

NOTICE CONCERNING COPYRIGHT RESTRICTIONS

This document may contain copyrighted materials. These materials have been made available for use in research, teaching, and private study, but may not be used for any commercial purpose. Users may not otherwise copy, reproduce, retransmit, distribute, publish, commercially exploit or otherwise transfer any material.

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specific conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.

Developing an Enhanced Geothermal System Resource In East-Central Arizona

Dennis W. Hughes,
Chief Operating Officer

Navopache Electric Cooperative, Inc.

ABSTRACT

Navopache Electric Cooperative, Inc. (NEC) is a rural electric transmission and distribution cooperative headquartered in Lakeside, Arizona. NEC provides electric service to over 40,000 consumers in its 10,000 square mile service territory covering east-central Arizona and west-central New Mexico. NEC owns and operates 263 miles of 69kv transmission lines and 3,457 miles of 14.4/24.9kv distribution lines. NEC is an “all requirements” customer of the Public Service Company of New Mexico and in 2008 delivered 434 gigawatt hours in retail sales to its membership.

NEC and Mohave Electric Cooperative (MEC), located in Bullhead City, Arizona, engaged the firm of Black & Veatch Corporation (B & V) in May of 2008 to conduct a feasibility study of geothermal resources within their service territories. Both cooperatives have knowledge that some geothermal resources have been identified in years past within their respective territories. In the mid- 1980’s, NEC attempted to secure funding from the Department of Energy (DOE) to drill an exploratory well in hopes of verifying a resource, but did not prevail in its effort.

In April of 2009, B & V and its partner GeothermEx, Inc., of Richmond, California, released the findings of their feasibility study which concluded that “EGS is a viable option within the NEC and MEC service territories on a technical and economic basis”. The feasibility study will be referenced in greater detail within this document.

Based on the positive outcome of the feasibility study, NEC has decided to seek funding to drill an exploratory well to further confirm the magnitude of the resource in its service territory. NEC has registered with the Federal websites, Grants.gov and FedConnect, to apply for various funding opportunities announced by the DOE under the stimulus program.

Introduction

NEC first became interested in developing a “hot-dry-rock” geothermal resource in the early 1980’s. The general manager at that time was C. Mac Eddy, who was a true pioneer in applying technology to the rural electric program. Mac implemented

time-of-use rate schedules, remote meter reading, demand side management techniques, and developed a sophisticated supervisory control and data acquisition (SCADA) system to manage the NEC power system, years before these ideas were embraced by small electric cooperatives.

Mac was a visionary and a self-taught scientist and engineer. He was an advocate for innovation and was eager to apply technology to the tasks of managing a rural electric cooperative. It was his interest in new technologies that set NEC on a course to explore the feasibility of developing a geothermal energy resource.

Mac followed the development of “hot-dry-rock” research being conducted at the Los Alamos National Laboratory in northern New Mexico. When the Fenton Hill Project became reality, Mac visited Los Alamos to learn more about the possible application of the technology within the NEC service territory. Soon after his visit to Los Alamos, Mac founded a partnership with Edward Kaufman, President of Pan American Energy Corporation.

Mr. Kaufman assembled a team of scientists, geologists, engineers and environmentalists to assist he and Mac in writing a grant application to the DOE.

Among the participants were John McNamara, Ellen Heckler, W. Richard Hahman, John Rowley and Robert Hendron, all of whom contributed their knowledge and expertise to the funding effort under the umbrella organization Pan American Energy Corporation.

Their application was hand delivered to the DOE in Oakland, California, on August 4, 1986, to respond to the DOE’s RFP # DE – RP03 – 86SF16386. The grant application sought funding to drill an exploratory well to determine the feasibility of developing a 50 megawatt geothermal generation resource. The grant application was not successful and the outcome of the competition did not result in any funding award to NEC. Inasmuch as generation capacity was not a critical issue for NEC in those days, Mac abandoned the project and turned his attention towards other issues which allowed him to implement technological solutions to improve utility operations.

Several years later in 1993, the USGS drilled a well near the area that Mac had proposed the NEC geothermal exploration project. The USGS was interested in evaluating possible geo-

thermal resources in the region and data collected from their test well confirmed a temperature of 164 degrees Fahrenheit at a depth of 4,500'. The well was named the Alpine Federal # 1 Well and was capped following the USGS drilling activity. The well head was recently located by NEC as it considered whether or not to try again to develop a geothermal resource. The drilling log from the Alpine Federal # 1 Well was released by the USFS to NEC and contributed to the data which was collected and analyzed by B & V in its feasibility study.

