4.4.3 Development of Tools for Measuring Temperature, Flow, Pressure, and Seismicity of EGS Reservoirs – 300 °C Capable Electronics Platform and Temperature Sensor System for Enhanced Geothermal Systems

Presentation Number: 017
Investigator: Tilak, Vinayak (GE Global Research)
Objectives: To develop a platform of electronics technologies that can operate at 300 °C and 10 km depth enabling the measurement of temperature, flow, pressure and seismicity in a EGS reservoir.
Average Overall Score: 3.3/4.0

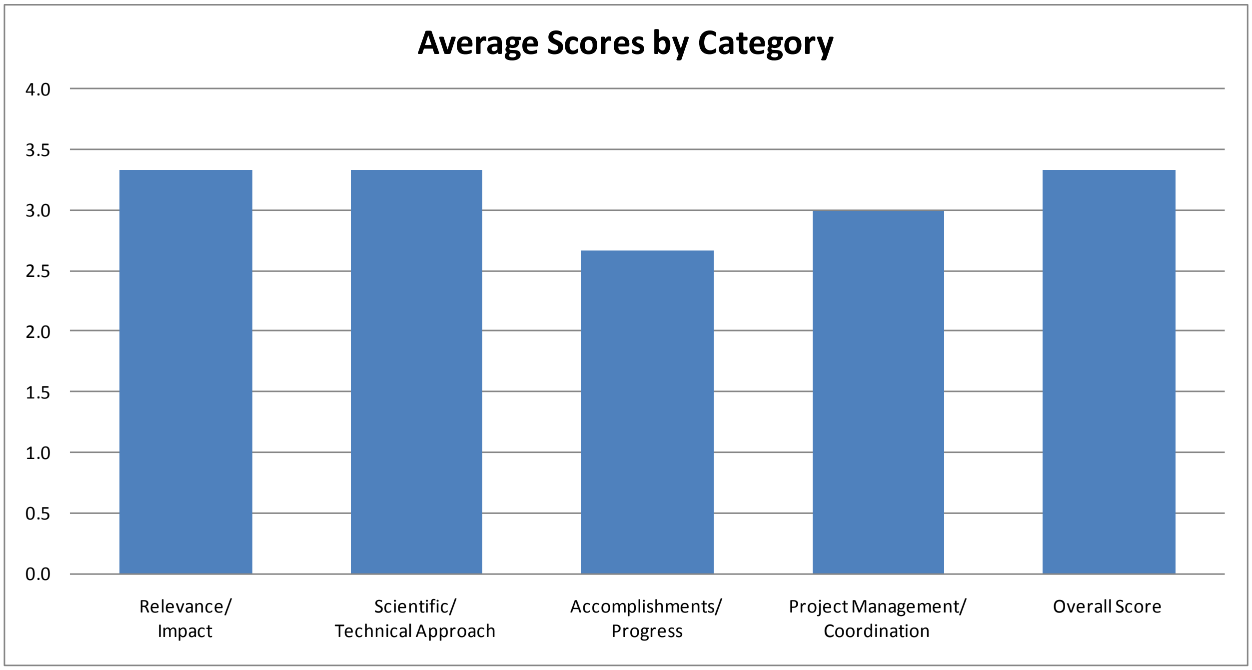

Figure 24: Development of Tools for Measuring Temperature, Flow, Pressure, and Seismicity of EGS Reservoirs – 300 °C Capable Electronics Platform and Temperature Sensor System for Enhanced Geothermal Systems

4.4.3.1 Relevance/Impact of the Research

Ratings of Three-member Reviewer Panel: Outstanding (4), Good (3), Good (3)

Supporting comments:

- Knowing temperature, flow, pressure and other properties of geothermal wells UNDER HOLE BOTTOM CONDITIONS is extremely important, so any progress that can be made to increase the resistance of tools to measure these properties is important. All such tools will have electronic components, that must either be flasked to resist the high-temperature (and pressure) conditions or be capable of standing those conditions directly. While flasking offers a simple solution, flasks eventually warm up and so have to be removed from the well to avoid overheating. For long-term installation, there is no alternative to having components that survive indefinitely under high-temperature conditions. This project addresses that need.

Building an operational amplifier for high-temperature operation is a good demonstration project as well as being valuable in its own right.

