Abstracts for Presentations at the Geothermal Energy Generation in Oil and Gas Settings Conference

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Beniot, Dick

Scaling and Corrosion Abatement

Throughout the world there are two primary scaling issues involving geothermal production. When many low to moderate temperature geothermal waters boil calcium carbonate scale is a common result. The scaling rates can vary considerably depending upon a number of factors. In the mid 1980s carbonate scale inhibition became a standard operating practice in many geothermal fields both in the United States and throughout the world. A number of chemicals have proven to be basically 100% effective in eliminating carbonate scaling. The primary difficulty in developing the carbonate scaling programs was development of reliable hardware systems for delivering 10 to 20 ml/minute of chemical below the flash point in the wells. Several types of delivery systems have now been proven to be very reliable and in most geothermal fields carbonate scale inhibition is viewed as a routine operation.

Silica scaling is a much more difficult challenge for high temperature geothermal systems where silica concentrations in the water may exceed 1000 parts per million. In the hotter fields the classical method for dealing with silica is to limit the amount of steam separated from the water, explaining why there are many single flash type power plants. Efforts involving acidification and addition of chemicals to the water have been underway for a number of years to reduce or eliminate silica scale precipitation but results to date have had limited success.

Corrosion is not typically a serious problem in geothermal fields, with the exception of the fields producing hypersaline brines or very high noncondensable gas contents. In the Salton Sea geothermal field the corrosion issue has been addressed by the use of sacrifical liners and titanium casings in the wellbores at considerable costs.

Blackwell, David

Geothermal Resources in Sedimentary Basins

The recent compilation of a Geothermal Map for North America included the use of extensive Bottom Hole Temperature (BHT) data from oil and gas exploration wells in addition to other thermal data sets. These data emphasize the extensive heat resource that occurs within drilled depths in the areas of hydrocarbon production. It is common to have hydrocarbon wells that reach temperatures of 300 to 400 °F, temperatures that are in the range considered developable for electrical energy production in the hydrothermal systems in the western US. However, many of the areas with such high well temperatures are outside of the areas in the western US typically associated with geothermal energy production. For example most of the Midwestern States and several eastern states are included in this category.

There are a number of scenarios for development. These are artificially divided into three for the purposes of discussion: coproduced fluids, geopressure fluids, and sedimentary EGS. These are briefly described and examples of development given for each case.

The category of coproduced fluids is based on the present production of water in association with hydrocarbon production. This category is very cost effective if the water is hot enough to generate electrical power (>200-225 °F). Several specific development cases will be discussed at this conference. Several thousand MW of electricity could be produced using only the present rate of waste fluid production.

There is hot water at some depth everywhere, but in the Texas Gulf Coast and East Texas for example the depths to temperatures of 300 to 400 °F are well within routine drilling ranges (10,000-18,000 ft). In the Gulf Coast the geopressure system well known and there has been a lot of additional drilling since the

change in attitude in the way that hot water is handled. It is the stored heat within the water that has value as it is used to generate electricity or used in other industries that require hot water.

Possibly the second most important constraint of this category involves transmission, especially as related to profit. When oil and gas is produced, these energy resources are rather easily placed within a delivery system, either a pipeline or a truck, to be shipped to the processing plant further development. Many O&G companies see their profit only at the wellhead, not in the finished product. However geothermal is different. When the hot water is produced, electricity must be produced near the wellhead so as to minimize heat loss in the pipeline. It is the electricity that is then "shipped out" to the retail or wholesale user. This is a distinct change in energy development that and O&G operator must realize. They can produce the water and they must produce the product before it is transmitted. The good news is actual transmission of the electricity may not be too difficult. For example, the Ercot grid system extends into areas of the Delaware and Val Verde Basins not only because of the wind farms that have been constructed, but also because of the need to deliver electrical power to the O&G infrastructure on the ground. Thus established electrical rights of ways that bring electricity to a producing field can also send electricity out of that field if hot water is used to generate electricity on site.

Finally, Texas geothermal energy production can help to release other energy resources presently in use for electricity production that might be better used elsewhere. For example, Matthew Simmons has indicated that natural gas has been one of the best sources of heat that we have, and finding a replacement for this energy resource is a problem. Thus the use of geothermal production for electricity generation would go a long way to free up natural gas for other industrial needs. Additionally, geothermal power plants may have the best all round availability factor of 97.5% or more of any energy resource in use.

