Calpine Geothermal Visitor Center Upgrade Project—An Interactive Approach to Geothermal Outreach and Education at The Geysers

Patrick F. Dobson[1], Danielle Matthews Seperas[2], Mark Walters[2], Chuck Howarth[3], and Scott Moulton[3]

[1]Lawrence Berkeley National Laboratory
[2]Calpine
[3]Gyroscope, Inc.

Keywords

The Geysers, sustainable energy, community outreach, Enhanced Geothermal Systems (EGS), induced seismicity

ABSTRACT

The Calpine Geothermal Visitor Center in Middletown, California, opened in 2001 with a series of displays highlighting the history and geology of The Geysers, geothermal drilling and power production technologies, and the Santa Rosa and Lake County wastewater to electricity projects. As part of a DOE-funded Enhanced Geothermal System field demonstration project at The Geysers, Calpine, in partnership with DOE, Lawrence Berkeley National Laboratory, Gyroscope, Inc., and Group Delphi, is conducting a major upgrade of the Visitor Center displays. The upgraded Visitor Center exhibits provide interactive displays that are designed to educate visitors about the key issues and benefits associated with geothermal energy. In addition to revisions of existing displays, new exhibits have been created to examine sustainable energy options and the challenges and potential of enhanced geothermal systems (EGS). The EGS exhibit describes the large scale resources that have been identified throughout the US, and provides examples from a number of the DOE EGS demonstration projects. The exhibit illustrates the need for stimulating existing fractures to create fluid flow paths required to extract energy from the hot rocks, and that this process can result in induced seismicity. Public acceptance of EGS is dependent on such educational efforts. The upgraded exhibits are scheduled to be completed in the summer of 2012.

Introduction

In 2008, the US DOE Geothermal Technologies Program awarded funding for Calpine's proposal "Demonstration of an Enhanced Geothermal System (EGS) at the Northwest Geysers Geothermal Field, CA", which was developed in response to a funding opportunity announcement for EGS field demonstration projects. The primary objective of this project was to reopen and deepen two existing wells within the NW Geysers and test the concept of permeability enhancement via shear reactivation and thermal contraction through low pressure water injection. Other key objectives of this project include demonstrating the technology used to monitor and validate the reservoir stimulation process (through coupled process modeling and seismic monitoring) and producing steam with reduced noncondensible gas content from the high-temperature reservoir. To date, the two wells (Prati State 31 and Prati 32) were successfully reopened and deepened, and a year-long stimulation of the high-temperature reservoir was initiated in the Prati 32 well in October 2011 (Garcia et al., 2012). This multidisciplinary research project is being conducted together with scientists at Lawrence Berkeley National Laboratory (LBNL).

An additional aspect of this project was a public outreach and education component, consisting of the following objectives:

- Reopen the Calpine Geysers Visitor Center to full-time operations
- Provide periodic public tours of an operating geothermal power plant
- Conduct community outreach/education of proposed EGS projects
- Enhance/upgrade exhibits at the Visitor Center
- Update and enhance the Geysers.com web site for EGS public outreach

The purpose of this paper is to highlight the work associated with the upgrade of the exhibits at the Geothermal Visitor Center. Team members from Calpine and LBNL conducted a careful review of the existing exhibits, participated in the selection of a company who could redesign and build the new exhibits, and contributed to the design process leading to the creation of the renovated visitor center displays.

The Calpine Geothermal Visitor Center, located in Middletown, California, was opened in 2001 (GRC Bulletin News Briefs, 2001). It consists of a lobby area, an exhibit hall featuring geothermal power displays, small offices, a conference room, a multipurpose room, a kitchen, and bathrooms. The Visitor Center building has many energy efficient features as well as several green

