4.2.4 Geothermal Testing Facilities in an Oil Field - Rocky Mountain Oil Field Testing Center

Presentation Number: 014
Investigator: Johnson, Lyle (RMOTC)
Objectives: To develop a long-term testing facility and test geothermal power units for the evaluation of electrical power generation from low-temperature and co-produced fluids.
Average Overall Score: 3.3/4.0

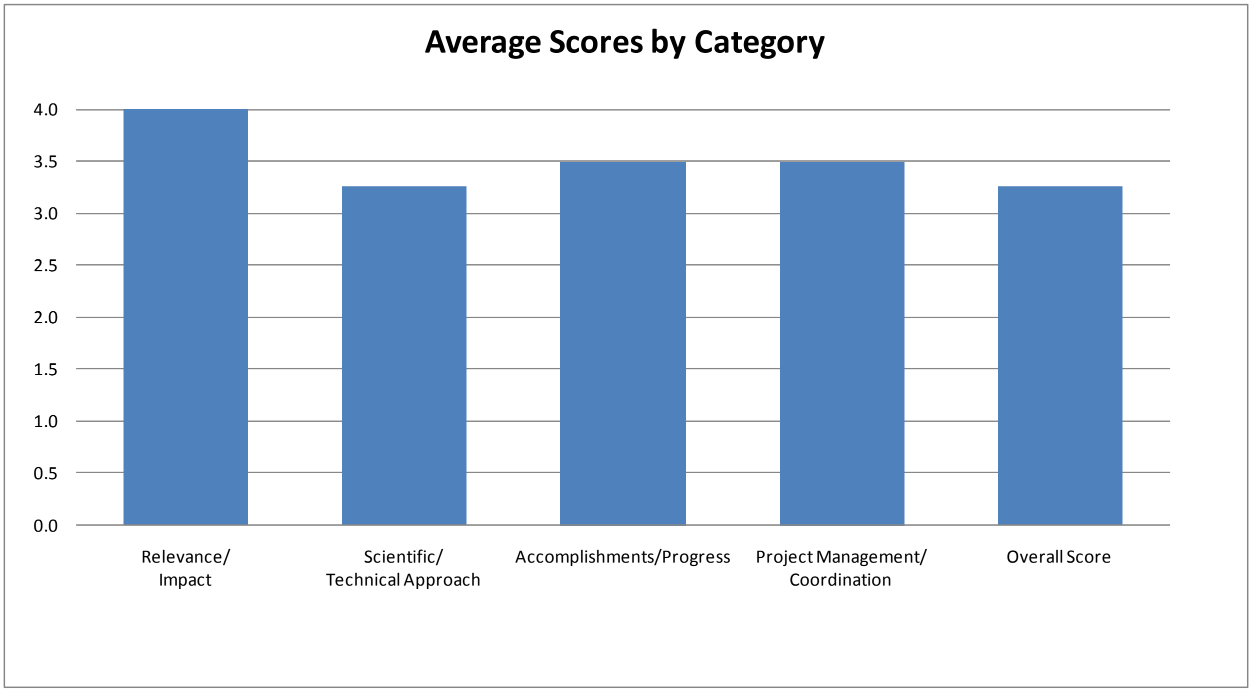

Figure 14: Geothermal Testing Facilities in an Oil Field - Rocky Mountain Oil Field Testing Center

4.2.4.1 Relevance/Impact of the Research

Ratings of Four-member Peer Review Panel: Outstanding (4), Outstanding (4), Outstanding (4), Outstanding (4)

Supporting comments:

- Having a test facility operating for an extended period in the field is outstanding.
- The Rocky Mountain Oil Test Center (RMOTC) project proposed to develop a long term testing facility for the evaluation of electrical power generation from low-temperature, co-produced geothermal fluids. The facility would provide the ability to conduct both long and short term testing of different power generation configurations to determine reliability, efficiency and to provide economic evaluation data.

Since August 2008 the RMOTC has effectively demonstrated the operation of an air cooled factory integrated, skid mounted, 250 kW Organic Rankine Cycle (ORC) power plant based on a water temperature of 170 °F and an average ambient temperature of 50 °F.

Concerning EGS, the RMOTC is considering the option of conducting EGS testing.