The development of Texas geothermal energy will change the future of both the oil and gas and the geothermal energy industries. It is the Texas oil and gas industry that is best suited to take advantage of this undeveloped energy resource in its near term development. And it is the O&G infrastructure in the form of data and personnel that can make this a reality.

Erdlac, Richard

Texas Geothermal Energy: A Focus On Permian Basin And Trans-Pecos Regions

The Delaware and Val Verde Basins form the deepest parts of the Permian Basin. They represent one of 5 regions within the state that have the potential for holding vast amounts of renewable heat energy. Temperatures well in excess of 212°F are present in deep wells. Using existing technology, this hot water, generally considered a liability when encountered in the O&G drilling process, holds the key for a restoration of the Texas oil and gas industry and its infrastructure for decades to differences. Drilling a well will cool the annulus around the well bore. Thus a temperature reading taken immediately after drilling will record a lower temperature than if some time is allowed to pass for equilibrium to be reached. Several wells were encountered with temperature values at the same depth as low as 20^{o}F and as much as 100^{o}F different over a period of time.

The Delaware Basin covers a minimum of 5,500 sq. miles. The only Texas geothermal plant, built in Brazoria County along the Gulf Coast, was estimated to have been capable of 1.1 MW from the heat energy out of the Frio Sandstone alone. Only one zone was produced at this site originally, so this number may be low as well. Investigations in the Gulf Coast within the Brazoria, Matagorda, and Corpus Christi fairways suggested the areas, the number of plants, and the number of wells per plant that could be developed. Using information from the Brazoria geothermal power plant, where produced brine was around 277^{o}F, along with these fairway estimates, we calculated that the Delaware Basin had a minimum range of geothermal generation of 264 to 933 MW. We anticipate that these values are very much on the low side. Information from an Ormat geothermal field in an Imperial Valley sandstone suggests that production for a 50 MW plant requires around 5,000 acres for production at a temperature of 300^{o}F. Applying these figures to the Delaware Basin suggests a maximum geothermal rating general, the recoverable stratabound geothermal resource in the region exceeds the energy that could be recovered from oil production.

Hays, Lance
Optimizing Separation and Power Generation from Two-Phase and Three-Phase Well Flows

Commission to regulate the exploration, development, and production of geothermal energy and associated resources for the purpose of conservation and protection of correlative rights. The Act required the Railroad

McKenna, Jason - No Abstract

Milliken, Mark

Tea Pot Dome Case Study, Wyoming

Naval Petroleum Reserve #3 is located at Teapot Dome field in Natrona County, Wyoming. The structure is a typical Laramide asymmetrical drape fold, bounded on the west by a basement-involved blind thrust fault. Commercial oil production occurred in the early 1920s for a brief period, followed by a long shut-in period. NPR-3 was opened to full field development in 1976. An abundance of relatively fresh hot water (180° - 200° F) was produced in association with Pennsylvanian Tensleep oil from depths of about 5000 ft. Water supply wells drilled to the underlying Mississippian Madison Limestone yielded rates exceeding 20,000 BWPD flowing at formation temperatures projected to be about 230° F. Artesian flow of the Teapot Dome geothermal system is caused by forced convection resulting from recharge in the Big Horn Range located 90 miles NW. The Big Horn recharge area represents a hydraulic head of about 8000 vertical ft above the NPR-3 surface. Pumping could increase rates by factors in the range of two to four. The geothermal gradient of 25° F per 1000 ft of depth at NPR-3 is 9% higher than the average for the Southern Powder River Basin. Fractured Precambrian basement granitic rocks at depths of 7000 ft and more may yield substantially larger volumes of water at temperatures exceeding 250° F. Power potential at NPR-3 from 130 MBWPD at 220° F would be 76 MW.