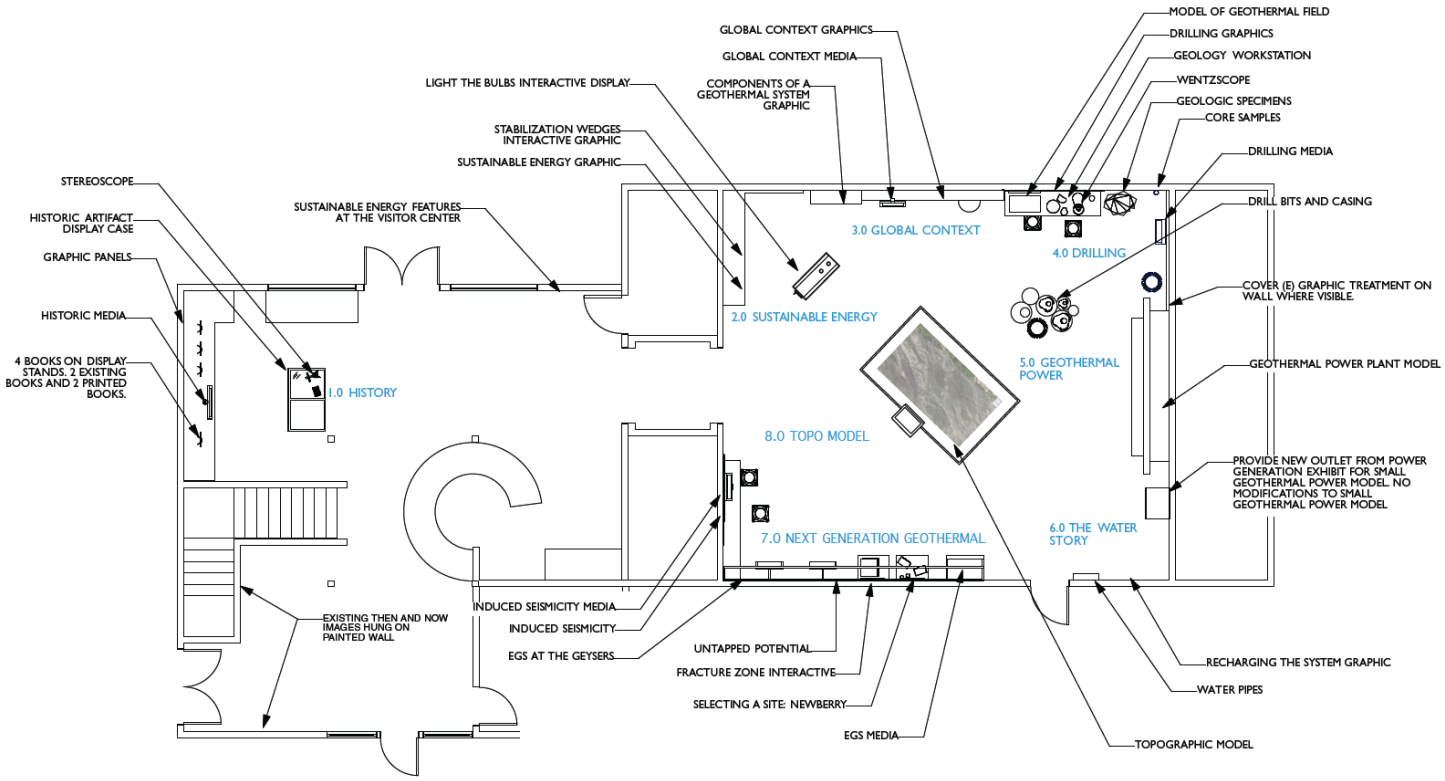

Figure 1. Schematic layout of exhibits at the renovated Geothermal Visitor Center.

energy technologies, including a solar panel array and a ground source heat pump (Chiasson, 2005). The exhibit hall contains displays on the history of The Geysers, the geology and tectonics of geothermal systems, the geology and drilling at The Geysers, the role of reclaimed water in sustaining steam production at The Geysers, an overview of steam pipelines and power plants, a hand crank generator and a seismograph, and a history of Calpine. A central 3-D diorama displays the surface topography of field, location of power plants, wells, and pipelines. In the front lobby there is a mineral collection from localities around The Geysers. Outside of the Visitor Center, there is a turbine rotor, a very large drill bit, an old electrical generating system, and a large globe. In spite of its fairly remote location, over 75,000 visitors have come to the Visitor Center since its opening. The Geysers power plant tours continue to be a draw for the public. Since increased community outreach to promote periodic tours kicked off in 2010, a total of 2,055 guests toured in 2010 and 2011. A total of twelve community tours are scheduled for 2012 and as of this writing, three of these events have been held, with a total of 510 participants in this year's power plant tours to date.

