Accelerating Geothermal Growth Through DOE Initiatives

With a little help from the government, geothermal energy has the potential to take a much larger share of the renewable energy market in the U.S. in the near future.

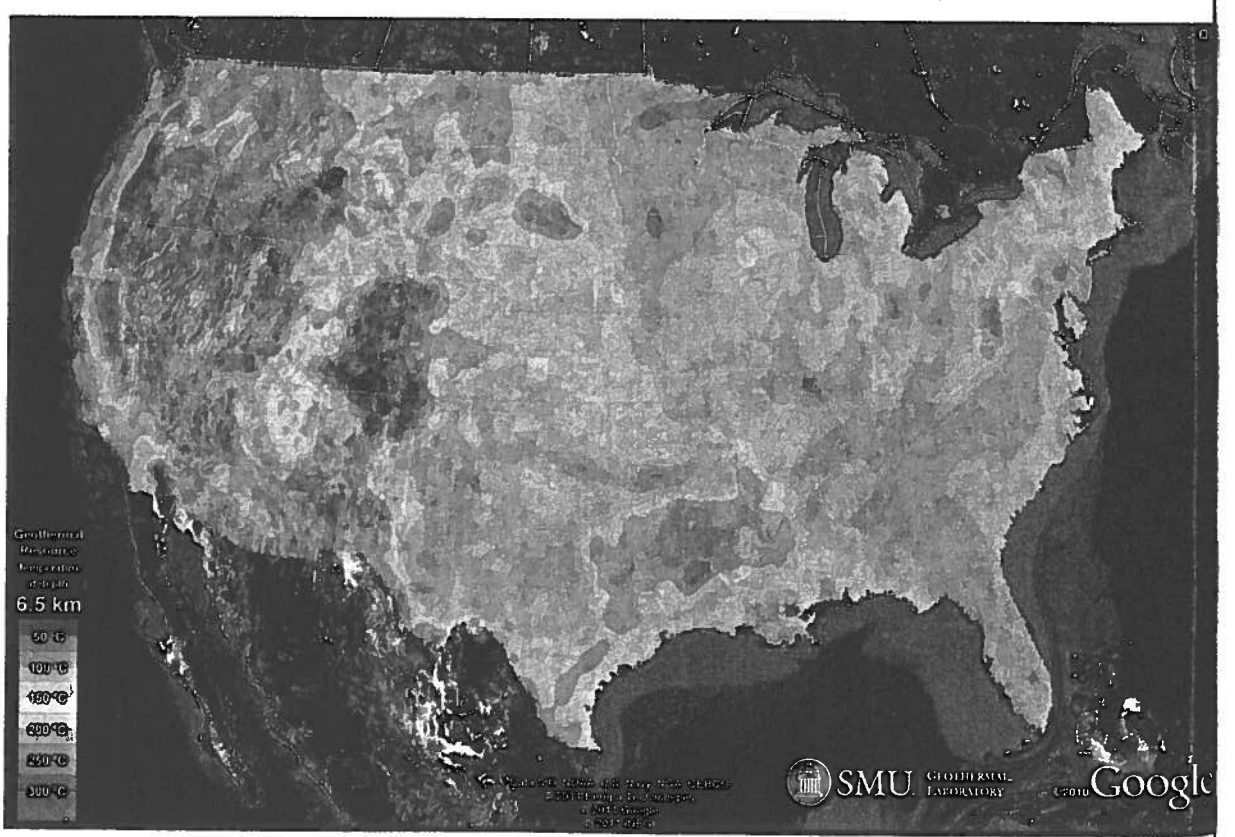
Charles W. Thurston, Contributor

The U.S. geothermal power industry is poised for a bit more rapid growth now that the U.S. Department of Energy's geothermal development program is maturing with demonstration-stage pilots. This acceleration of growth also will be spurred on by an increasing number of municipalities and utilities that are turning to geothermal as an alternative energy option for either renewable mandate or investment reasons, industry executives say. While the U.S. geothermal power market is still somewhat tepid in comparison to the international market, U.S. technology exports will help U.S. companies weather the wait for a more rapid domestic market expansion.

