2013

Final Scientific Report

Middlesex Community College Geothermal Project – DE – EE0000323

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Final Scientific Report

Project Award # - DE- EE0000323

Project Title: Middlesex Community College Geothermal Project

Principal Investigator: Prof. Jessie Klein

Project Manager: Gina Spaziani, Dir. Of Budget & Financial Services

Executive Summary
The purpose of the project was to install a geothermal system in the trustees house on the Bedford campus of Middlesex Community College. In partnership with the environmental science faculty, learning activities for environmental science courses were developed to explain geothermal energy and more specifically the newly installed system to Middlesex students. A real-time monitoring system highlights the energy use and generation.

Description of the Project and activities

Project # MMC0901-EC2 "Trustee's House Ground Source Heat Pump" and ECM #21.4 called for the abandonment and demolition of the three existing A/C condensers and air handling systems and the full design and installation of a new high efficiency closed loop "geothermal" ground source heat pump (GSHP) system to reduce operational costs. The system will have a Performance Monitoring system to record and report the energy usage to verify ECM compliance. This new GSHP system is required to integrate seamlessly with the existing gas-fired boilers and air coils that will remain to provide supplemental and backup heating to the newly installed system.

Scope of Work Performed

- **Full GSHP System Design including closed loop well field layout, flow and head loss calculations, piping/circuit design and manifold design**
- **Completion of construction drawings, submittals and final as-built drawings**
- **All regulatory permitting as required for CLGSHX system installation**
- **Construction stakeout land survey and final as-built land survey**
- **Drilling and installation of geothermal wells as specified**
- **Installation of HDPE loop piping in geothermal bore and back-filled with thermally enhanced bentonite grout**
- **Water containment during drilling and proper disposal of drilling spoils**
- **Trenching, excavating, bedding, backfilling and soil compaction required to install horizontal HDPE piping, headers and circuits**

- Pressure testing, flushing, purging and filling of geothermal loops and piping system
- Demolition and proper disposal of old HVAC equipment
- Complete GSHP equipment installation in mechanical room and attic
- Installation of Energy Metering/Monitoring System
- System Commissioning, Test and Balancing
- Operations and Maintenance Plans and Procedures
- Training of Facility Personnel

Project Execution

The project was implemented in three major phases – 1) System Design & Permitting, 2) Exterior well field drilling and ground loop construction and 3) Interior piping and heat pump installation. The system design is fully documented in the supplemental material provided with this report. The Trustee's House geothermal project required the abandonment and demolition of the existing air conditioning condensers and associated air handlers located in the basement and attic. The gas-fired boilers remain to provide Domestic Hot Water (DHW) service and back-up heat capability through the existing hydronic heating coils installed in the forced hot air ductwork throughout the building. The abandoned primary heating and cooling systems were replaced with a high efficiency closed loop Ground Source Heat Pump (GSHP) "geothermal" well system to reduce operational and maintenance costs as well as reducing greenhouse gas (CO_2) emissions.

The final closed loop system required drilling seven well bores. All bores are 6 inches in diameter and spaced 20 feet on-center to a depth of approximately 500 feet each providing a total closed loop ground source heat exchanger (CLGSHX) size of 3,500 feet. Two 1-1/4" high density polyethylene (HDPE) pipes were inserted into each well with a u-bend connection at the bottom and running the length of each well bore. All well supply and return lines were manifolded "reverse return" five feet below grade to a single 3" supply and return line brought through the building foundation. Within the building, the ground loop transitions to cooper piping to utilize convention pipefitting methods for all interior connections.

