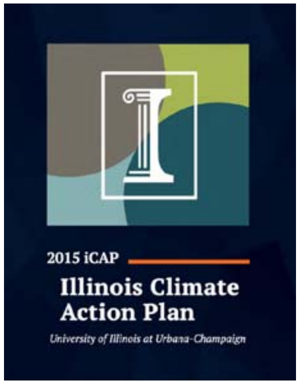
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



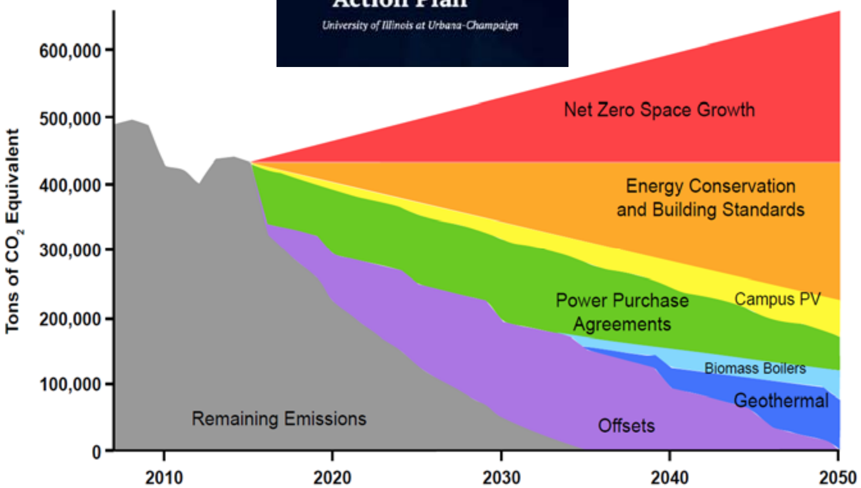


Figure 3: 2015 iCAP Wedge Diagram showing only energy emissions projected, with potential clean energy scenario

Modified from Holcomb et al. (2017)

GeoHRC: Large-Scale, Deep Direct-Use System in a Low-Temperature Sedimentary Basin

Project Officer: Arlene Anderson

Total Project Funding:

November 13, 2017

Principal Investigator
Yu-Feng Forrest Lin
University of Illinois at Urbana-Champaign

Deep Direct-Use Feasibility Studies Technical and Economic Working Group Kick-Off Meeting

Main Objectives

- Determining the feasibility of designing a Geothermal District Heating and Cooling (GDHC) system for the University of Illinois at Urbana-Champaign (UIUC) campus utilizing geothermal deep direct-use (DDU)
- Collaborating with the DOE Working Group and other DDU teams for assessing the technical and economic potential of DDU feasibility
- Optimizing the workflow to assess project Levelized Cost of Heat (LCOH) on benchmarking models with the DOE Working Group
- Reviewing project inputs, such as technology parameters and building energy use data, to assess feasibility

Project Objectives

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Project Innovations

- Evaluating the capacity of the geologic formations in the Illinois Basin (ILB) to provide geothermal energy for large-scale direct use
- Investigating the feasibility of well installation and arrangement scenarios for extracting and injecting geothermal fluid from and to two potential deep geologic sedimentary rock formations in the ILB
- Designing potential cascading applications, such as district heating and cooling at the UIUC campus
- Identifying challenges to commercialization of this technology (including regulations, equipment, and economics) for analogous cascading applications (e.g. military installations) in the ILB

Project Objectives

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Impact on the Geothermal Technologies Office's Goals (7/10)

- Improving processes of identifying, accessing, and developing geothermal resources
- Overcoming technical obstacles and mitigating risk
- Determine the feasibility of deep direct-use in areas of high thermal demand
- Overcoming deployment barriers
- Accessing additive values
- Collaborating on solutions to subsurface energy challenges
- Supporting early-stage research and development to strengthen the body of knowledge upon which industry can accelerate the development and deployment of innovative geothermal energy technologies

Project Objectives

Potential Challenges

- Project Management
  - Fund transfer to DoD laboratory (federal agency) as subcontractor.
- Geology
  - Estimating the thickness of St. Peter Sandstone
- Model
  - Optimal water extraction rate to meet energy demand(s)
- Infrastructure
  - Handling of formation fluid with high salinity, suspended solids, and other impurities: temperature and pressure changes may lead to precipitation, scaling, or settling
  - Existing equipment efficiency for low-temperature geothermal fluid
- Commercialization
  - New experience working with the DOE-led DDU Feasibility Studies Technical and Economic Working Group and other project teams