Mines, Greg

Overview of Contributors to the Cost of Geothermal Power Production

There are numerous contributors to the cost of generating electricity from geothermal energy. Capital costs are incurred beginning during the exploratory phases of a project and continue through the completion of the power plant construction and well field development. Once power generation begins, the operating costs associated with both the plant and the well field will also influence the power generation cost. Factors such as the resource temperature and geothermal fluid flow rates will impact the ability to generate power, as will both the availability of water and the ambient conditions. This presentation will provide a brief overview of the various contributors to the cost of geothermal power and the factors that influence the magnitude of the various contributions. The emphasis of the presentation will be on those costs when a binary power plant is used as the energy conversion system.

Petty, Susan

U.S. 2006 Enhanced Geothermal Systems Resource Evaluation

As part of a study lead by Dr. Jefferson Tester of MIT, conducted for the U.S. Department of Energy Geothermal Technologies Program, the feasibility of developing a substantial amount of the energy needed in the future to supply electric power across the US from Enhanced Geothermal Systems. As part of this study, the amount of power production potential is being evaluated. Maps developed here at SMU by Dr. David Blackwell combined with calculations of heat in place, recoverable heat, conversion efficiency and the area with resource that can be accessed were used to determine the developable resource. The area of the US and individual states underlying parks, recreation areas, wilderness and other undevelopable areas was excluded from the study. Only a 10 temperature drop in the rock was allowed. Using very conservative estimates, this developable resource ranges from 4.3 to 43 x 10^6 MWe. The penetration of this resource into power markets was studied using project economics developed using the GETEM costing code developed for the US DOE Geothermal Technologies Program. The resource is so large that even without considering recovery of a heat mined from the reservoir, the resource can be considered sustainable. While only a small fraction of this resource might be developable in the near future at economic rates, the potential for technology improvement, including results of the Soultz project in France and the Cooper Basin project in Australia, can improve economics to allow more than 50,000 MWe to become economic over the next 40 years.

Petty, Susan

Development of Geothermal Power from the Poplar Dome Oilfield, Montana

The existence of a geothermal resource in the permeable formations of the Poplar Dome was first detected when oil wells drilled into the Madison Limestone produced hot water. The field produces about 20,000 BPD of water over 265°F (130°C), and this could be doubled if the hottest wells that were uneconomic for oil but produce hot water were recompleted. Enhancing unused high temperature wells and recompleting at the intervals with highest temperature could increase the overall temperature of the fluid to 155°C (300°F). Economics for power generation for two scenarios were calculated using the GETEM geothermal costing model developed by the DOE Geothermal Technology Program. In the first, wells of opportunity producing already at the southeast side of the oilfield are collected and used to supply a 1 MW stand alone binary power plant similar to that used at the Wendell-Amedee KGRA near Susanville, CA. The plant is assumed to run unattended with telemetry of data to a facility in Denver, CO where the performance is monitored. Oil is separated from the water in the pro injectate reduces energy extraction. Multi-lateral well completions work to improve fluid residence time. Either excessive overpressure or extensive sedimentary formation volume is required to sustain power production in the absence of fluid injection. Mature oil and gas fields, especially those under waterflood, are reasonable candidates for power production.

Smith, Russel - No Abstract

Smith, Tim

Overview of Renewable Energy Credit Markets

The market for Renewable Energy Credits (RECs) is growing rapidly in the United States. There are currently 21 states that have a mandate in varying stages of development for load-serving entities, and over 5 million megawatt-hours of RECs were sold to voluntary customers in 2005. RECs are a complicated concept to grasp, and this problem is magnified by a lack of any national standard. All markets, both mandatory and voluntary, are unique in their rules and definitions. REC markets are very illiquid, and there is little transparency. This makes understanding the markets and keeping up to date with them is typically difficult.

The goal of my presentation will be to give an overvie will be required mainly driven by increased transportation and electrical generation demands. Also, fueling a high-efficiency U.S. 2050 light-duty fleet (80 mpg equivalent) with H_2 produced by coal gasification would require capture and sequestration of ~2 billion tons of CO_2/yr. Analysis highlights primary energy production shifts to renewables away from fossil fuels, geothermal energy's ultimate potential, CO_2 sequestration requirements, opportunities for increasing efficiency, and potential technology gaps. The closed nature of the methodology bounds supply and flow volumes quantitatively and comprehensively, prompting debate about real needs and enabling cross-sector discussions. Future analyses will explore other possibilities for geothermal energy under different assumptions and under additional constraints (e.g., economic, technical) to highlight their broader implications.