The inside of the well bores were back-filled with thermally enhanced bentonite grout around the HDPE pipes to improve the thermal conductivity between the circulating ground loop fluid and the walls of the well bore and ground. All pipe trenches, well bores and pipes were covered to grade with no exposed equipment, well heads or plumbing visible from the surface. The entire geothermal piping system is closed closed loop and has no direct exchange with the ground or ground water at any point. The pipes were filled with a 85/15 water/propylene glycol mixture, which is a non-toxic food grade antifreeze. This solution will circulate throughout the ground loops and heat pumps preventing degradation to the performance of the system due to poor water quality or exposure to outside elements. Additionally, because the system is closed loop, it requires relatively low circulating pump energy to move the heat exchange fluid around the loop. In addition, a Variable Frequency Drive (VFD) circulator pump was employed to further reduce energy consumption. This closed loop geothermal system will provide a low maintenance, lower operational cost, and highly effective building conditioning system and have a longer lifespan than conventional HVAC equipment.

The local ground conditions deliver a fairly constant year-round temperature of 50°F± to the interior water loop. This interior water loop circulates through the three heat pumps installed within the building. The heat pumps take heat from the ground loop water in the winter and send the chilled water back to the ground loop to be reheated and returned to the exterior/interior water loops. These heat pump systems result in a highly efficient heating system by moving heat to and from the ground providing a free heat source rather than creating heat with a fossil fuel based system. In the summer, the above process is reversed and the interior heat pumps remove heat from the building and re-inject it back into the ground loop. This dumps excess heat into the earth, which is at a much lower temperature than the outside air, making it highly efficient compared to the traditional A/C condenser system being replaced.

New packaged controls were provided for this installation to ensure the highest possible efficiency and compatibility with the existing DDC system on campus. The proposed control system will allow for proper monitoring, operation, and management of the system, while accurately indicating operating conditions to facilitate timely maintenance, repair, and backup operation when required. These controls will maintain low operational costs by conditioning only the areas that actually need it. This leads to a much greater level of comfort and control inside the building.

Research Components

While there was no specific research component to this project , it does have an educational component in not only the classroom learning activities developed by the faculty but in the real-time monitoring system available to all students. The project also benefits the overall college compliance with the state mandate to reduce our carbon footprint.

Projects Activities

As decribed above, project activities included preliminary design, state bid process and awarding of the contract, final design, site preparation, well drilling and finally installation of equipment. The energy monitoring system and education components were also deliverables of the grant.

Learning activities including review of existing materials on US DOE web sites www.eere.energy/gov/geothermal to give students an overview of geothermal. Instructors used power point presentations and participated in a debate on the use of geothermal energy in Hawaii. A mapping exercise was done to locate areas where geothermal has the greatest potential for reducing US dependence on fossil fuels.

Products – publications

There were no publications based on the project but the college did participate in a public announcement of the project that was covered by the local press. Articles are attached.

Collaborations

The project was result of a strong collaboration between Middlesex Community College and the State Department of Capital Asset Management who is responsible for construction projects on state property. As a public institution, we have authority to self manage many projects but benefited greatly from the expertise of the energy group in the planning phase and from the expertise of the construction group during the installation of the system. We also benefited from a partnership with the State Department of Energy Resources and its Leading by Example team who also provided support for the project.

Technology / Patents

Technology access was a standard closed loop system for a structure the size of the Trustee House. There are no patents associated with this project.

Data monitoring system – As part of the project MCC required the installation of a geothermal monitoring system that could be accessed by students, faculty and staff to see real-time data on the operation of the system. Faculty developed learning activities based on the data elements available and facilties staff are also able to assess the operations.

See screen shots from the system below:

ConecoEnergy

Login

DashboardSavingsData

Welcome

Welcome to the GxTracker™ Dashboard. This page contains basic operating information about your geothermal system and acts as a central point for a number of related data products.