One of the objectives of the DOE-funded educational and outreach activities for the Calpine EGS demonstration project was an upgrade of the existing Visitor Center, with the focus of adding an exhibit on EGS concepts. Many of the exhibits contained outdated information and were not educationally focused. Most of the displays were not interactive. The goal of the revitalization of the Visitor Center is to create upgraded exhibits that will engage visitors, provide a larger context for geothermal power as a green energy option, and to examine key challenges facing the wide-scale development of enhanced geothermal systems not just at The Geysers but elsewhere in the United States.

Figure 2. Historical exhibit.

Three companies submitted bids for the proposed visitor center upgrade project. The bids were evaluated on the basis of presentation, creativity, experience, and references from previous projects. The winning bid was submitted by Gyroscope, Inc., a museum planning, architecture, and exhibition design company in Oakland, California. They have partnered with Group Delphi, an exhibition design and fabrication firm located in Alameda, California, to develop and create the updated Visitor Center displays. The project is currently in the final design and exhibit construction phase. The new exhibits are scheduled for completion during the summer of 2012.

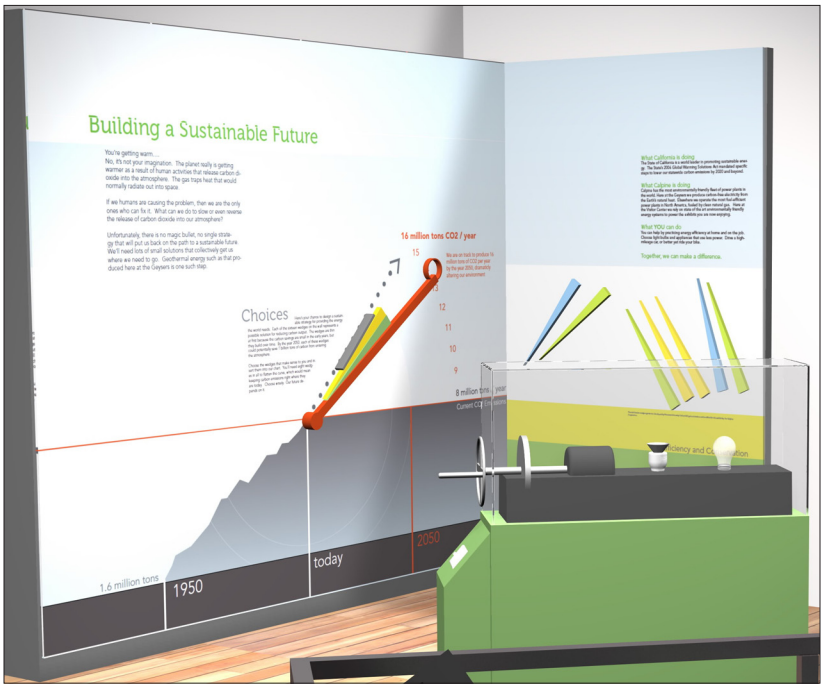

Figure 3. Sustainable energy options.

Key Elements of the Visitor Center

The new design of the Visitor Center exhibits (Fig. 1) contains the following focus areas:

1. History of The Geysers
2. Sustainable Energy
3. Global Context of Geothermal Energy
4. Drilling and Geology of The Geysers
5. Generation of Geothermal Power
6. Water and Reinjection at The Geysers
7. Next Generation Geothermal (EGS) and Induced Seismicity
8. Interactive Topographic Model of The Geysers

A short summary of each of these elements is presented below.

History of The Geysers

The exhibit on the history of The Geysers is located in the foyer of the Visitor Center. The Geysers has a rich history, starting when the hot springs were used by Native American tribes, spanning a period where it was a resort destination, up until it became a commercial power production site in 1960 (Hodgson, 2010). Upon entering the building, the visitor is greeted by a colorful display of photographs and a video display of historic film footage of early geothermal drilling at The Geysers (Fig. 2). This exhibit will have historical artifacts for visitors to inspect and a stereoscope allowing visitors to view historic images of The Geysers.

