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Storing Blue Northers

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Even in "normal" years, nature delivers Texans stifling hot summers and bitter cold winters. Modern Texans cope with these extremes by air conditioning homes, schools, churches, shopping centers, and even baseball stadiums.

This year-round indoor comfort consumes a great deal of energy. Heating and cooling bills often exceed house payments; and consumers certainly pay for air conditioning costs of offices, industries and stores.

Oldtimers in the state have been heard to say, "What August needs is a good blue norther." Not a bad idea, according to scientists at Texas A&M University. In fact, next winter three professors plan to store the blue northers and save them for August.

Drs. D. L. Reddell, W. B. Harris and R. R. Davison will cool water during the winter, store it underground, and retrieve it for cooling during the summer months. The same system could store warm water heated by the sun and use it to heat buildings during the winter.

Solar energy is probably one of the more glamorous alternative sources of home heating because it is clean, renewable, and safe. One of the major drawbacks to using solar energy for space heating, however, has been the problem of storing it until it is needed.

Harris and Davison, chemical engineers at Texas A&M, have designed a system of production and injection wells, cooling ponds, and solar heaters to produce naturally heated and cooled water and store it underground. They patented the concept in 1975 under the name of "Solaterre."

Concept Studied

The procedure of injecting water into an aquifer--a water-bearing layer of earth--and then pumping it out again is, of course, not a simple one. Agricultural engineer Reddell has spent years developing computer models--mathematical descriptions--to determine the feasibility of (1) using water to store heat or cold, (2) storing water underground, and (3) using the earth as an insulator.

Reddell's research, funded by the Texas Water Resources Institute and the Center for Energy and Mineral Resources, concludes that enough naturally heated and chilled water can be stored and retrieved from aquifers to make the concept a feasible alternative to present heating and cooling methods. His research has shown that:

1. Groundwater is a renewable resource and is available close enough to the surface in over 80 percent of Texas.

2. Groundwater movement is very slow (10-20 feet per year in most aquifers), so a large majority of injected water could be recovered.

3. Most aquifers are capable of storing vast amounts of heated or cooled water.

4. The heated or cooled water would have different densities and viscosities from the natural groundwater so that there would be little mixing with the existing groundwater.

5. The native aquifer rocks must be heated or cooled to the injection water temperature which will result in an initial heat loss. From preliminary heat transfer models of the system, Reddell estimates that heating or cooling the rock can probably be accomplished within three to five injection cycles.

6. After the initial heat loss, maximum storage efficiency would be 80 to 85 percent of the injected heat. Although the earth is an excellent insulator, as much as 20 percent would be lost to layers above and below the aquifer and to other water in the aquifer.

7. Energy requirements for pumps and sprays in the system would be negligible--less than one percent of that produced.

8. Construction costs of a system large enough to air condition 20 houses would be only $2,000 per house.

System Under Construction

Reddell hopes to verify these conclusions by actually constructing and operating a system to produce, store underground, and retrieve chilled water. He has received a grant from the U.S. Department of Energy for construction of a prototype system on Texas A&M University property ten miles west of the main campus. The purpose of the study is to determine if cold water can be produced, reinjected, stored, and then retrieved according to the researchers' design.

The system now under construction will include two production wells, eleven observation wells, and a cooling pond. Two 60-feet- deep wells, 20 inches in diameter, will be drilled about a quarter of a mile apart. Each production well will be capable of extracting water from underground or injecting it for storage.

Observation wells will be drilled at the test site for instrumentation and measurements. They will be used to monitor water levels and temperature profiles in the aquifer. These observation wells will be 50 to 600 feet from the cold water injection well and 2.75 inches in diameter.

When drilling the observation wells, Reddell plans to take formation samples every two feet of depth. The formation samples will be supplemented with cores from throughout the section and given laboratory analysis for porosity, specific yield, permeability, heat transfer coefficient, and heat storage properties.

Water temperature profiles in each of the observation wells will be maintained to evaluate heat movement in the aquifer and to locate the sources of heat losses. Temperatures will be measured in each observation well automatically each hour at every five feet of depth. The temperature data will be recorded and analyzed on the computer.

Researchers plan to manually measure water levels of each observation well to analyze the effects of injections and withdrawals.

Even though aquifers under Texas vary greatly in size, type, quality, and pressure, practically any aquifer within 200 feet of the earth's surface could be used for this type storage system.

