings, or industrial or agricultural process use, with property access rights to the geothermal resources. Possible use cases include community or campus heat pumps or direct use (e.g., space heating, district heating, industrial processes, greenhouses, aquaculture).

Deliverable Requirements: Single PDF document containing a map (clearly showing the identified site, surface area containing the geothermal resource, and location of end uses) and a two-page written narrative. Narrative includes descriptions of the site, why the site was selected, and why the site is appropriate for the selected use case (see "Description of Task"). The two-page limit does not include the map.

Appendix B. Resource Assessment

Description of Task:

- Geothermal resource characterization at the proposed location
- Description of how this resource can be accessed
- Description of why this resource is adequate for the selected site and end use (temperature, required flow rate, available/required infrastructure, etc.).

Guidance: This is intended to be a literature review and analysis of available data at the proposed location. Teams are not expected to conduct surveys or collect their own data. The resource assessment should demonstrate that the geothermal resources at the site are adequate for the selected use case. Teams must use relevant and reputable data to conduct the assessment.

Deliverable Requirements: Five-page PDF document containing characterization of the geothermal resource, a description of resource access, and a description explaining how the resource is adequate for the selected use case (see "Description of Task"). The five-page limit is inclusive of all text and figures, but a list of references cited is not included in the five-page total.

Possible Resource: GeoRePORT and protocol documents, available at https://openei.org/wiki/GeoRePORT/Protocol. The direct use/heat protocols for GeoRePORT are expected to be released in the final quarter of 2021, until then, the power production tool can still be used to guide the resource assessment for your direct-use application.

Appendix C. Environmental and Permitting Analysis

Description of Task:

- Potential environmental impacts (e.g., biological resources, cultural resources, other environmental sensitives) applicable to the selected site.
- Proposed mitigation measures to address potential environmental impacts.
- Table summarizing applicable federal, state, and local permits/approvals for the selected site.

Guidance: This is intended to be a literature review and analysis based on available data at the proposed location and a review of applicable permits/approvals issued by federal, state, and local authorities. Teams are not expected to conduct surveys or collect their own data. The environmental and permitting analysis should include full consideration of the environmental impacts and permits/approvals required to develop a geothermal project at the site. Teams must use relevant and reputable data to conduct the assessment.

Deliverable Requirements: Five-page PDF document containing potential environmental impacts and proposed mitigation measures as well as a table summarizing applicable federal, state, and local permits/approvals required at the selected site. The five-page limit is inclusive of all text and figures, but a list of references cited is not included in the five-page total.

Possible Resource: GeoRePORT Socio-Economic Assessment Tool (SEAT) and associated protocol document, available at https://openei.org/wiki/GeoRePORT/Protocol; GeoVision Analysis Supporting Task Force Report: Barriers, available at https://www.nrel.gov/docs/fy19osti/71641.pdf; the Regulatory and Permitting Information Desktop (RAPID) Toolkit, available at https://openei.org/wiki/RAPID; Bureau of Land Management E-Planning National NEPA Register (access to Bureau of Land Management Geothermal NEPA Documents), available at https://eplanning.blm.gov/eplanning-ui/home.

Appendix D. Usage Assessment

Description of Task:

- Visual aid (chart or graph) showing annual energy end usage for the community or campus
- Description of how the usage matches the available geothermal resources
- Conclusions drawn from available data.

Guidance: The visual aid should clearly demonstrate the community or campus energy usage. The written narrative should explain why the usage is appropriate for the available geothermal resources at the site, and should clearly articulate conclusions drawn from available data.

Deliverable Requirements: A single PDF document containing a visual aid (graph or chart) and a four-page written narrative describing how the usage matches the geothermal resource and conclusions drawn from available data. The four-page limit does not include the visual aid or references cited.

Appendix E. Economic Feasibility Analysis

Description of Task: Identify life cycle cost and required payback period (return on investment).

Guidance: Teams should use appropriate methodology and calculations to determine economic feasibility. This includes calculations of payback period (return on investment), as well as potential future monetary savings.

Teams are strongly encouraged to use GEOPHIRES (see "Educational References"), a freely available program that has built-in assumptions for direct-use geothermal cases. The program is Python based and relatively simple to use for even the novice coder. For comprehensible instructions on running both Python and the program, see the GEOPHIRES User Manual, provided in "Educational References."