Sustainable Energy

The role of geothermal energy is examined within the context of other sustainable energy sources that will not contribute to significant emissions of greenhouse gases. Geothermal energy is considered as one of many different components required to address this global climate and energy issue. This exhibit (Fig. 3) will provide visitors with the opportunity to evaluate different energy and conservation options, using the wedge stabilization approach of Pacala and Socolow (2004), to see how the projected increases in atmospheric CO_2 might be reduced as the result of renewable energy. The exhibit also includes a hand-crank generator that demonstrates the different energy requirements of incandescent and LED light bulbs to illustrate how technological advances can impact our energy needs and the decisions consumers make daily that can make a difference.

Global Context of Geothermal Energy

This exhibit focuses on the key features of geothermal systems, namely elevated heat flow and permeable rock within which circulating fluids are heated and can be tapped to extract

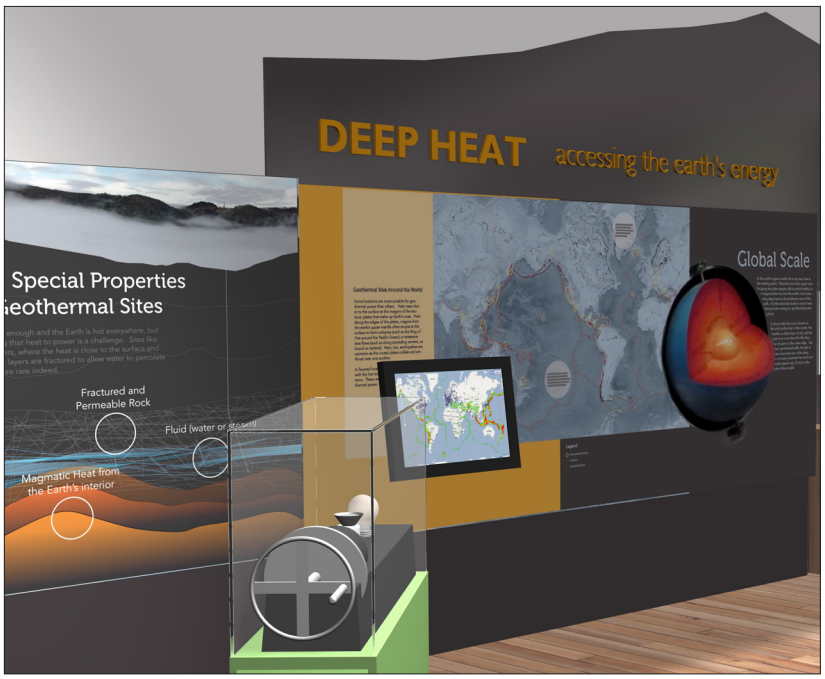

Figure 4. Distribution and characteristics of geothermal systems.

geothermal energy. A tectonic map of the world depicts the association of many (but not all) geothermal systems with volcanic activity, especially along the Pacific Ocean's "Ring of Fire". A cutaway globe shows the different layers of the Earth and the role that plate tectonics (especially subduction zones and spreading centers) play in the localization of volcanism and elevated heat flow in the Earth's crust.

Drilling and Geology of The Geysers

This exhibit focuses on displaying aspects of geothermal drilling technologies and the geology of The Geysers geothermal system. Drilling videos depict the key features of a drill rig and the different types of drilling activities (such as mud and air drilling and setting casing) involved in creating a connection between a geothermal reservoir found at depths of around 8,000 feet and the surface. Drill bits and other drilling materials provide the visitors with a tactile connection to the drilling process. A geologic map and cross section of The Geysers demonstrate the key role that young intrusive rocks have had in supplying heat to the geothermal reservoir and depict how wells are drilled to tap the geothermal resource. Representative rock samples (greenstone, greywacke, and granite) from the main geologic units of The Geysers are displayed, and key minerals found in the reservoir rock, such as feldspar and amphibole, can be viewed in hand samples and under the microscope.