Today's Weather (Degrees Farenheit)

Current 51°

High 54°

Low 36°

Forecast

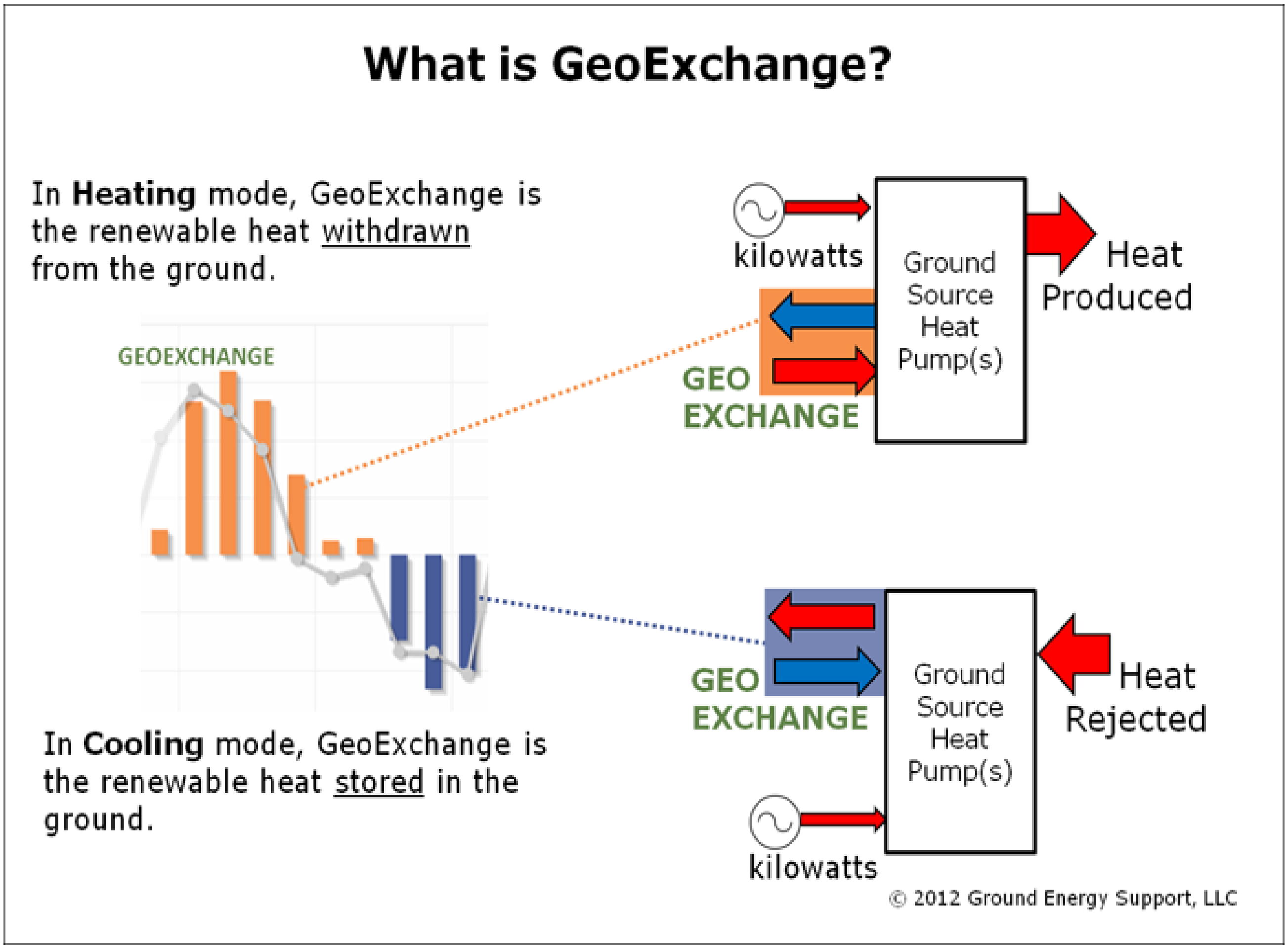
Sources: National Weather Service, wunderground.com

Explanation

GeoExchange

The thermal energy exchanged with the ground.