GEOPHIRES can calculate many different cost components of a geothermal project, including but not limited to its overall lifetime costs, operation and maintenance costs, and the levelized cost of heat or electricity. Many different types of geothermal plants can be evaluated, including direct use, electric, and hybrid.

If the team has no familiarity with Python or certain project characteristics are unknown, they may still use relevant assumptions and default values in GEOPHIRES (listed below in Table E-1) for their economic assessment. Other resources for performing an economic assessment without the assistance of GEOPHIRES are listed in the Economics subsection of "Educational References," below.

Table E-1. GEOPHIRES Default Values and Assumptions

Input Parameter	Default Value	Description
Reservoir depth	3 km	Depth of the reservoir.
Geothermal gradient	50°C/km	The change in temperature as depth in the reservoir increases. GEOPHIRES divides the reservoir into different rock "segments" of different thicknesses, each having its own geothermal gradient.
Number of production wells	2	
Number of injection wells	2	
Production well diameter	8 in.	Inner diameter of production wellbore.
Injection well diameter	8 in.	Inner diameter of injection wellbore.
Production wellbore temperature drop	5°C	Geofluid temperature drop between the reservoir and the surface.
Injection wellbore temperature gain	0°C	Fluid temperature gain at the injection well.
Production flow rate per well	50 kg/s	Rate at which well can produce fluid.
Reservoir volume	125,000,000 m3	Volume (depth x surface area) of the geothermal reservoir.
Productivity index	10 kg/s/bar	Ratio of production well flow rate over production well inflow pressure drop.
Injectivity index	10 kg/s/bar	Ratio of injection well flow rate over injection well outflow pressure drop.
Production wellhead pressure	Water vapor pressure (at initial production temperature) + 344.7 kPa	

Input Parameter	Default Value	Description
Plant outlet pressure	Production wellhead pressure – 68.95 kPa	Equals the injection wellpumps suction pressure.
Injection temperature	70°C	Geofluid temperature at injection wellhead.
Reservoir heat capacity	1000 J/kg/°K	Constant and uniform reservoir rock heat capacity.
Reservoir density	2700 kg/m3	
Reservoir thermal conductivity	3 W/m/°K	
Reservoir porosity	0.04	Fraction of reservoir comprising pore space.
Reservoir permeability	1x10-13 m2	
Pump efficiency	0.75	The efficiency (out of 1) of production and injection well pumps.
Utilization factor	0.9	Fraction of the year which the plant is running (can vary significantly with direct-use projects).
End-use efficiency	0.9	Thermal efficiency (out of 1) of the direct-use application.
Surface temperature	15°C	
Plant lifetime	30 years	The amount of time the plant is up and running.
Fixed charge rate	0.1	The percentage of the total plant cost that is required over the project life per year to cover the minimal annual revenue requirements. This concept can be compared to a home mortgage.
Discount rate	7% per year	Approximates the rate of interest earned on investments.
Fraction of investment in bonds	0.5	Fraction of the geothermal project that will be financed through bonds.
Inflation rate	0.02	Approximates the rate of economic growth and inflation in value of the dollar.
Inflated bond interest rate	0.05	Defined in GEOPHIRES as: (1 + inflated bond interest rate) = (1 + deflated bond interest rate) × (1 + interest rate). This parameter characterizes the cost of debt.
Inflated equity interest rate	0.1	Defined in GEOPHIRES as: (1 + inflated equity interest rate) = (1 + deflated equity interest rate) × (1 + interest rate). This parameter characterizes the cost of equity.
Combined income tax rate	0.3	Defined in GEOPHIRES as: using (combined income tax rate) × (revenue – deductible expenses) – investment tax credits.
Gross revenue tax rate	0	
Investment tax credit rate	0	
Property tax rate	0	
Inflation rate during construction	0	

Deliverable Requirements

- Three-page document [PDF document]
- List of references cited is not included in three-page total.

Appendix F. Stakeholder Engagement Strategy

Description of Task:

- Identify and interview relevant stakeholder(s) for selected site
- Presentation of key findings from interviews
- Developed messaging for materials to educate stakeholders about geothermal potential at the selected site
- Create a visual aid/tool (e.g., video, presentation, model, interactive website) to engage and educate local stakeholders about the geothermal potential of the community or campus geothermal direct-use case
- Description of how and with whom this tool was shared
- A plan for sharing the tool more broadly

Guidance: Depending on your selected site, there will be a variety of local, relevant stakeholders. Through this task, you should work with and interview key stakeholders for your site. For example, this could be a governing board or leadership for your site, local government officials, and people who would be the end users of the geothermal energy. During the first part of the challenge, you should engage these decision makers in your site selection progress.

