NATIONAL LABORATORY OF THE ROCKIES

Cohort 2

Technical Assistance for the University of Hawaii at Mānoa, Honolulu, Hawaii

The Energy Technology Innovation Partnership Project (ETIPP) worked with the University of Hawaii at Mānoa to determine the technological and market feasibility of shallow geothermal heat exchanger technology for building cooling and energy efficiency applications.

Project Summary

The University of Hawaii at Manoa (UH Mānoa) joined ETIPP to explore the feasibility of developing shallow ground heat exchangers (GHEs) for cooling across O'ahu and at a specific site on the island. Geothermal energy technologies provide possibilities to augment the electric grid in areas with recent volcanic activity and ample underground water flow, like the Hawaiian Islands. Geothermal heat pumps take advantage of relatively constant temperatures just under the earth's surface, using GHEs to exchange heat with the earth. UH Mānoa established three main objectives for its ETIPP project:

1. Understand which datasets were necessary to evaluate GHE feasibility, models that would be used, and barriers to installing a test case.
2. Investigate the ideal policy, regulatory, and business conditions for implementing a pilot project, and for more broad deployment of GHEs throughout Hawaii.
3. Help developers build capacity or receive new skill training in Hawaii to install these technologies in buildings.

In Hawaii, the need for cooling dominates energy loads. For GHEs to work as designed in warm areas, like Hawaii, removal of subsurface heat is required. Regional groundwater flow can sweep heated water away from GHE boreholes, allowing the systems to maintain their functionality.

Population Size
1.4 million

Lead Lab
Lawrence Berkeley National Laboratory

Technology Focus
Geothermal

Regional Partner
Hawaii Natural Energy Institute

Hawaii's mountainous terrain and geology favor strong groundwater flow, which researchers investigated as a means to remove heat from the GHE.

Lawrence Berkeley National Laboratory (LBNL) researchers used geographic information systems (GIS) to develop favorability maps for closed-loop and open-loop systems at the regional scale.

- In open-loop geothermal systems, wells are drilled to extract and inject groundwater, allowing the movement of thermal heat to and from the earth. These GHEs use cooler ground water from outside the system for the cooling process and expel the warmer water afterward.
- Closed-loop GHE systems continually circulate a heat-transfer solution through pipes, which transfers heat to and from the ground via thermal conduction. Groundwater needs to have temperatures that are low enough to effectively cool buildings, and groundwater flow in a GHE system works to remove built-up heat.

Project Outcomes

Spatial maps used to determine GHE favorability for this project considered physical properties, recycled water management zones, underground injection zones, and inland water quality. The LBNL team ranked each property as favorable, neutral, or unfavorable, summed the rankings for each property, then superimposed excluded regions, such as habitats for endangered species.

Researchers assessed feasibility of a GHE to meet cooling loads at three sites using numerical modeling and techno-economic analysis. They considered building energy efficiency, cultural factors, and economic data to develop favorability maps for closed- and open-loop GHE systems. For the site-specific feasibility analysis at the UH Mānoa's Stan Sheriff Center, researchers used a hydrogeologic model to analyze groundwater flow of a closed-loop system at the site.

Restrictions on water quality—mandating that groundwater must be left in its natural state—diminished the available area for GHE system deployment across the island, while many coastal areas showed high favorability.

Key Takeaways

The GIS analysis indicated that wide areas of O'ahu were favorable for GHE development, and that a shallow GHE would be technically feasible at the Stan Sheriff Center, a building with a high cooling load in an area surrounded by open space. However, with groundwater temperature so close to air temperature, constructing a viable GHE would be challenging. Additionally, economic analysis showed that favorable financing terms must be obtained for the system to be cost-effective.

Future work could look into sea-water-source systems, in which cold water could enable much bigger temperature differences than are available in shallow groundwater systems, resulting in better GHE performance. Going forward, UH Mānoa may also consider exploring financing for closed-loop GHE for its campuses to advance the project.

Additional Information

Managed by the National Laboratory of the Rockies, ETIPP is a community-led technical support program for coastal, remote, and island communities to access unique solutions and increase energy resilience. By uniting federal agencies, national laboratories, regional organizations, and community stakeholders, ETIPP provides tailored technical support to help communities achieve affordable, reliable solutions to their energy system challenges. This collaborative model leverages the combined expertise and resources of its partners to deliver comprehensive, practical solutions that align with local needs.

Learn more about ETIPP, its communities, and partner network at nlr.gov/state-local-tribal/energy-technology-innovation-partnership-project.

Cover image: O'ahu's steep terrain and highly permeable volcanic rock enable large groundwater flow, a must for successful ground heat exchangers in Hawaii, where load is cooling dominated. Pictured here is the view from Kaena Point., the western tip of O'ahu's North Shore.
Photo from Christine Doughty, Lawrence Berkeley National Laboratory

NATIONAL LABORATORY OF THE ROCKIES

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nlr.gov

The National Laboratory of the Rockies prints on paper that contains recycled content.

The National Laboratory of the Rockies is a national laboratory of the U.S. Department of Energy, Office of Critical Minerals and Energy Innovation, operated under Contract No. DE-AC36-08GO28308.

NLR/FS-5700-98992 • May 2026