The project is innovative and effectively addresses known technical barriers for geothermal power generation from an actively operating oil production facility. This is an excellent demonstration site to incorporate geothermal co-production in an oil field environment. The project has successfully established the capabilities of energy production from low-temperature geothermal resources.

This is a viable technological application for the geothermal industry in cooler climates and advances the science and technology but more work is required in addressing whether this technology will work in other low-temperature resource locations with different water chemistry and compositions of oil and gas mass fractions, and whether this co-production technology will be economical enough in warmer climates with more stringent environmental discharge requirements.

It is this reviewer's opinion that smaller ORC units may require a longer payback period just based on economy of scale, and what ORC systems are available in the market. It is anticipated that smaller systems will not be as efficient as a larger ORC unit in climates where the average annual temperatures exceed 50 °F, and have different total dissolved solids, water compositions to RMOTC's production well(s) and have differing flow rates. This however, is dependent on a geothermal resource's water chemistry, well head temperatures and pressures, ambient conditions, cost of equipment, engineering costs, and not to mention site mitigation costs, permitting costs, available infrastructure, and utility power rates.

The project has successfully established the development of an air cooled ORC power plant. The project has successfully proven that a remote distributed power system will work. It also broadens the potential for geothermal co-production in some locations and provides the following additional positive benefits:

- improves the competitiveness of geothermal co-production
- increases resource/electricity availability, flexibility and reliability of geothermal power
- provides a reasonable alternative to fossil fuel in relation to environmental concerns including greenhouse gases, health and safety benefits and mitigating adverse impacts
- reduces capital costs or operation and maintenance costs

- provides a platform for the development of a renewable technology
- includes technology transfer activities as part of the project

As part of their technology transfer, the RMOTC proposed their facility as an active demonstration laboratory to transfer lessons learned to any interested party. It is through these types of demonstration projects that an energy producing company will be informed and may consider implementing this small-scale ORC technology.

- The project is making very good progress toward the objectives and appears to have been well publicized and successful. The project is fortunate in having a high quality water fraction but I am not sure that the water quality has been well characterized. Indeed I would like to see such demonstration plants include water quality analyses for both fluid and gas compositions. The efficiencies and performances of the oil/water/gas separation equipment also should be characterized and perhaps this should be an additional task. Any scaling or evidence of oil build up in the heat exchanges also should be investigated in future studies.

- The question asks about the relationship to EGS systems. This project has nothing to do with EGS. I am reviewing it against the broader goal of expanding the use of geothermal energy, in this case to low-temperature resources. This project provides a platform where power plant manufacturers can test and improve their hardware and oil field operators can gain confidence about the practicality of using co-produced water to generate electricity. The facility has been shown to be functional and is in the process of testing equipment from one manufacturer. Assuming this facility will continue to be available for demonstrations by other manufacturers, it will contribute to the DOE goals.

4.2.4.2 Scientific/Technical Approach

Ratings of Four-member Peer Review Panel: Good (3), Outstanding (4), Good (3), Good (3)

Supporting comments:

- There has been a lot of outstanding work in this program, but a critical aspect is missing. One of the biggest risks of power production from co-produced fluids is degradation of heat transfer due to fouling of exchanger surfaces from scale and/or oil buildup. The value of this program would be significantly enhanced if fouling factors and pressure drop in the heat exchangers were carefully tracked and reported.

- RMOTC personnel utilized the appropriate scientific/technical methods and procedures to achieve project objectives with the available funding and personnel. The technical approach is based on sound engineering principles and is incorporated into the deployment of the testing facility. The initial testing facility conceptual design was logically planned and can accommodate future test variations. Project deployment is well grounded and focused on completion of goals and objectives. The test facility addresses engineering design, power plant specifications for both long and short term testing of different power generation ORC configurations. In addition, the RMOTC designed their OCR test unit to accommodate differing well flow rates and performed an accurate analysis of what the ORC system is capable of handling and achieving optimum power generation. Testing included determining the reliability, efficiency and economic evaluation data.

Before sizing the ORC power plant RMOTC staff performed a resource assessment of their oil field to determine the proper mixed fluid flow rates, temperatures and enthalpy calculations necessary for the proper deployment of a small scale ORC system.