"This industry has been reborn in the last few years and there is actual growth in the number of companies involved: we are now seeing more companies producing geothermal than five years ago, and more companies actively developing than there were two years ago," said Karl Gawell, executive director of the Geothermal Energy Association (GEA) in Washington.

DOE's Geothermal Program Rolls Out

DOE's Geothermal Technology Program (GTP) was strategically expanded in 2008 and won funding of $368 million under the Recovery Act. Although roughly $40 million a year has been applied to the program over the recent past, President Obama's



The geothermal resource temperature at 6.5 km throughout the U.S. Credit: Google and SMU Geothermal Laboratory.

"Christmas wish list" to Congress included $101 million for 2012, according to Douglas Hollett, Washington-DC-based GTP manager. Within the broad GTP program, which includes dozens of technology projects, enhanced geothermal systems (EGS) is the primary development target.

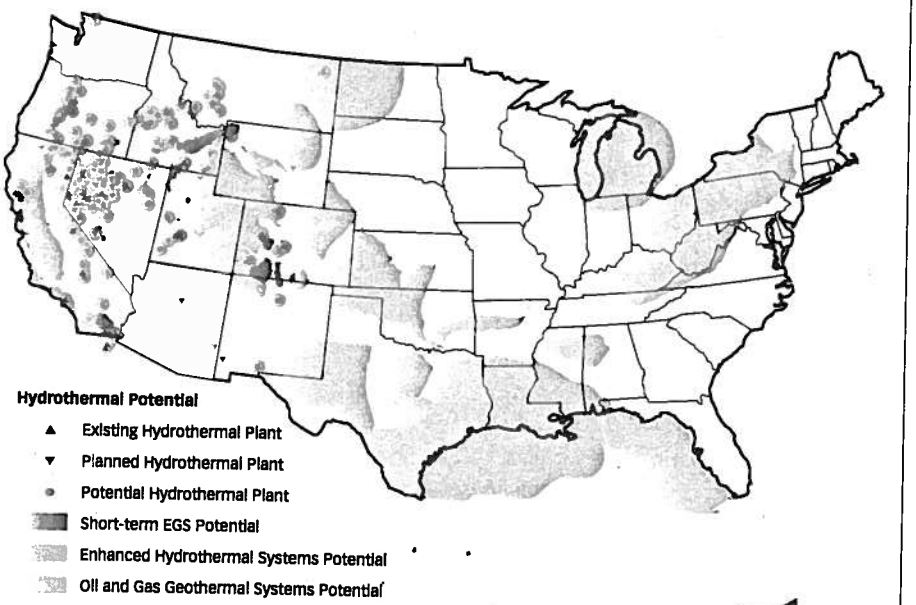
"Hands down, EGS is the most promising geothermal technology under development today," said Tom Williams, the laboratory program manager for geothermal at the National Renewable Energy Laboratory (NREL) in Golden, Colo. EGS reserves often require water injection, and in some cases, like Calpine's Geysers facilities, municipal grey water is used to community advantage.

Hollett explained, "We now have seven EGS demonstration projects at various stages of activity in several states (including California, Idaho, Hawaii, Nevada and Oregon), and each is moving along with high hopes. The goal is to develop a 5-megawatt pilot by 2020, which will be significant." To get there, DOE is trying to solve a myriad of technology problems simultaneously. "Among technology targets, three leading problems are: the need for drilling faster and more efficiently; the need for better stimulation technology; and the need for high temperature electronics for work in bit steering or down hole measurements," Hollett noted.

Indeed, many of the federal laboratories have geothermal projects underway. But at NREL, "the biggest thing we are working on is cooling systems for geothermal generators. At peak demand time, you can use some water at an otherwise dry-cooled unit and increase power output by 25 percent," said Williams. "The project may move into a field test next year," he said.