During the second part of the competition, you should develop a visual aid. This could be a short video, presentation, model, interactive website, or some other creative tool to engage these stakeholders and others about the geothermal potential of your direct-use case.

Deliverable Requirements: For the Progress Submission, a 10-slide PowerPoint briefing deck saved as a PDF is required. For the Final Submission, update the briefing deck and include the visual aid/tool.

Appendix G. Stakeholder Engagement event plan

Description of Task: A description of the in-person stakeholder engagement event that you would hold, should your team win first, second, or third place.

Guidance: Depending on your selected site, there will be a variety of relevant local stakeholders. For this task, you should plan an in-person stakeholder engagement event to educate relevant stakeholders about your proposed project. This event will take place within three months of the winner's announcement and should be held at or near the selected site. The universities of the team captains from first, second, and third-place winning teams will be given a $10,000 University Support Cash Prize to assist with planning and holding this event. A letter of support/commitment to hold the event from the university must be included with your final deliverable package.

Deliverable Requirements: For the Final Submission, a four-page document, including a letter of support from the team captain's university, describing the stakeholder engagement event that you will hold should your team win first, second, or third place.

Appendix H. Curriculum Supplement

Description of Task:

- Identify a school near your selected site and work with a teacher (any grade K–12) to identify appropriate state standards for your selected grade level. Alternatively, teams may work with a local accredited institution of higher learning to create geothermal content to be added to an existing certificate/degree program.
- Develop an interdisciplinary curriculum unit to teach students about geothermal energy and heating, including appropriate lesson plans, handouts, assessment tools, etc.
- Provide a Standards Document aligning your unit with the appropriate state and local standards (K-12). Provide a Program Alignment Document showing how the unit will fit into an existing or planned certificate or degree program (post-secondary).

Guidance: Teams performing this elective module will design an interdisciplinary curriculum unit to teach students about geothermal energy and heating. The unit should contain a minimum of five learning experiences, including at least one hands-on activity, and provide appropriate lesson plans and teaching materials for each of these experiences.

Deliverable Requirements: For the Progress Submission, a five-page PDF document identifying the school that you will be working with, the grade level that your curriculum will be designed for, an outline of the curriculum unit, and a draft Standards Document or Program Alignment Document. The five-page limit is inclusive of all text and figures, but a list of references cited is not included in the five-page total. For the Final Submission, a 20-page (maximum) PDF document inclusive of all lesson plans, student worksheets/handouts, assessments, and all related documents. Teams may also submit a digital resource that is part of their curriculum unit, which does not count towards the 20-page limit. Any digital resource produced must be posted on a publicly available website.

Possible Resources: Edutopia.org, https://www.edutopia.org/blog/planning-best-curriculum-unit-ever-todd-finley; State Office of Education (for the school that you are working with).

Appendix I. Reservoir Modeling

Description of Task:

- Provide and reference relevant well and reservoir characterization parameters and discuss key subsurface uncertainties impacting performance predictions.
- Describe software application(s) selected for modeling well and reservoir performance.
- Present modeled rates, pressures, and temperatures in plots of low, mid, and high case scenarios.
- Describe data gathering programs needed to reduce uncertainties and improve performance predictions.

Guidance: Teams performing this elective module will predict well and reservoir performance at the proposed location. Teams are not expected to conduct surveys at the site or collect their own subsurface data. Reservoir modeling should provide rates, pressures, and temperatures needed for use in another module (i.e., the Preliminary Economic Feasibility Analysis).

Deliverable Requirements: Five-page PDF document describing one or more field development scenarios, software applications used in the analysis, and subsurface data with associated uncertainties used in reservoir models. The description of field development scenarios includes well types (e.g., vertical and/or horizontal wells), well completions (e.g., the need for stimulations such as hydraulic fracturing), the recommended number of wells, and the spacing between injectors and producers. Uncertainties in key subsurface parameters are quantified and used in predictions of low, mid, and high case scenarios. A brief description of data gathering activities needed to reduce subsurface uncertainties and improve performance predictions is expected. The five-page limit is inclusive of all text and figures, but a list of references cited is not included in the five-page total.