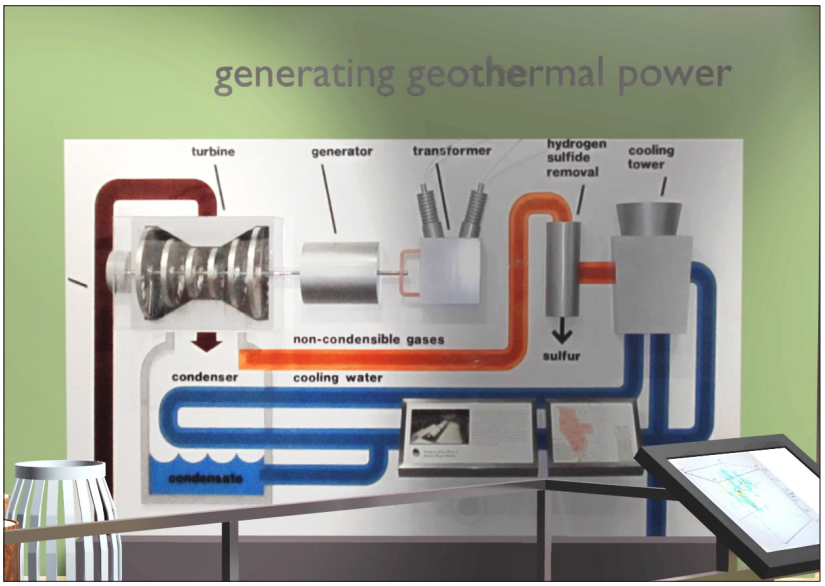

Figure 6. Schematic model of a geothermal power plant.

Generation of Geothermal Power

This display is a carryover from the previous set of exhibits and provides a schematic depiction of the key components of a geothermal power plant. Steam coming from the geothermal production wells is fed into the turbines, which spin the generators to produce electricity. Spent steam then exits to the condenser unit, where cooling water cools and condenses the steam. Noncondensible gases are passed through a hydrogen sulfide scrubbing unit to minimize the impact of gas emissions on the environment. The steam condensate is then piped to injection wells to resupply the geothermal reservoir with water that can be reheated at depth to become steam once again.

Figure 5. Geology and drilling exhibit.

Water and Reinjection at The Geysers

In the 1980s, a peak in electrical power generation at The Geysers was followed by a precipitous drop in power production, linked to a decline in reservoir pressure (e.g., Brophy et al., 2010). A technical committee sponsored by the California Energy Commission developed a series of recommendations to reduce decline rates and thus extend the productive life of the field (Goyal and Pingol, 2007). One important suggestion of this committee was to supplement the volume of injection water by bringing in outside sources of water to The Geysers. This led to the development of two injection projects: the Southeast Geysers Effluent Pipeline, which carried lake water and secondarily treated waste water from the Lake County Sanitation District starting in 1997, and the Santa Rosa Geysers Recharge Project, which delivered tertiary treated waste water from the City of Santa Rosa beginning in 2003 (California Energy Commission, 2002; Dellinger and Allen, 2004). These changes resulted in a stabilization of the geothermal reservoir and sustained levels of power production at The Geysers (Khan and Truschel, 2010). Currently, these two pipeline projects can deliver about 20 million gallons of water a day to The Geysers. This water is distributed by a network of pipelines to dozens of injection wells throughout the field.

Figure 7. Water and reinjection at The Geysers.

Next Generation Geothermal (EGS) and Induced Seismicity

This exhibit shows the key technical issues associated with making widespread deployment of EGS projects economically viable. An underlying premise of EGS is that there are abundant geothermal resources (up to 100,000 MWe based on the MIT (2006) report) within the US where there are temperatures greater than 150°C at depths between 3 and 10 km. If sufficient permeability can be created in these hot rocks, then fluids can be injected from the surface, circulated through the rocks, and the resulting hot fluids can be used to generate electricity. Reduced drilling costs and improved reservoir stimulation methods are critical to making this concept a reality.

Another portion of this exhibit provides a summary of the DOE-funded EGS demonstration project in the northwest portion of The Geysers geothermal field. One of the two wells in this projects, Prati 32, encountered a bottom-hole temperature of 400°C, the highest measured to date at The Geysers. This well was converted into an injection well in an effort to stimulate fracture permeability in the high-temperature reservoir, reduce the concentrations of noncondensible gases (NCG) in the steam, and enhance reservoir pressures (Garcia et al., 2012). Since injection was started in October of 2011, increases in reservoir pressure and a reduction in NCG have been observed in two neighboring wells, and steam production from the Prati 25 well has led to an increase in power generation from The Geysers field. Updates on the progress of the NW Geysers EGS demonstration project will be displayed.