- The approach was well designed and the performance was well described. The modifications made during the test runs were good and overall a very sound technical approach to the work.

- (I rated this as good)The technical barrier is the uncertainty that oil field producers have about using equipment to generate power from co-produced water. The technical approach is to do it and publish all information about the experience, which will reduce the "uncertainty risk" and encourage the use of this technology. This approach will only be effective if the project provides information that allows extrapolation to use at different locations. Having the facility operated by an entity that is not selling particular equipment makes the dissemination of information more likely, and the PI is to be commended for the extent that data are being documented. It is unclear to me what data are needed to convince a user that this approach would be viable given the regulatory issues and conditions in different states and field conditions. I would encourage the PI to evaluate what measurements would be required to make the results from this facility generalizable to the largest number of sites.

4.2.4.3 Accomplishments, Expected Outcomes and Progress

Ratings of Four-member Peer Review Panel: Outstanding (4), Outstanding (4), Good (3), Good (3)

Supporting comments:

- Extended operation on the co-produced fluid has been outstanding.

- The quality and qualifications of the research team, equipment and facilities are superior. The project has an excellent chance of successful completion given the support by Ormat Nevada, Inc. and the GTP.

  The location to demonstrate this low-temperature ORC technology at Teapot Dome Oil Field, Natrona County, Wyoming is excellent. The climatic conditions are favorable for this test facility. This is a great test location to further refine the science and make the necessary adjustments to small ORC systems that may eventually go into service nationally and internationally.

  This project is well thought out as evidenced by RMOTC's deployment strategy. In Phase 1, RMOTC installed an air cooled factory integrated, skid mounted 250 kW Ormat ORC power plant. RMOTC performed an analysis of projected generator performance and collected six months worth of data from September 2008 to February 2009. As expected the output power fluctuated with daily ambient temperatures. The net power output averaged 171 kW with a range of 80 to 280 kW. The unit produced over 586 MWh from 3 million barrels of hot water. The online percentage for the unit during this period was actually 91%.

In Phase 2 RMOTC followed up by making various modifications to the ORC system and support equipment. They collected more system performance and temperature data to determine the optimum power generation parameters from September 2009 through April 2010. Phase 2 has averaged 198 kW net power output and produced over 732 MWh from 3.4 million barrels of hot water. The online percentage has been 97%. As of May 18, RMOTC reported that power output of the ORC over the last 60 days had averaged 212 kW with a control set point of 220 kW.

Their present plan is to run the unit for two years and expand operations to accommodate a second 250 kW unit and several smaller 75 kW units.

This reviewer believes that larger ORC systems should be considered for testing to simulate the larger production zones in oil and gas fields in California, Texas, and Louisiana.

The level of work productivity underway is timely and on schedule with respect to the budget. The accomplishments thus far against planned goals and objectives, technical targets, awards, seem to be on schedule and responsive to the original timelines, goals and objectives.

- The work undertaken so far with the air-cooled unit has been very good and the results are good. Planning for the water-cooled units also seems very sound.
- (I rated this as good) This project is making a lot of progress, and the facility is good for the task. The PI has a level of practical experience that will make the results more likely to influence Oil field operators.

4.2.4.4 Project Management/Coordination

Ratings of Four-member Peer Review Panel: Outstanding (4), Good (3), Good (3), Outstanding (4)

Supporting comments:

- No comments.
- The project has an excellent chance of successful completion given the support by DOE GTP and Ormat Nevada Inc. and RMOTC's match share.

  The budget is reasonable, and the cost share provided by the RMOTC is indicative of their willingness to make a financial investment to make this testing facility a success. The budget seems appropriate for the scope and complexity of the project. This is a workable project given the budget, technical difficulty and qualifications of the RMOTC and Ormat.

Budget:
EERE (GTP) - $775,000 to $1,135,000
FE (RMOTC) - $400,000 to $900,000

The milestones accomplished thus far are compatible with the goals and objectives and budget. It appears that the technical, policy and spending plans for the project have been carried out successfully. The work presented was clear and the project was executed in a logical manner.

Weaknesses:

RMOTC claimed a payback period of 5.1 months but no economic analysis or data were presented to substantiate a favorable return on investment.