Possible Resource: GEOPHIRES tool and reference materials are available at https://github.com/NREL/GEOPHIRES-v2. While this tool is primarily for techno-economic analysis rather than high-fidelity reservoir modeling, it may be appropriate for initial, low-fidelity reservoir simulations (using the built-in reservoir models) when key subsurface information is limited. High-fidelity reservoir modeling may be conducted using 3D reservoir simulators, such as TOUGH3, STOMP-GT, FEHM, OpenGeoSys, Leapfrog Geothermal, TETRAD-G, and FALCON.

Appendix J. Direct-Use System Design

Description of Task:

- Qualitative description of direct-use system design, including details on selected technology and necessary components/equipment.
- Quantitative analysis of system design, including but not limited to discussion of required system size (e.g., MWth), required temperatures and flowrates, well design (e.g., depth, diameter, count), required distribution network, and any other design components specific to the proposed project.
- Discussion of how the system design component integrates with the usage assessment component.

Guidance: Direct-use system design is an important component to a successful geothermal project. System design commingles the supply and demand sides of the project, as a proper design must consider both the available geothermal resource (supply) and the end use (demand) to ensure that the technical specifications of the system are well defined and the system is properly sized. This is intended to be in the style of an engineering report, which qualitatively describes the proposed direct-use system, including the selected technology and necessary components/equipment, in addition to providing quantitative analysis that demonstrates the team's due diligence in designing the system. The report must also explicitly describe how the system design and usage assessment are integrated, which demonstrates that the team considered the end-use (demand) side of the equation as well as the resource (supply) side. If the geothermal production temperature is too low as required by the end-use application, teams could consider a heat pump system to boost the production temperature.

Deliverable Requirements: Five-page PDF document containing description of the proposed direct use system, including the selected technology and necessary components/equipment, as well as a quantitative analysis that specifies the technical considerations of the system design, such as required system size (e.g., MWth), required temperatures and flowrates of the geothermal and/or working fluid, well design (e.g., depth, diameter, count), required distribution network attributes, and any other design components specific to the proposed project. The document must also contain discussion on the integration between the proposed system design and the usage assessment. The five-page limit is inclusive of all text and figures, but a list of references cited is not included in the five-page total.

Possible Resource: GEOPHIRES v2.0: Open-source geothermal techno-economic simulator, https://doi.org/10.1186/s40517-019-0119-6 and https://github.com/NREL/GEOPHIRES-v2; GeoVision Analysis Supporting Task Force Report: Thermal Applications, available at https://www.nrel.gov/docs/fy19osti/71715.pdf; Performance, Cost, and Financial Parameters of Geothermal District Heating Systems for Market Penetration Modeling under Various Scenarios (Beckers and Young, 2017) available at https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2017/Beckers.pdf.

Appendix K. Project Development and Solicitation

Description of Task:

- Identify the local leaders, decision makers, or utilities who would build and maintain your proposed project.
- Work with the identified stakeholder team to develop the appropriate RFP package for the proposed project.
- Develop a proposed vendor distribution list for the RFP.

Guidance: In partnership with the local leaders, decision makers, or utilities that would ultimately build and maintain the proposed project, teams completing this module will prepare the full RFP document(s) for their proposed geothermal direct/district use case. Teams will need to provide a project overview, guidelines for bidders, project description and requirements, as well as project deliverables and scope. The final RFP document will contain a full RFP timeline, including the proposal deadline, evaluation window, selection deadline, notification deadline, and project deadlines. Teams will also provide a list of potential vendors to send the RFP document to, as well as identifying any other resources for sharing the RFP with the broader vendor community.

Deliverable Requirements: For the Progress Submission, a five-page PDF draft RFP Overview Document including project overview, proposal guidelines, and project description and requirements. For the Final Submission, a 10-page PDF document including the final RFP for your proposed project, a RFP scoring matrix, and a potential RFP distribution list. The page limit is inclusive of all text, tables, and figures.

Appendix L. Educational References

General

Better Buildings Solution Center Geothermal Case Studies
https://betterbuildingssolutioncenter.energy.gov/search?f%5B0%5D=field_technology%3A433

Bureau of Land Management, "Geothermal Energy"
https://www.blm.gov/programs/energy-and-minerals/renewable-energy/geothermal-energy

Bureau of Land Management E-Planning National NEPA Register (access to BLM Geothermal NEPA Documents)
https://eplanning.blm.gov/eplanning-ui/home.

