**Engineering Planning Study Proposal: Open Geothermal at ISTC**


**Project Lead Contact Information**

Todd Rusk
toddr@istc.illinois.edu
Engineer
Illinois Sustainable Technology Center

(217) 244-5716
1 Hazelwood Drive
Champaign, IL 61820

**Secondary Contact Information**

Tim Lindsey
tlindsey@istc.illinois.edu
Associate Director
Illinois Sustainable Technology Center

(217) 333-8940
1 Hazelwood Drive
Champaign, IL 61820


## I. Detailed Project Description

The Illinois Sustainable Technology Center (ISTC) would like to investigate the feasibility of implementing an open-loop geothermal system to reduce the energy required for heating and cooling the building. This document is a proposal to perform the preliminary engineering planning study that will be required prior to implementation.

The motivation for this project is the opportunity to reduce our total building energy use and greenhouse gas emissions by 25% - 50%. Please refer to our building energy efficiency proposal for a detailed analysis of ISTC energy use and the associated greenhouse gas emissions. Another motivation for this project is the opportunity for significant water use reduction. The cooling system at ISTC (and many other campus locations) involves the use of a cooling tower to provide cooling water for the chiller's condenser. This cooling tower consumes an estimated 1 million gallons of water per year, most of which is evaporated and the rest of which is bled away to maintain specific cooling water quality parameters. Figure 1 schematically depicts the cooling system at ISTC. Successful implementation of this geothermal system would eliminate the use of the cooling tower and the water it consumes.

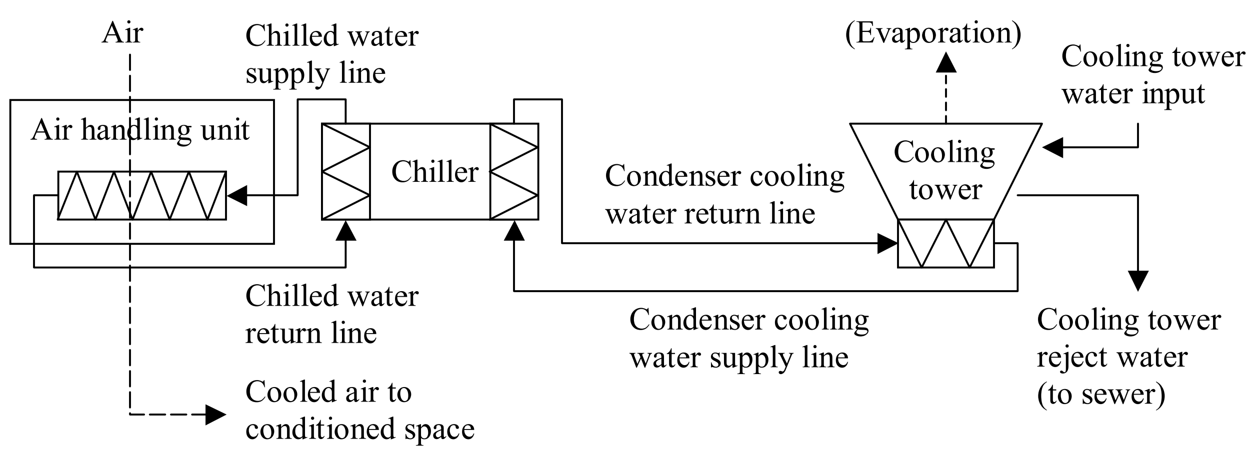


**Figure 1:** Schematic depiction of the cooling system at ISTC. The system uses water to cool the chiller condenser. The condenser cooling water is cooled by exchanging heat with water in a cooling tower. The water in the cooling tower is evaporatively cooled.

If successful, this project has the potential for replication in other campus buildings. We envision implementing the system in a scalable fashion so that it would be possible to increase the system capacity to provide heating and cooling for other nearby buildings.

*Geothermal heating & cooling, open-loop systems vs. closed-loop systems:*

Geothermal systems rely on the thermal mass and the constant temperature of the earth to provide an efficient source of heating and cooling. In a common configuration, a heat pump is connected to the earth and the conditioned space by separate heat exchangers. In winter, the heat pump extracts heat from the ground and transfers it to a conditioned space. In the summer, the heat pump extracts heat from a conditioned space and transfers it to the earth. Heat pumps used in this manner can operate at efficiencies that significantly exceed what is possible with conventional heating and cooling systems.

There are many ways to set up a geothermal system. A common configuration is a closed-loop system. In this configuration, fluid circulates through one or more heat exchange loops (small diameter copper tubing) in order to exchange heat from the heat pump to the earth or vice versa. An advantage to this configuration is that it is well known by installation professionals and the environmental regulatory community. Some disadvantages to this configuration are:

- Pumping fluid through long lengths of small diameter tubing requires a lot of electrical power.
- Limited heat exchange capacity per heat exchange loop may require extensive ground preparation in order to install multiple heat exchange loops.
- Practical engineering and economic limits of heat exchangers dictate that the temperature difference between the earth and fluid in the heat exchange loop will usually not be less than $10^{o}$F. The size of the temperature different limits the efficiency of the heat pump.