While the decade-long GTP program is aimed at establishing the commercial viability of geothermal power generation, the budget war in Washington leaves financial continuity a challenge. "Something we do on a daily basis is to fine-tune where our research dollars are going; you could liken it to a financial portfolio in which you focus your efforts on the things that are working the best, balancing them with the things that have the biggest impact," Hollett said.

Short-Term Geothermal Energy Potential — Fig. 1



A geothermal energy map shows potential for short-term EGS (green), enhanced hydrothermal systems (gray) and oil and gas geothermal systems (yellow). Existing plants are shown with a purple triangle, planned plants are shown with a pink upside-down triangle and potential plants are shown via a blue circle. Credit: NREL.

Utilities, Cities Embrace Geothermal

While utilities, especially in the West, are helping to drive the expansion of geothermal power on a larger scale, municipalities and educational institutions are helping to drive smaller scale applications including power and heating/cooling systems.

Among utilities, some like Las Vegas-based NV Energy have been utilizing geothermal power under power purchase agreements since the 1980s. As a result of their comfort level and experience, geothermal is increasing within their renewables mix. "We expect a large number of geothermal generating facilities to come online over the next two years before the tax credit cut-off in 2013," said Bobby Hollis, the geothermal executive at the utility. NV Energy anticipates that geothermal will increase as a power source from 42 percent of the utility's renewable energy supply now to about 50 percent over the near term, leading the nation in geothermal usage as part of its overall sourcing. Renewables make about 15 percent of the utility's total generating facilities.

Certain strategically oriented utilities may also move beyond power purchase agreements for geothermal energy and make direct equity investments. At NV Energy, "there very well may be opportunities over the near term for us to own a geothermal facility instead of being a power off-taker, if we can show value for customers and it pencils out," said Hollis.

At the same time, more municipalities – like Aspen, Boise, and Reno – are turning to geothermal heat and/or power as a renewable resource.

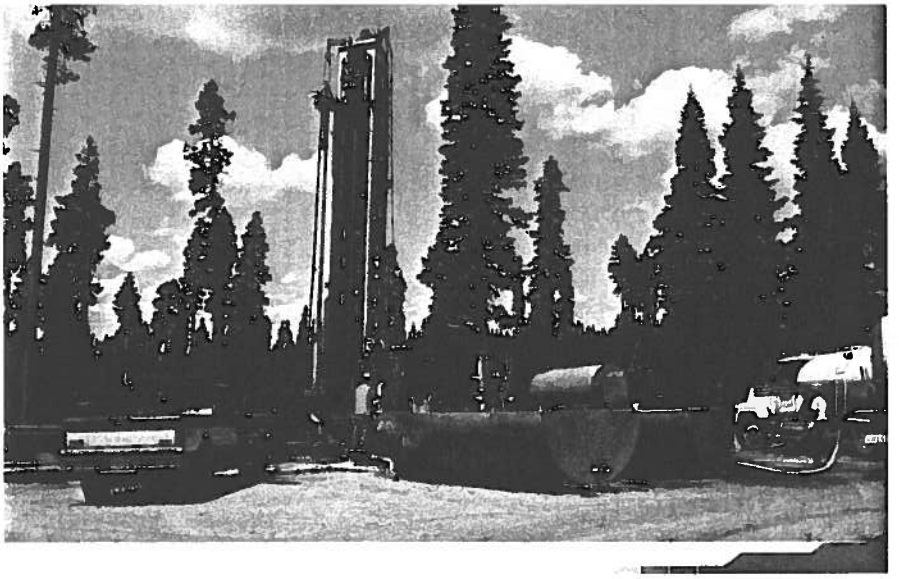
"There looks to be an interesting market opportunity with small government entities," said Williams. "The smaller scale economy involved in a municipal geothermal system may not attract utilities, but these systems can have a huge impact on people in the community. There are driving factors at work beyond dollars and cents, such as creation of sustainable local jobs and enhanced quality of life," he added. Similarly,

Ohio State University in Columbus, which is developing a $10 million geothermal project, is an example of an institution that is embracing the source.