Project Status – October 2009

In April of 2009, B & V and GeothermEx released their final report entitled "Navopache and Mohave Electric Cooperatives – Enhanced Geothermal System (EGS) Evaluation", B & V Project Number 161412.0010. The final report confirmed the existence of geothermal resources to the extent that it could without having drilled a test well. The study identified several traditional hydrothermal geothermal resources in eastern AZ and western NM, within the NEC service territory. It also recommended that a 5 megawatt EGS project was feasible in the Nutrioso, AZ, area.

The EGS project is appealing to NEC for numerous reasons over the development of a traditional geothermal resource. There is ample private land available to NEC through a lease / purchase option for development of an EGS project. The land being considered today is the same tract which Mac Eddy had

made arrangements to lease at the time the original effort took place. The location of the traditional geothermal resources are predominantly on USFS land which may complicate the process for commercial development of a generation facility.

The private land which NEC is negotiating a lease for has an existing NEC 69kv transmission line located upon it which will facilitate the interconnection process and minimize the associated costs. The location of the traditional geothermal resources is close to an existing transmission corridor, however the lines are owned by another utility and are operated at 345kv. To interconnect at that voltage would increase interconnection costs and would require a partnership with another utility.

Next Steps

The B & V feasibility study examined the data collected from the Alpine Federal #1 Well drilling log and estimated the likely temperature to be near 350 degrees Fahrenheit at a depth of 10,000 feet (See Figure 1). This information along with the heat flow maps of the NEC service territory near the Alpine Core Hole, and the positive recommendation of the study, has prompted NEC to move forward with the project (See Figures 2 and 3).

The project cannot move forward until NEC has secured funding to drill an exploratory well in order to confirm that the resource is of adequate size to develop a commercial generation facility.

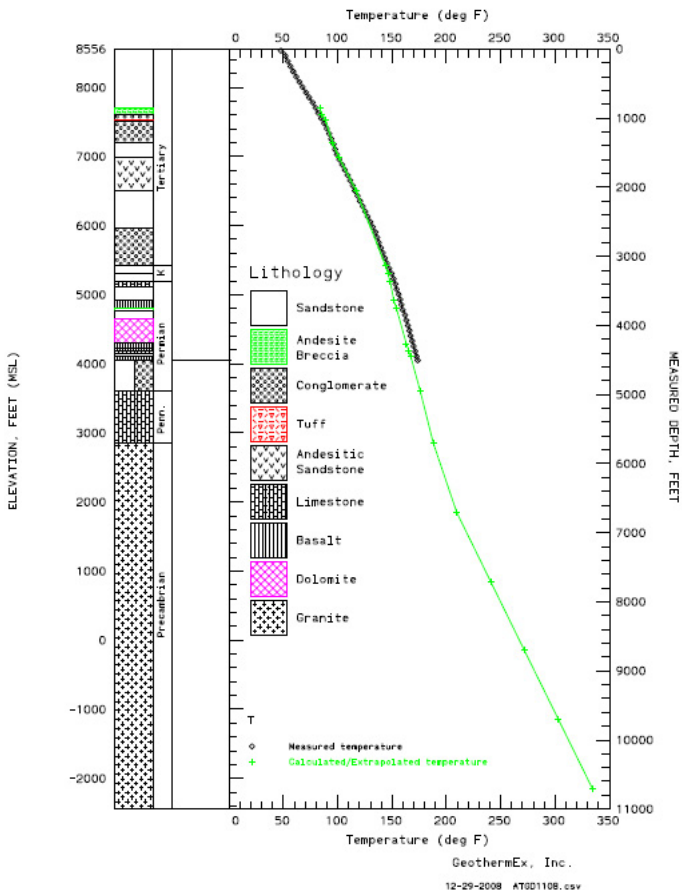


Figure 1. Measured and extrapolated temperature data, Alpine 1 core hole.