The Glasford Aquifer lies directly beneath the certain portions of the campus area. At ISTC we expect to find a 15- to 20-foot thick, water-saturated layer of sand/gravel, at a depth of approximately 120 – 160 feet, and we would like to investigate the feasibility of implementing an open-loop geothermal system that uses this ground water as the heat exchange fluid. After exchanging heat with the heat pump, the water would then be reinjected into the aquifer, at a suitably distant location from the source well to avoid creating a thermal short circuit. Because the water is used as a non-contact heat exchange medium, it will be safe to return to the aquifer. Some advantages of this type of configuration, relative to close-loop systems are:

- Pumping water through large diameter pipe requires less electrical power.
- Greater heat exchange capacity per heat exchange loop means there can be fewer wells and shorter pipe lengths to be installed.
- By using ground water as the heat exchange medium, the heat pump can operate more efficiently than would be possible with a close-loop geothermal system.

Project Objectives:

There are some uncertainties with respect to the implementation of an open loop geothermal system on campus. Therefore the project objectives are to address the sources of uncertainty.

1. Awareness of open geothermal systems
   - Open geothermal systems as described in this proposal have been successfully installed and are operating at many locations around the world. Despite the advantages to this type of system, it is relatively less known in the U.S., and it is not well known among the environmental regulatory community or among key facilities and administrative personnel at the university.
   - We have already begun to address this issue by initiating a process of targeted education. We have arranged for Dr. Fred Michel of Carleton University (Canada), an expert on this type of application, to deliver a presentation and answer questions at a specially organized meeting on December 9, 2008, that includes key administrative and facilities personnel from the university, university environmental regulatory specialists, the Student Sustainability Committee and its advisory committee, and the project team of experts. The project team includes: Todd Rusk, mechanical engineer (ISTC); Doug Walker, groundwater hydrologist (Illinois State Water Survey); Tom Holm, geochemist (Illinois State Water Survey); and Dick Berg, geologist (Illinois State Geosurvey). We also hope to bring in geothermal expertise from the Smart Energy Design Assistance Center (SEDAC).
2. Physical and chemical characterization of the aquifer

   The physical and chemical characteristics of the aquifer and the groundwater need to be thoroughly characterized in order to maintain the integrity of the aquifer and the ground water; to ensure chemical compatibility between the ground water and the heat pump; and to ensure the adequacy of the ground water supply for the intended purpose. This project will involve the installation of two test wells to be used for the following purposes:
   - Test the hydraulic conductivity of the aquifer. This helps to determine how quickly water can be drawn from a single well and how far additional wells must be spaced in order to deliver the required amount of ground water flow for heat exchange.
   - Determine the extents of the sand/gravel layer. This helps to determine the total availability of ground water to be used for heat exchange in the nearby area.
   - Determine the aquifer's geophysical heat exchange capacity. This involves evaluating the potential for changes in the ground water temperature due to its use as a heat exchange medium, and it will help to determine how much heat can be sustainably extracted from and delivered to the aquifer.
   - Collect and analyze samples of the aquifer sand and ground water. These analyses will help to answer the following questions:
     - What is the likelihood that undesirable contaminants will be released from the sand into the ground water?
     - What is the likelihood of significantly altering the chemistry of the ground water?
     - What is the likelihood that the ground water will cause heat exchanger corrosion or fouling? How to deal with this potential problem?
3. Environmental permitting – installation and operation of a re-injection well
   - To ensure sustainable use of ground water, implementation would require the installation and operation of a re-injection well. We expect that the Illinois Environmental Protection Agency (IEPA) will require a permit to operate a re-injection well. Project personnel will open and maintain a dialog with IEPA, both to

create awareness within IEPA of this application of ground water and to gain an understanding of what measures the IEPA would require before granting a permit.

4. Integration of an open geothermal system with ISTC's existing HVAC system
   - ISTC's heating, ventilation, and air conditioning (HVAC) system was not originally designed with the intention of integrating a geothermal heating/cooling system. Implementation of an open geothermal system will require an engineering investigation to determine how to integrate the proposed geothermal system with the existing HVAC system. Project personnel will perform preliminary engineering analyses and consult with UIUC F&S technical staff and technical representatives of HVAC equipment manufacturers to meet this objective.

Project deliverable:

The product of this project will be a final report that assesses the feasibility of implementing an open geothermal system at ISTC and describes the costs and requirements of full implementation.

