Clemson engineers to create model underground energy-storage facility

June 10 2010

With a new twist on an old idea, two Clemson University environmental engineers are developing ways to store "waste" energy underground to cut heating and cooling costs and reduce carbon emissions.

Ron Falta and Fred Molz have received a $991,000 grant from the U.S. Department of Defense to create a Subsurface Thermal Energy Storage (STES) system that can be used as a model for energy efficiency.

Five military bases are being considered for the pilot project, among them the Marine Corps Recruit Depot at Parris Island and the Marine Corps Air Station in Beaufort, as well as locations in California and Rhode Island.

"This technology has the potential to greatly reduce energy costs and greatly reduce carbon emissions," said Falta, a professor in Clemson's environmental engineering and Earth sciences department. "At the same time, it allows for the integration of renewable energy into the infrastructure of the base, and it provides a clear path for reducing base carbon emissions and carbon footprint."

Using the natural insulating properties of underground sediments to store hot and cold material is an old engineering concept. The new twist is using a conventional heat pump to move heat between buildings and the subsurface: moving heat from the ground to the building in the winter, then heat from the building to the ground in the summer.

The Subsurface Thermal Energy Storage system differs from conventional geothermal heat pump designs in that it takes advantage of waste energy — such as heat produced in power production or low-cost solar heat collectors — to create an artificially hot zone beneath the surface. It then takes advantage of natural winter chill to create an artificially cold subsurface zone.

By using the hot water source in the winter and the cold water source in the summer, the geothermal heat-pump system can achieve higher heating and cooling efficiency than a conventional system.

"STES is a technology where low-cost or waste energy, heat or cold, is harvested when it is produced or when it is available, stored in the subsurface using borehole heat exchangers or water wells, and then used when the heat or cold is expensive or difficult to obtain," said Molz, an emeritus professor in the department. "This method of heating and cooling is far more efficient than conventional HVAC systems, and it could be 15 percent to 30 percent more efficient than current geothermal heat pump systems."

That could be a boon to the Department of Defense, which the engineers said spends about $3.5 billion a year at its bases on energy, much of which goes to heat and cool buildings.

"This technology could be widely applicable to buildings at Defense Department and other government facilities, particularly those in the northern two-thirds of the United States," Falta said. "We believe this technology could be applied at all scales, ranging from a single-family home up to a large manufacturing building."

Geothermal heat-pump projects are gaining popularity in energy-conscious Europe, North America and Japan. The Clemson engineers point to statistics that show the number of such heating and cooling

systems has been growing at a rate of about 10 percent a year for the past decade.

The focal point of this four-year research project, sponsored by the Defense Department's Environmental Security and Testing Program, will be an existing building of roughly 20,000 square feet. The engineers will retrofit an existing building's heating and cooling system rather than creating one from scratch to prove that the project can be used in a wide variety of settings.

They will measure temperatures and energy use before and after the Subsurface Thermal Energy Storage installation and fine-tune the process over time.

"If the project, compared to the best current ground-coupled heat-pump technology, achieves a minimum of a 15 percent energy savings, a 10-year payback and a carbon footprint reduction of 15 percent, we will declare it an unqualified technical success," Molz said.

Provided by Clemson University