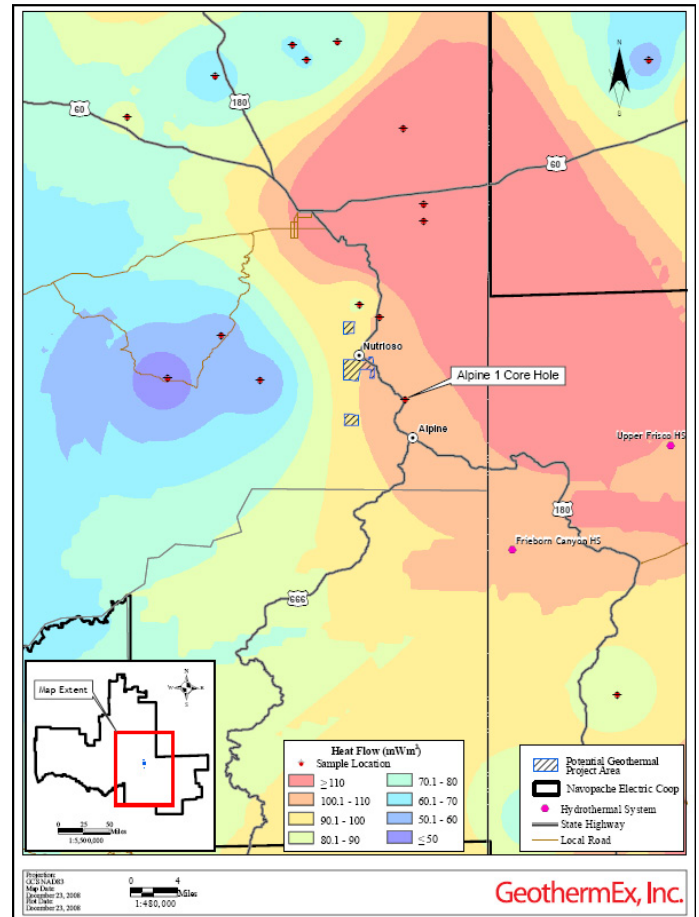


Figure 2. Lands potentially available for geothermal development in the Navopache area.

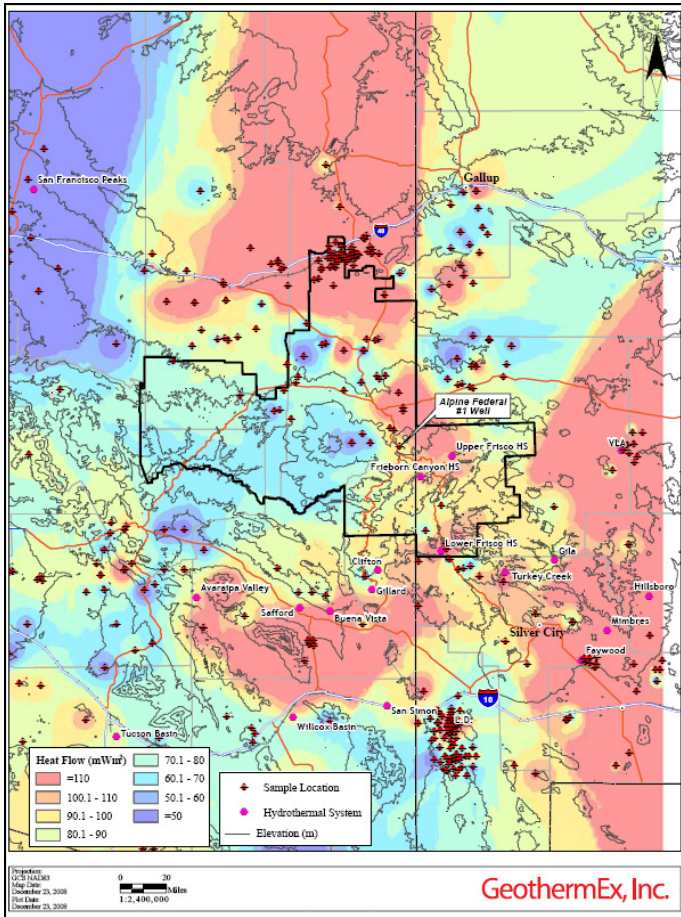


Figure 3. Heat flow map, Navopache Coop area.

Toward that goal, NEC has engaged a grant writer to apply for DOE funding for an EGS Demonstration Project and to search for other funding opportunities.

The first FOA (Funding Opportunity Announcement) from DOE expired July 30, 2009. We had not moved our project along to the extent that it needed to be to make the initial DOE deadline, however, we are hopeful that another FOA will be forthcoming. Efforts continue to identify and secure other possible sources of funding so that an exploratory well can be drilled on the property upon which NEC is finalizing a long-term lease agreement.

NEC has received a pledge of cooperation and assistance from Dr. Paul Morgan, Professor Emeritus, Department of Geology, Northern Arizona University. Dr. Morgan has indicated his desire to further the development of geothermal resources in Arizona and to bring a university link to the NEC project.

Conclusions and Recommendations

The conclusion of the feasibility study by B & V and GeothermEx is that EGS is a viable option within the Navopache and Mohave service territories on a technical and economic basis. Both service territories contain moderate to good geothermal resource with heat flow rates that are similar to other successful EGS pilot projects. The technical feasibility of an EGS facility at these temperatures has recently been demonstrated by a project in Germany. Although EGS is not the lowest cost renewable energy technology, it may be one of the better long-term options due to its potentially competitive cost at a small scale, base load generation profile and siting flexibility.

The recommended course for NEC to pursue is to further evaluate specific sites for factors such as land availability, water availability, environmental and cultural issues, and technical potential. It would then be recommended that NEC and Mohave partner with a small to medium size geothermal developer and jointly fund the higher risk exploration stage of a project. The partnership should engage the DOE to play a role in risk mitigation by providing funding assistance at this exploration stage.