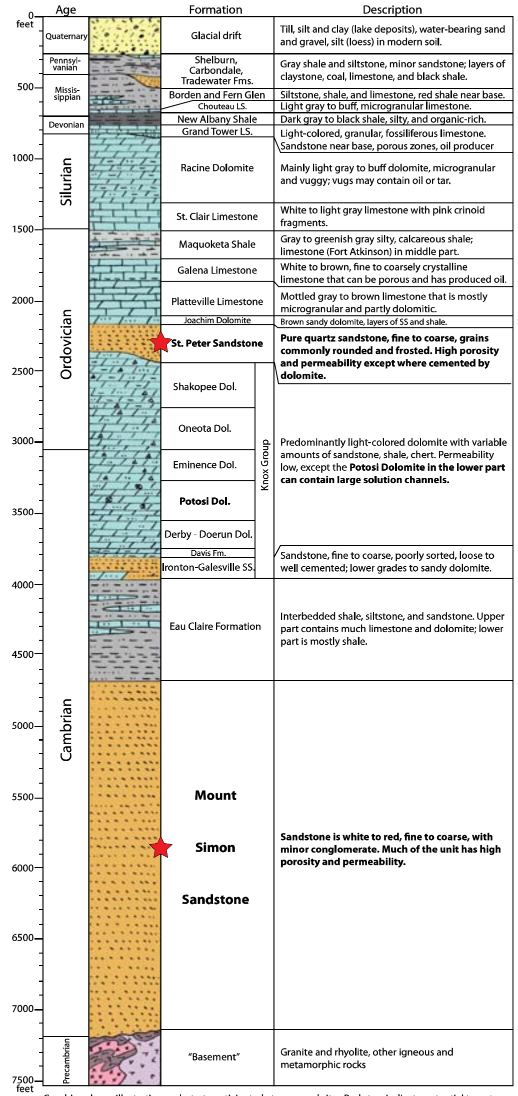
Technical Scope Summary

Site Suitability

- Site at UIUC campus was chosen based on future need of geothermal resource.
- Subsurface geology is known from previous studies.
- Target formations (aquifers) have broad regional extents (10 to over 100 miles), consistent properties, and sufficient thickness to supply required water flows.

Thermal Resources: St. Peter and Mt. Simon sandstones

- Excellent reservoir characteristics (Φ and k)
- Suitable temperature for DDU applications (92-116 ^{o}F)
- Estimated thermal energy production of 40-64 MMBtu/hr per well



Graphic column illustrating rock strata anticipated at proposed site. Red stars indicate potential targets

Potential Energy Usage: UIUC Energy Farm has 4 buildings and 5 thermal loads of interest (>10,000 square feet and >125 MMBTU)

- One large greenhouse (GH3) and two smaller ones (GH1&2)
- One mixed use building (office-OFC and warehouse-WHS)
- Future expansions for labs, offices and classroom within next 3 years are in discussion
- Heating and cooling load analysis to establish dynamic and site-specific end use demands and cascading options
- Site analysis including sizing simulations of above-ground flow lines/pumps, selection of piping materials, and estimation of power requirements and costs

Modeling Novelties: integrate reservoir and wellbore modeling to evaluate geothermal resource potential of St. Peter and Mt. Simon sandstones in the ILB.

- Using a doublet system (production and injection wells)
- Model heat losses and gains in wells
- Perform wellbore design to achieve efficient heat delivery

Infrastructure Novelties

- Flexibility of operating for heating, cooling, or dual usage
- Configurations tailored with respect to specific geothermal fluid conditions and energy end use to improve energy efficiency and reduce costs
- Ability configured for cascading applications

Technical Scope Summary

Methods for Costs and Benefit Analysis

- GEOPHIRES software for Levelized Cost of Direct Use Heat
  - Sean Wallace @ Army-CERL
  - Koenraad Beckers @ NREL
- NIST BLCC Building Life-Cycle Cost software
- Life-Cycle Cost and supplementary measures of cost effectiveness
  - Net Savings
  - Savings-to-Investment Ratio
  - Adjusted Internal Rate of Return
  - Simple and Discounted Payback Periods