- This research would allow electronics to be placed in the well at temperatures up to 300 °C. This would empower all types of new data collection and diagnostics, especially helpful for monitoring reservoirs so that corrective actions can be taken to extend the life of EGS reservoirs.

- The primary objective appears to be development of an electronics package that can survive a 300 °C down-hole environment and feed temperature and/or other information to a data collection system either down-hole or at the ground surface. A secondary objective appears to be development of a temperature sensor that will measure high temperatures and provide output to the electronics package. Such a system will be necessary to furnish information about down-hole conditions to geothermal system operators at the surface.

  It is likely that the resulting technology will have broader application in other high-temperature environments, such as power plant operations.

4.4.3.2 Scientific/Technical Approach

Ratings of Three-member Reviewer Panel: Outstanding (4), Good (3), Good (3)

Supporting comments:

- Silicon carbide-based electronics offer excellent potential for high-temperature application. Building a SiC based Operational Amplifier is a good demonstration project as well as being useful in its own right.

  The parallel efforts to find sensors and passive components to be associated with the SiC electronics is a logical approach towards an eventual complete system. Simultaneous development of ceramic packaging is also a valuable contribution to the overall goal. The use of accelerated aging methods is useful but needs to be checked for validity by some real long term tests.

- The silicon circuit appears to have the temperature rating and sensitivity required for monitoring temperature and pressure. The next step is to package a device for testing in well conditions.

- The approach for the first year was to qualify appropriate materials and components for service at 300 °C; to develop a temperature sensor to operate in the same conditions; and to qualify characteristics of materials for a packaging system. This appears to have been accomplished in terms of the sensor and an amplifier and measurement of the temperature resistance of candidate components. Later work will focus on assembling the components into working subsystems and testing at high temperatures.

4.4.3.3 Accomplishments, Expected Outcomes and Progress

Ratings of Three-member Reviewer Panel: Good (3), Fair (2), Good (3)

Supporting comments:

- Development of the Operational Amplifier is a good achievement. Parallel development/testing and integration of passive components appear to be progressing well, and the collaboration with Auburn University concerning packaging is valuable. The future plan, to continue development of the electronics package and to make a temperature sensor appear logical and feasible.

- This project is about 4 months behind schedule due to a breakage of equipment/supplies that had to be reordered. They are making every effort to catch up and prevent a similar set back.

- The objectives for year 1 are reported to have been achieved, including development of a temperature sensor and an integrated circuit amplifier with preliminary tests at room temperature. However, survival times for the components have been estimated by modeling based on results of short term tests, and should be investigated further with longer duration testing conducted in parallel with ongoing development work. This will help to validate the modeling. To the extent that the final elements would be subjected to high pressures simultaneously with high temperatures, they should be so tested. This is especially true for the temperature sensor, unless the final packaging will protect it while still allowing accurate temperature measurement.

  The solid state amplifier appears to have passed a short term test at 300 ^{o}C.

4.4.3.4 Project Management/Coordination

Ratings of Three-member Reviewer Panel: Good (3), Good (3), Good (3)

Supporting comments:

- The project appears to be running well.

- Hind sight is 20/20 and this project would not have suffered the delay had additional supplies/equipment been on hand. They appear to be working to overcome the schedule.

- The various work elements are planned in a reasonable sequence. Some work on packaging elements was done, but it is not clear how much of this work was contributed by the subcontractor. A specific decision point is identified at the end of year 1.

4.4.3.5 Overall

Ratings of Three-member Reviewer Panel: Outstanding (4), Good (3), Good (3)

Supporting comments:

- Overall, a valuable project. Long-term, down-hole measurements of reservoir conditions must eventually rely on the use of electronics that can survive indefinitely under hole-bottom conditions. Silicon carbide-based circuitry offers this possibility so research in this field can provide the essential first steps that will ultimately lead to the development of a wide range of sensor (and possibly other) down-hole tools.

- The silicon offers a far higher temperature than other materials. This research has a high promise and should be continued, it is key to continuously monitoring reservoirs and real time data.

- Overall, the work in progress should result in a temperature resistant solid state apparatus for measuring temperature down-hole in Enhanced Geothermal Systems. (Final packaging and testing will need be done in separate projects.) If this project succeeds, the resulting capability will be applicable to other EGS monitoring systems. Consequently coordination between this and related work should be maintained where possible in view of proprietary matters.

4.4.3.6 PI Response

No response.