In addition to information on The Geysers EGS project, this new exhibit features an EGS favorability map of the US. It also contains a core sample from the Newberry Volcano (Oregon) DOE EGS field demonstration site, as well as a borehole televiewer image of fractures from the Raft River Geothermal Field in Idaho, the site of another DOE EGS project. Interactive geologic models illustrate the process of fracture stimulation.

One key challenge associated with EGS is the mitigation of induced seismicity associated with reservoir stimulation and injection activities. The Geysers geothermal field is the site of numerous microseismic events that are associated with injection.

Figure 8. Key features of enhanced geothermal systems.

An extensive microseismic array has been installed at The Geysers to monitor seismic activity and guide field operators to minimize the effects of microseismicity on the surrounding communities. Ongoing research is being conducted at The Geysers and other geothermal fields to advance our understanding of how injection induces microseismic activity, and to develop ways to better predict the location, abundance, and magnitude of the events.

To help the public understand the relation between EGS and seismicity, the exhibit includes several interactive components, including a computer display of real-time and historic seismic data associated with injection at The Geysers, and a visitor-operated seismograph illustrating that the seismic events, while numerous, are quite small.

Interactive Topographic Model of The Geysers

The centerpiece of the upgraded exhibits is a large interactive white model that will depict the topography of The Geysers region. The model surface is accurately contoured to show local topography. An overhead video projector projects precisely registered images and datasets onto the map. Using a smaller touch screen, visitors can select different types of information to be displayed on this three-dimensional topographic backdrop, including the location of production and injection wells, power plants, and steam and injection pipelines. Other important features such as the geology of the area and the locations of nearby communities and roads can also be displayed.

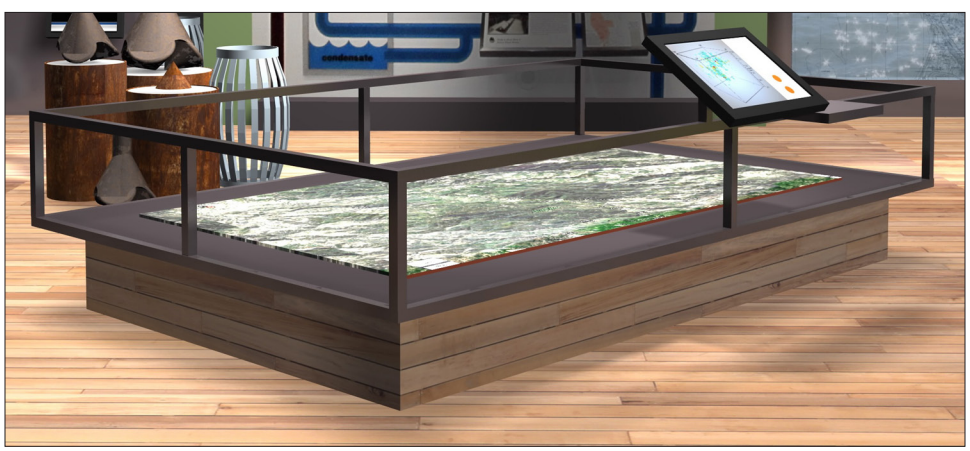

Figure 9. Interactive topographic display of The Geysers.

Concluding Remarks

Community outreach and education are key activities needed to build the future of geothermal energy development. The exhibits at the upgraded Visitor Center will increase the public's awareness of geothermal energy as a sustainable energy option. These new exhibits focus on sustainable energy and enhanced geothermal systems, and address the most significant aspects of geothermal systems: the requirements for rocks with elevated subsurface temperatures, existing fractures, and circulating fluids. Videos and displays highlight the key components of drilling technologies used to drill wells that inject water into, and extract the hot fluids from, the geothermal reservoir. A schematic model illustrates the power conversion technologies used to convert the hot fluids into electricity. The companies designing and fabricating the new exhibits, Gyroscope Inc. and Group Delphi, have worked closely with scientists and engineers at Calpine and LBNL to ensure that the key features of The Geysers geothermal field, and of geothermal systems in general, are addressed. The use of interactive displays will enhance the educational experience of future visitors to this revitalized center.