Technical Objectives & Milestones

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Task No.	Task Title	Milestone No. in SOPO	Milestone Description	Milestone Verification Process	Anticipated Months from Start	Anticipated Quarters from Start
1	Life Cycle Cost Analysis (LCCA)	1	Modifying Existing Model for LCCA	Present the preliminary concept of LCCA tool in the Peer Review meeting.	1	Q1
2	Geology	2.1.1	Geologic Modeling	Review preliminary geological modeling inputs with the Technical and Economic Working Group and upload resulting data to the DOE-GDR.	6	Q2
3	Modeling	3.1	Flow Modeling	Review preliminary scenarios with the Technical and Economic Working Group and upload resulting data to the DOE-GDR.	9	Q3
3	Modeling	Year 1	Provide temperature to assess project LCOH with an emphasis on benchmarking models.	Present to the Technical and Economic Working Group all preliminary data and modeling inputs in Q4 Working Group Meeting.	12	Q4
2	Geology	2.3	Geocellular Modeling	Review preliminary geocellular modeling inputs with the Technical and Economic Working Group and upload resulting data to the DOE-GDR.	15	Q5
4	Infrastructure	4.4	Potential GES Assessment	Review preliminary GES assessment with the Technical and Economic Working Group and upload resulting data to the DOE-GDR.	18	Q6
4	Infrastructure	4.2	Geothermal Fluid Handling	Review preliminary designs for handling geothermal fluids with the Technical and Economic Working Group and upload resulting data to the DOE-GDR.	21	Q7
5	Commercialization	8	Market Demand and Transformation	Final feasibility report and identifying the top scenarios	24	Q8

Proposed Metrics

Quantifiable Techno-economic Assessment on Site Suitability and Thermal Resource

- Assess geologic resource
  - geothermal gradient
  - surface heat flow
  - temperature at depth
  - depth to temperature
  - drilling depth
- Assess operating systems
  - production temperature
  - operating temperatures
  - well mass flow rate
  - lifetime
  - discount rates

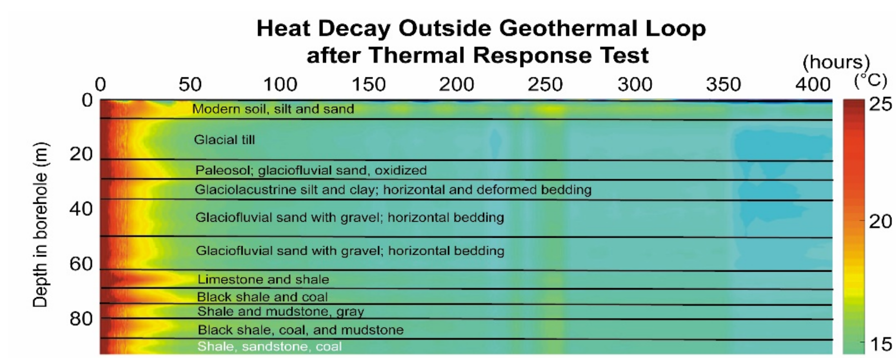
Proposed Metrics

Quantifiable Techno-economic Assessment on Potential Energy Usage

- Incorporate user-defined inputs from demand assessments
  - temperature curve
  - daily demand
  - yearly demand
  - peak demand
  - hot water demand

Quantifiable Techno-economic Assessment on Modeling and Infrastructure Novelties

- Surface costs will include
  - water treatment
  - piping, pumping
  - heat exchange
  - electricity inputs
- Maintenance costs will derived from
  - reinjection temperature
  - pipe diameter
  - heat exchanger size
  - performance curves
  - pumping energy



Proposed Metrics

Quantifiable Techno-economic Assessment on Methods for Costs and Benefit Analysis

- The primary output will be on an economic basis of levelized cost of heat (LCOH) in units of $/MMBTU
- Assessment will move beyond a life-cycle cost approach and extend into environmental benefits such as reductions in greenhouse gases (GHG) or water consumption per MMBTU and increases in thermal efficiency
- Review preliminary regulatory findings with the Deep Direct-Use Feasibility Study Technical and Economic Working Group for potential costs and benefit impact

Anticipation and Collaboration with the DOE Working Group in Quarterly Meetings and Beyond

- Sharing data and information with other awardees to assist DOE in benchmarking the technical and economic parameters of DDU and to evaluate the technically and economically feasibilities by approximately 20 hours per quarter in preparation and collaboration activities
- Year 1 is to determine the best way to assess LCOH with an emphasis on benchmarking models
- Year 2 will review model inputs (e.g., technology parameters and building energy use data) and to rank project feasibility

Data Management Plan (DMP) and Data Quality Assurance

- Providing guidance and standards to help determine the DDU feasibility
- Offering free exchange of ideas and information with project development to benefit future innovation on DDU technology
- Loading data as fully indexed databases at regular intervals into the U.S. DOE Geothermal Data Repository, which will enforce uniqueness, consistency, and data integrity
- Making data and metadata available in the primary content and format used in the study, with a clear rationale for the selection of appropriate standards documented through the reports
- Providing all data sources, inputs, and outputs will ensure that all viable data and strategies developed will be available to other researchers in the field