The aquifer to be used in the field study averages 50 to 60 feet below the land surface. The groundwater, between 65 and 70 degrees in temperature, is in a mixture of fine to coarse sand, gravel, silt, and clay. It is high in sodium, calcium, chloride, and iron content.

Spray Cooling Pond

One of the objectives of the study is to collect design data for spray cooling ponds in warm, humid climates at low water temperatures. Harris and Davison have the responsibility for the design, construction, and operation of the spray cooling pond. A major design problem for the researchers has been the sparsity of data on spray ponds.

According to them, spray ponds are very sensitive to weather conditions and are not as widely used to cool water as more conventional cooling towers.

The spray pond now under construction will measure 50 feet wide, 100 feet long, and 5 feet deep. It will be lined with a rubber liner to prevent water seepage and to prevent the water from becoming turbid. The pond should be adequate for supplying 10 million gallons of water at temperatures of 50 degrees or below over an average winter in Central Texas.

Water will be circulated through 133 spray nozzles at a rate of about 600 gallons per minute. Nozzles 7 feet high will spray water up to 17 feet above the water surface. Harris and Davison estimate that less than 10 percent of the water will be lost through evaporation.

When the pond temperature drops below 50 degrees, water will be injected into the aquifer at rates less than 200 gallons per minute. The cooling pond will operate from October through March whenever water can be cooled to less than 50 degrees. Most cool water will be made at night, but injection can go on during the day. Starting in mid-May, the cold water injection well will be pumped and the cold water recovered. Careful records will be kept on the volume and temperature of the water pumped. This cycle will continue for at least three years to allow some statistical variation of weather data and to determine overall long-term efficiency of the system.

At the present time, no buildings exist nearby for air conditioning, but a new university agricultural complex is planned approximately one mile from the cooling site. Reddell feels that his system could be used to air condition this complex.

For the first few years the cold water will be allowed to heat up the pond to simulate the return water from an air conditioning system. The warm water from the pond will then be injected into the production well and stored until winter. Records will be kept on volume and temperature of the injected water.

Pumping cold water and injecting warm water will continue until the first of October; then the colling cycle will begin again in November when temperatures drop low enough.

Data to be Analyzed

Data collected in the three-year study will be used to evaluate the cold water aquifer storage system for air conditioning puposes. It will also be used to evaluate and verify exisiting numerical models of heat and mass transfer in groundwater aquifers.

"The collected data on the volumes and temperatures of the water pumped and injected at each of the two wells along with the water temperature profiles and water level data collected at each of the eleven observation wells will allow an evaluation to be made of the efficiency and economics of storing the winter's cold in groundwater aquifers," Reddell summarizes.

Student Contributions

Four agricultural engineering graduate students associated with Reddell have made significant contributions to the system design. Lynn Ebeling has used computer modeling to analyze the heat transport concept. David Reed is constructing a laboratory-sized aquifer--a 22-feet-long, 4-feet-deep sand box--to verify Ebeling's calculations.

Bill Stevens and Randy Chen are developing instrumentation for measuring water temperature at the field site. They want to be able to measure temperature of the earth above and below the aquifer as well as the water at various distances from the surface and from an injection well. The instrumentation must be designed so that it will not affect the flow or temperature of the water.

Another graduate student, Elston Grubaugh, is back at the computer to develop yet another system--one with as many as a dozen cold water injection wells. His study will include analysis of placement of wells and storage capabilities of aquifers.

Related Studies

The Texas A&M University field site may be the first in the world to store chilled water and retrieve it from underground. Data from the field tests will be made available to scientists at the University of California at Berkeley and at the United States Geological Survey who also have developed numerical models of the concept.

Reddell hopes to use the data gained from this study to evaluate several other systems of energy utilization from groundwater. These systems include the accumulation and extraction of heat energy in geothermal reservoirs, the long-term storage of hot water from solar energy collectors in aquifers, and the storage of waste heat from power plants and other industries in aquifers.

The most important thing to be learned, according to Reddell, is how much water injected at a certain temperature can be regained at that or a similar temperature. That is what will readily determine whether the design is feasible for commercial application.

Blue northers in August? Stored summer sun for winter heat? The concept is certainly a pleasant alternative to ever-increasing fuel bills and rapidly-diminishing energy resources.