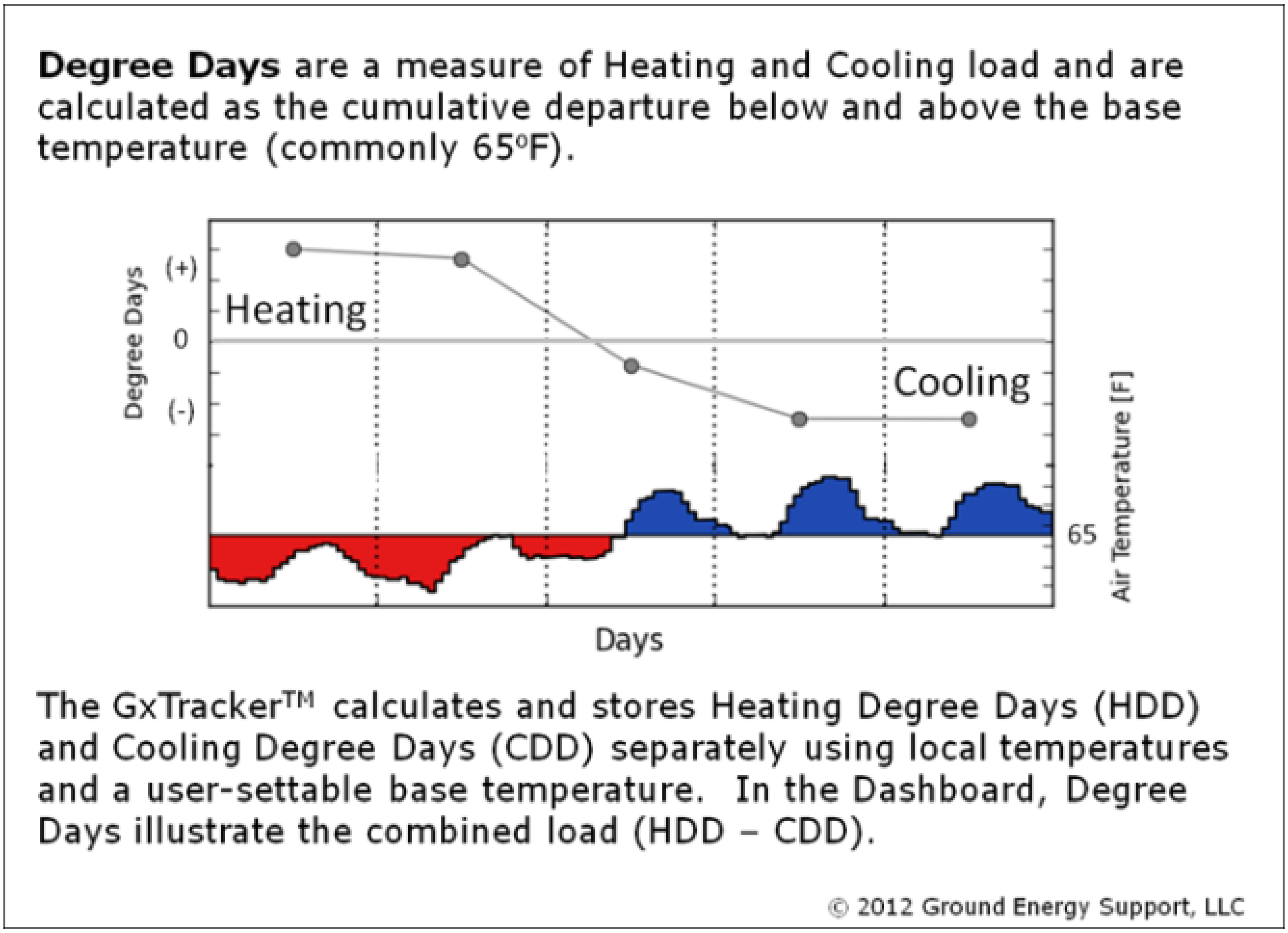
Learn More



Degree Days

Heating & cooling load based on outdoor temperature

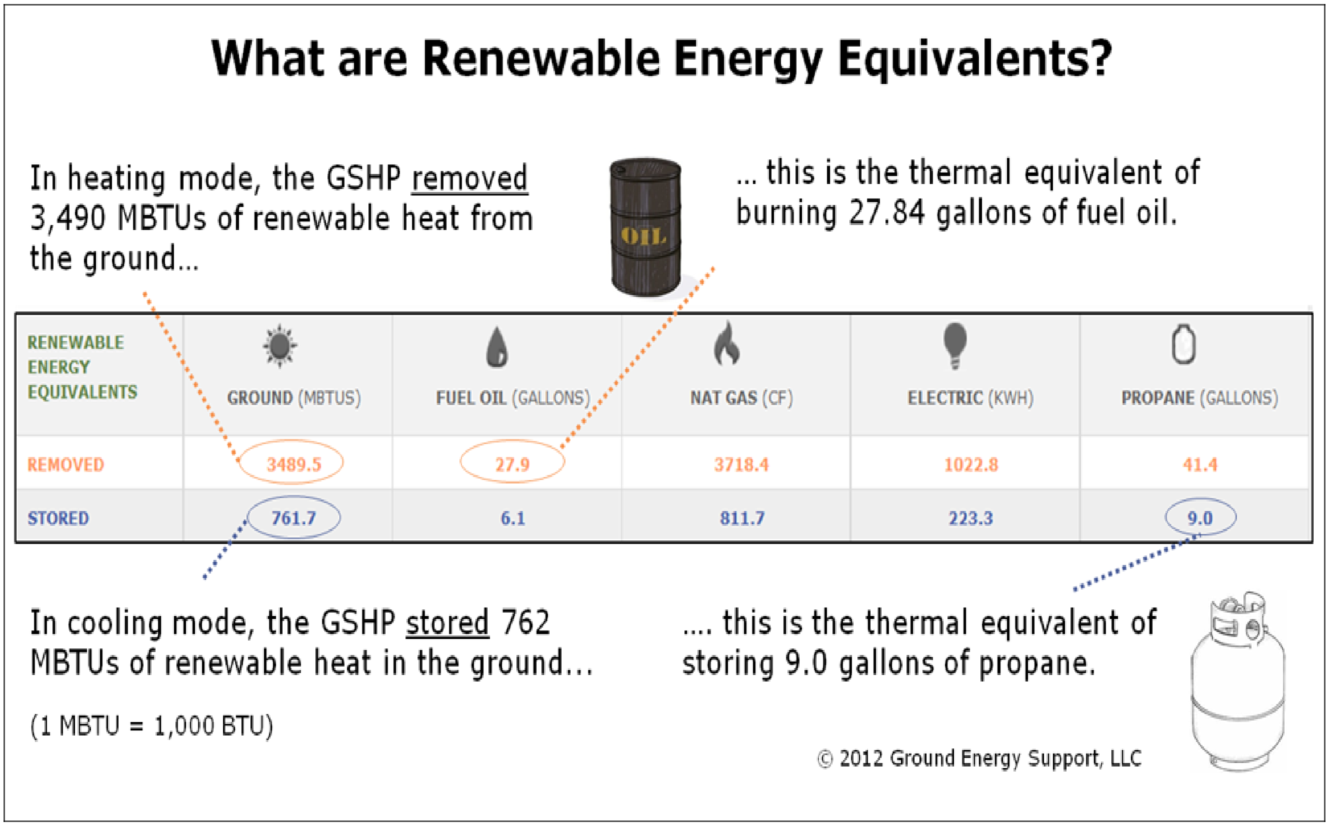
Learn More



Energy Equivalents

Conventional fuel needed to produce GeoExchange

[Learn More]



GxTracker™ Data

College monitoring site: http://www.groundenergy.com/console/dashboard/75/

Enclosed documents

CD set – As built drawings of system & O & M documentation manuals

Press releases for project announcement of completion /grant funds