California Energy Commission, "Geothermal Energy in California"
https://www.energy.ca.gov/data-reports/california-power-generation-and-power-sources/geothermal-energy

DOE Geothermal Educational Resources
https://www.energy.gov/eere/geothermal/educational-resources

DOE Frontier Observatory for Research in Geothermal Energy (FORGE)
https://www.energy.gov/eere/forge/forge-home

Geothermal Rising, "What is Geothermal?"
https://geothermal.org/what.html

GeoVision: Harnessing the Heat Beneath Our Feet
https://www.energy.gov/eere/geothermal/geovision

Idaho National Laboratory, Environmental and Geological Engineering
https://inl.gov/research-program/sustainable-resource-recovery/

Lawrence Berkeley National Laboratory Geothermal Systems Program
https://eesa.lbl.gov/programs/geothermal-systems/

NREL Energy Basics: Geothermal
https://www.youtube.com/watch?v=rpgJWYp2OLA

NREL Advancing Geothermal Research with Impact Analysis
https://www.youtube.com/watch?v=l4oKi2spRPE

NREL, "Geothermal Research"
https://www.nrel.gov/geothermal/

Pacific Northwest National Laboratory, "Geothermal Energy: Harvesting the Earth's Natural Heat"
https://www.pnnl.gov/geothermal-energy

Regulatory and Permitting Information Desktop (RAPID) Toolkit
https://openei.org/wiki/RAPID

U.S. Energy Information Administration, "Geothermal Explained"
https://www.eia.gov/energyexplained/geothermal/

U.S. Environmental Protection Agency, "A Student's Guide to Global Climate Change: Geothermal Energy"
https://archive.epa.gov/climatechange/kids/solutions/technologies/geothermal.html

U.S. Fish and Wildlife Service, "Energy Development: Geothermal Energy"
https://www.fws.gov/ecological-services/energy-development/geothermal.html

U.S. Geological Survey Geothermal Resources Investigations Project
https://www.usgs.gov/energy-and-minerals/energy-resources-program/science/geothermal?qt-science_center_objects=0%23qt-science_center_objects

Curriculum Planning

Edutopia.org, "Planning the best curriculum unit ever"
https://www.edutopia.org/blog/planning-best-curriculum-unit-ever-todd-finley

Data

Geothermal Data Repository
https://gdr.openei.org/

NREL Geothermal Prospector
https://maps.nrel.gov/geothermal-prospector/

Southern Methodist University, "Geothermal Lab Data and Maps"
https://www.smu.edu/Dedman/Academics/Departments/Earth-Sciences/Research/GeothermalLab/DataMaps

Economics

GEOPHIRES github contains its Python script, user manual, papers describing its use, and sample input and output files.
https://github.com/NREL/GEOPHIRES-v2

OpenEI Transparent Cost Database
https://openei.org/apps/TCDB/transparent_cost_database

Beckers, K. and K. Young. 2017. Performance, Cost, and Financial Parameters of Geothermal District Heating Systems for Market Penetration Modeling under Various Scenarios.
https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2017/Beckers.pdf.

Short W., Packey, D.J., and Holt T. 1995. A manual for the economic evaluation of energy efficiency and renewable energy technologies. Golden, CO: NREL. https://www.osti.gov/biblio/35391

A helpful reference for determining drilling costs:
Lukawski, M.Z., Anderson, B.J., Augustine, C., Capuano Jr, L.E., Beckers, K.F., Livesay, B., & Tester, J.W. 2014. Cost analysis of oil, gas, and geothermal well drilling. Journal of Petroleum Science and Engineering 118, 1-14.

Resource Assessment

GeoRePORT and protocol documents
https://openei.org/wiki/GeoRePORT/Protocol
While this tool is for power production rather than direct use, it may still be useful to guide your resource assessment for your direct use application.

Conference Papers

DOE Office of Scientific and Technical Information research database
https://www.osti.gov/

Geothermal Rising Library
https://www.geothermal-library.org/

International Geothermal Association Geothermal Paper Database
https://www.geothermal-energy.org/explore/our-databases/conference-paper-database/

Stanford Earth
https://pangea.stanford.edu/ERE/db/IGAstandard/search.php