Air versus Water Cooling in Engineered Geothermal Systems

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Authors Bio: The authors represent a collaboration between Oak Ridge National Laboratory (ORNL) and Sandia National Laboratory (Steve Wright). The project, led by Adrian Sabau (ORNL, Materials Science and Technology Division (MSTD)) includes the computational efforts of Hebi Yin (also ORNL-MSTD), power cycle experience of Lou Qualls (ORNL, Advanced Reactor Systems and Safety Division), and physical properties calculations of Joanna McFarlane (ORNL, Energy and Transportation Science Division).

Abstract: To address problems such as greenhouse gas emissions and energy security, the US is considering large investments in renewable sources such as geothermal energy. Hydrothermal systems – that have the advantages of plentiful heat, water, and permeable rock – already produce about 3 MWe and more systems are in development. However, the potential for generating electricity from geothermal resources extends well beyond the traditional sources in the Western US. The US Department of Energy is actively supporting research on enhanced and engineered systems that may overcome issues such as low-permeability rock, limited water, and the drilling of deep wells. One of the issues associated with engineered geothermal systems is siting, and beyond the concern about rock type is the performance of the power conversion system under ambient conditions. Engineered sites can be located in areas where surface water is limited or water use rights are an issue. One way of minimizing water use is to have a power cycle that can work efficiently with air cooling rather than water cooling. Oak Ridge National Laboratory is developing more efficient power cycles that take advantage of the physical properties of mixtures of refrigerants in Brayton or organic Rankine cycles. Experiments on an air-cooled test loop employing 10% isobutane in CO_2 have given a respectable 18.1% cycle efficiency versus 14.5% for pure super-critical CO_2, demonstrating a 25% increase. These experiments are complemented by thermodynamic calculations that have demonstrated the effects of sizing of components in supercritical versus transcritical cycles for mixtures of supercritical CO_2 and SF_6. In these calculations, air temperatures are varied between 10 and 40°C to account for seasonal variability.