Project Personnel – Roles and Responsibilities:

- Todd Rusk, mechanical engineer, ISTC
  Todd Rusk will be responsible for overall project management; completion of objectives 1, 3, and 4; and completion of the final report.
- Doug Walker, groundwater hydrologist, ISWS
  Doug Walker will serve an advisory role related to groundwater hydrology, and he will supervise graduate student work on project object 2.
- Tom Holm, geochemist (ISWS)
  Tom Holm will serve an advisory role related to geochemistry, and he will supervise graduate student work on project objective 2.
- Dick Berg, geologist (ISGS)
  Dick Berg will serve an advisory role related to geology, and he is supervisor to the well driller.

Project sustainability:

- Sustainability encompasses economic, environmental, and social practices that meet the needs of current generations without jeopardizing the ability of future generations to meet theirs. This project relates to sustainability in that it reduces the environmental and economic impacts of operating a campus building.
- The proposed location is ISTC. We have consulted with UIUC Facilities & Services to ensure that the project proposal and location are appropriate.
- Typically the life cycle of a geothermal system is rated at 25 – 50 years. The anticipated savings would continue throughout this life cycle. If successful, this type of project can be replicated in other campus buildings.

**II. Budget & Fundraising**

1. Detailed budget

- We request a total amount of $27,800 for this project. This engineering planning project will have no effect on the life-cycle operation and maintenance costs of this building.

| | Budget Item | Request Amount | Cost Share |
|---|---|---|---|
| | 12/9/08 Education and awareness event with Dr. Fred Michel | | $4,500 |
| | Drill 2 wells, drill rig rental 4 days @ $1,800/day | | $7,200 |
| Well construction | Well casing, well #1<br>2" dia well (no pump) | $400 | |
| Well construction | Well casing, well #2<br>4" dia well (with pump) | $600 | |
| Well construction | Surface protection for 2 wells | $500 | |
| Well construction | Well pump | $1,000 | |
| Well construction | Well pump electrical | $500 | |
| | Chemical analysis of aquifer sand and water | $5,000 | |
| | Materials for heat exchanger/ground water compatibility testing | $500 | |
| Personnel colsts | Todd Rusk<br>Salary + Fringe Benefits<br>@ 25% FTE, 6 months | $9,300 | |
| Personnel colsts | 2 Graduate students, part time | $10,000 | |
| | **Total:** | $27,800 | $11,700* |
| | | **Total Request Amount:** | **$27,800** |
| | | **Total Project Cost*:** | **$39,500** |

*This amount does not reflect an additional amount of cost share to compensate for project time by Drs. Doug Walker, Tom Holm, and Dick Berg.

- This engineering planning study will generate no savings, but we anticipate that if implemented, the open geothermal system could generate a savings on the order of $60,000 - $120,000 per year.
- Without funding by the Student Clean Energy Committee, this project is unlikely to move forward.

2. Fundraising
    - We have raised funds that amount to at least 30% of the total project cost. We will provide additional cost share in the form of (as yet unquantified) in-kind personnel services. See the asterisk under the budget table.

## III. Timeline

- If funded we expect to complete the project within 6 months of receipt of funds.

## IV. Energy, Environmental and Economic Impact

1. Energy and cost savings
    - If the open geothermal system is implemented, the projected annual savings potential is on the order of $60,000 - $120,000 and 4,000 - 8,000 MMBtu. These figures are based on an anticipated energy savings potential of 25% - 50% and on the following data from ISTC energy utility records:
        a. $250,000 total annual cost of electricity and natural gas
        b. approximately 16,000 MMBtu total annual energy use
    - This project is an engineering planning study so its life is limited to the 6 month project duration. If the open geothermal system is implemented, the system life expectancy would be 25 – 50 years.
    - No significant energy inputs are required to complete this study. The only notable source of energy use will be to operate the well pump for groundwater hydrology testing and water sampling.
2. Environmental impact
    - If the open geothermal system is implemented, projected annual $CO_2$ emissions reductions would be on the order of 1 – 2 million pounds per year.
    - If the open geothermal system is implemented, we anticipate an annual water use reduction of approximately 1 million gallons.
    - No significant negative environmental impacts are anticipated.
3. Social impact
    - No significant social impacts are anticipated.
4. Economic impact
    - Other than the annual and life-cycle cost savings described above, no significant other economic impacts are anticipated.

## V. Outreach and Education

- This project will be visible to students because we will make a poster for presentation at Environmental Horizons, we regularly hire student employees, and because we offer student tours of our facility.
- The potential for involvement in classroom curricula exists, because we collaborate with faculty, and several of our staff have taught courses on campus before, including “Environmentally Conscious Manufacturing.”
- We have media, marketing, and outreach specialists, in addition to our technical expertise. We regularly publicize our work and findings by press releases, case studies, technical publications, and presentations. The results

of this project could be magnified because we also provide training and perform pollution prevention and energy efficiency technical assistance to organizations in the industrial, commercial, and public sectors.