A discussion concerning lowering the cost of extracting energy from resources of progressively higher ambient temperatures would have been useful. Also, no information or data were provided that discussed operation and maintenance costs of production wells and power plants.

A summary of the budget was provided, but a detailed break-down of expenses was not included.

- The management has been very effective. My only comment regarding additional work would be to include detailed chemical analysis of water and gas chemistry and some assessment of the efficiency of the water/gas/oil separation process. I was not clear if an actual date for installation and evaluation of a water-cooled unit had been decided.
- (I rated this as outstanding) The project has moved along a path towards successful completion.

4.2.4.5 Overall

Ratings of Four-member Peer Review Panel: Good (3), Outstanding (4), Good (3), Good (3)

Supporting comments:

- An outstanding project in many aspects, but it could be improved with careful tracking and reporting of heat exchanger performance over time.
- Overall the project met all technical and operational expectations given its unique location and excellent qualifications of the RMOTC and Ormat personnel.

  The project attempts to address research and development barriers. However, the question of whether this co-production ORC technology will overcome significant market barriers in warmer climates such as in California and other markets with more stringent waste discharge, noise, and air emissions requirements is unknown.

Commentary:

The State of California, which has the largest geothermal production and significant untapped geothermal potential from hydrothermal resources, and underdetermined geothermal potential from its vast oil and gas production fields, has very stringent environmental requirements that could prevent energy producers from considering doing business in California. In attempting to address the technology transfer aspect of this project and other geothermal power generation technologies that could be adapted to California, energy developers must consider many other aspects to their environmental project plans.

As California's oil production declines, it becomes increasingly more difficult to extract oil from oil-wells with less of the total fluids produced as oil and more of it as water. The State of California under the auspices of the Public Interest Energy Research and the Geothermal Resources Development Account Programs will provide research and development funding to address this problem through implementation of hybrid projects. Hybrid projects may include another renewable component such as solar, wind, biomass, storage technologies or any variation of geothermal energy co-production from oil and gas fields.

Generation of by-products of spec gas from oil and gas fields is a significant air pollution problem in California. When such gas cannot be conveniently sent to gas pipelines, it becomes "stranded" from commercial markets and a problem for the producer. For most of California's oil production history gas production, even when it is not stranded, has been considered a low value fuel. The gas must be disposed in order to allow continued production of the higher value oil.

In some instances, even pipeline quality gas cannot be sold because there are no natural gas pipelines nearby; similarly, many urban natural gas pipelines are shutdown because of encroaching urban renewal. This is especially challenging in the Los Angeles Basin with its recent proliferation of high rises through several existing oilfields. Gas that cannot be sold into natural gas pipelines must be suppressed, flared or vented. In the Los Angeles basin, venting is not acceptable because of the potential impact on nearby dwellings and businesses; even flaring is increasingly limited because of emissions limitations. If the gas is suppressed or re-injected into the well, it stymies oil production.

California has extremely rigid air emission standards for electrical generators. This electric power generation would reduce emissions. The electricity generated from waste gas would offset the high cost of power otherwise purchased by the oil producer, shifting the economics significantly in favor of production. If successful, off-gases would generate more power, reduce oil production costs, increase oil production and reduce emissions as well. At the national level, the benefits of increased oil production would reduce import needs, thereby helping towards national security. Off-gases project will reduce methane from vented gas, reduce NOx from flares, and reduce CO_2 by offsetting generation elsewhere, helping towards the goals of the greenhouse gas reduction act, California AB 32.

It would be useful to find means to make electricity from the energy in stranded gas. The electricity may be used by the producer, or sold to the utility. This power would require no additional fuel, thus saving fossil fuel imports, and also cleaning the environment. With new technologies now available, the gas behind shut-in wells or wells once considered uneconomic can be used by conversion into direct heat.

- I questioned if I might rate this as outstanding and a World-class project and perhaps it is almost at that level. However, given that the assessment of the water-cooled unit has yet to take place I have scored it good at the present stage of progress.
- (I rated this as good) This will accomplish the goals of the project, and should encourage more utilization of energy from water in oil and gas wells.

4.2.4.6 PI Response

No response.