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EGS -- Status and Technology Needs

J. L. Renner
Consultant, Inver Grove Heights, Minnesota

The forerunner of today's Enhanced Geothermal Systems or EGS is the Hot Dry Rock program at Los Alamos National Laboratory which conducted tests of stimulation of fractures in a granitic body during the period 1974 trough 1995. Japan and England also conducted stimulation tests of volcanic and granitic rooks. The hot dry rock project near Soultz-sous-Forêts, France achieved flow rates as high as 25 l/sec and is operating a 1.5 MWe scientific pilot plant module. The most aggressive EGS project worldwide is underway in the Cooper Basin of Australia in granitic rocks near oil and gas fields in the Basin. Wells drilled by Geodynamics Limited in the Cooper Basin are the highest-temperature EGS wells drilled to date with temperatures as high as 283°C at about 4,900 meters. This temperature corresponds to an approximate temperature gradient of 55°C/km, well above the average worldwide conductive gradient of about 17°C/km. A stimulated well at Geodynamics Habanero has a reported flow rate of 40 kg/sec., the highest reported EGS flow worldwide. A binary power plant has been constructed at Habanero but is awaiting operation due to recompletion of the geothermal wells caused by hydrogen embrittlement of the casing.

The U. S. Department of Energy (DOE) also conducted a program of research and experimental well stimulations in geothermal fields from 1979 to 1984. The experiments included both hydraulic fracturing and chemical treatments. All of the tests were at least partially successful. Although hydraulic stimulation has had only limited use in geothermal fields since that time, acid treatments to clean out the near wellbore region are widely used internationally.

DOE is cooperating with the geothermal industry in cost-shared field tests of stimulation methods at several sites within the western United States. These methods will include injection of cool fluid into the reservoir to stimulate thermal cracking at injection pressures less than that required to enable activation of shear on existing fractures, hydraulic stimulation at pressures sufficient to initiate shear movement but at pressures less than that required for tensile fracture, and injection at sufficiently high pressure to initiate tensile fractures. Chemical stimulation will also be tested.

A seminal report on the status and potential of EGS, "The Future of Geothermal Energy -- Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century" was prepared by a panel of experts led by the Massachusetts Institute of Technology in 2007. The report concluded that EGS can become a large, viable alternative energy resource by the mid-21st century concluding that "with a reasonable investment in R&D, EGS could provide 100 GWe or more of cost-competitive generating capacity in the next 50 years." In early 2008 the U. S. Department of Energy published "An Evaluation of Enhanced Geothermal Systems Technology" which reviewed the conclusions and methodology of the MIT report and summarized the technology needed to make the MIT estimate a reality.

The DOE study concluded that three critical elements must be demonstrated before EGS can become a commercial reality:

1. A commercial-scale reservoir must be created and maintained.
2. Reservoir production must be sustainable. MIT suggested that 200°C fluid would require a flow rate of about 80 l/sec for economic viability.
3. Wide spread production will require operation over a range of sites with differing geologic characteristics.

The DOE report recognized that formation of a fracture network is of critical importance and that oil-field technology should be adapted. The report also recognized that for the development of high-temperature EGS, oil-field technology will have to be adapted to a higher temperature environment. For wide spread application of EGS in areas of the United States with temperature gradients of one to two times average, high-cost, deep wells will be required. Dramatic reduction in the cost of drilling or improvements in drilling technology will likely be required.

The critical economic elements of EGS development include the energy produced by each well (a function of flow rate and temperature), the depth at which suitable temperatures are found (a function of temperature gradient related to heat flow and thermal conductivity of the subsurface), the cost of drilling to the required depth, the amount of re-drilling and re-stimulation required to maintain both flow rate and temperature, and the cost of the energy conversion system. The non-linear nature of the relationships between the increased energy content of higher temperature fluids at greater depths, the increased cost per foot of drilling deeper and the improved efficiency of energy conversion at higher temperatures makes economic evaluation of the relationship between energy conversion-temperature and well depth complex. DOE is utilizing a geothermal economic model (GEOTHERM) to study these relationships.