Acknowledgments

This work was funded by the Assistant Secretary for Energy Efficiency and Renewable Energy, Geothermal Technologies Program, of the U.S. Department of Energy under the U.S. Department of Energy Contract Nos. DE-FC36-08G018201 (to Calpine) and DE-AC02-05CH11231 (to LBNL), and by Calpine Corporation. Many people have contributed to all of the improvements in the upgraded Geothermal Visitor Center. John Farison of Calpine led the initial efforts to secure funding for the renovation project. Numerous personnel from Gyroscope and Group Delphi have made significant contributions to this project, including Kevy Vona, Rick McKee, and David Salinger. Mack Kennedy, Ernie Majer, and Marcelo Lippmann of LBNL and Paul Graham, Craig Hartline, Karl Urbank, Tim Conant, and John Avery of Calpine have provided technical guidance and suggestions for many of the exhibits. A special acknowledgment goes to Joe Beall, consulting geologist, for providing invaluable technical oversight of the exhibits content and graphics. Nic Nickels and Jimmy Vaughan of Baker Hughes made vital contributions to the new drilling videos, and TigerX developed some of the animation sequences. Brian Berndt of Calpine provided information to track down historic film footage of The Geysers. Cheri Kendrick (Bottle Rock Power) and Bob Young (NCPA) provided photos and plant data for their respective Geysers sites. Joe Moore and Bridget Ayling of the Energy and Geoscience Institute of the University of Utah contributed a core sample and borehole televiewer images for the EGS display. Prof. Gordon Brown of Stanford University generously donated two mineral samples for the new exhibits. Billy Roberts (NREL) provided us with the latest version of the EGS favorability map for the US. Lauren Boyd of the DOE Geothermal Technologies Program provided helpful feedback on the preliminary designs. Susan Hodgson played a key role in shaping the historical displays. Alison Mannwieler Hill, Mary Ellen Rudee, Jill Gibbs, and Guy Tipton provided steadfast accounting and administrative support needed to bring this project to completion. We thank Kathy Enedy for her review of our manuscript.

References

Brophy, P., Lippmann, M.J., Dobson, P.F., and Poux, B., editors (2010) The Geysers Geothermal Field Update 1990-2010, Geothermal Resources Council Special Report 20.

California Energy Commission (2002) Santa Rosa Recharge Project: GEO-98-001. Final Report 500-02-078V1; http://energy.ca.gov/reports/2003-03-01_500-02-078V1.PDF.

GRC Bulletin News Briefs (2001) Calpine Opens Geysers Geothermal Visitor Center, GRC Bulletin, May/June 2001, p. 85.

Chiasson, A. (2005) Calpine Geothermal Visitor Center Middletown, California. Geo-Heat Center Bulletin, September, 2005.

Dellinger, M., and Allen, E. (2004) Lake County success — Generating environmental gains with geothermal power. Geothermal Resources Council Bulletin 33, 115–119.

Garcia, J., Walters, M., Beall, J., Hartline, C., Pingol, A., Pistone, S., and Wright, M. (2012) Overview of the Northwest Geysers EGS demonstration project. Proceedings, 37th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, Jan. 30-Feb. 1, 2012, SGP-TR-194.

Goyal, K.P., and Pingol, A.S. (2007) Geysers performance update through 2006. Geothermal Resources Council Transactions 31, 435–439.

Hodgson, S.F. (2010) A Geysers album – Five eras of geothermal history. California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, Publication TR 49, 2nd edition, 73 p.

Khan, M.A., and Truchsel, J. (2010) The Geysers geothermal field, an injection success story. Geothermal Resources Council Transactions 34, 1239–1242.

MIT (2006) The future of geothermal energy: Impact of enhanced geothermal systems (EGS) on the United States in the 21st century. http://www1.eere.energy.gov/geothermal/pdfs/future_geo_energy.pdf.

Pacala, S., and Socolow, R. (2004) Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. Science 305, 968–972.

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California.

Ernest Orlando Lawrence Berkeley National Laboratory is an equal opportunity employer.