Foreign Markets Loom

About 60 percent of the member companies of the GEA now do business overseas, said Gawell. While there is not yet a "green bank" that finances renewable energy development in the United States, the U.S. Export-Import Bank (Ex-Im) and the U.S. Overseas Private Investment Corp. are doing yeoman's duty in financing U.S. geothermal technology exports. While some Ex-Im funds are loaned directly for specific projects, as in recent geothermal deals in Turkey, other funds for geothermal projects are loaned as part of a more generally targeted bundle, like the $1 billion earmarked for lending within Indonesia in January 2010.

Indeed, traditional geothermal-tapping countries like Indonesia are setting the stage for large-scale growth. Currently, the state oil company PT Pertamina is mulling a U.S. $0.10 per kilowatt-hour (kWh) tariff for geothermal power to make development more attractive to foreign investors. Similarly, the Middle East/Africa and Latin America are warming rapidly to geothermal projects. In fact, leading U.S. purveyor Ormat Technologies has won contracts in Kenya, Guatemala and Nicaragua.



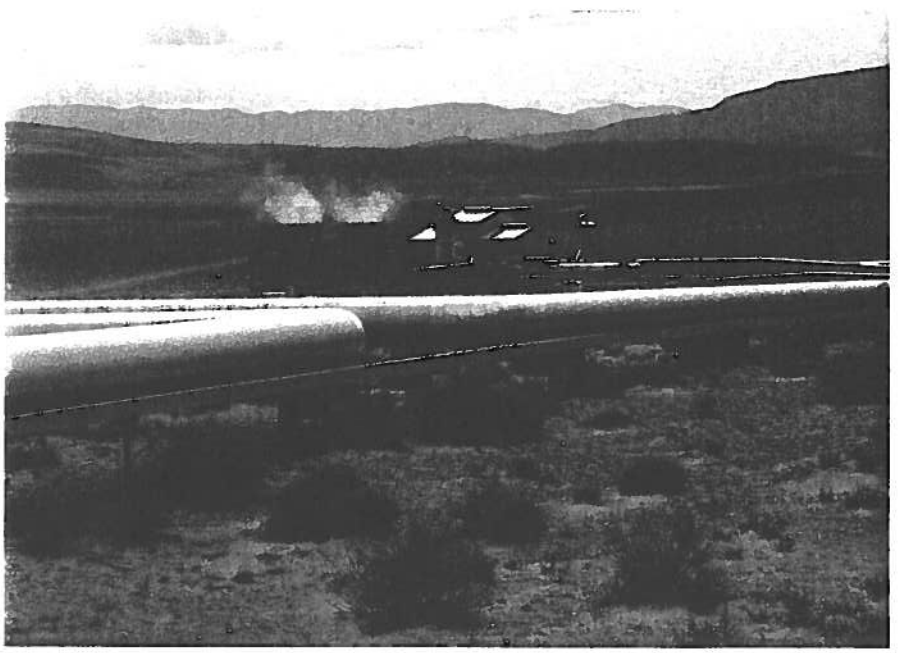
The Newberry Geothermal Project is about 30 miles southwest of Bend, Ore., at the Newberry Volcano. Credit: DOE.

Limits to Growth

Proving geothermal resources at a likely geothermal power site is still a major drag on the timeline of projects today. DOE's many technology development projects – including satellite scanning – should help speed and standardize reserve definition. According to a blue-ribbon panel assessment of DOE's GTP in June 2011, "the U.S. Geological Survey estimated in 2008 that 30 GW of undiscovered geothermal resources could be found in the western United States. This provides an opportunity for a 10-fold increase compared to today's installed capacity."

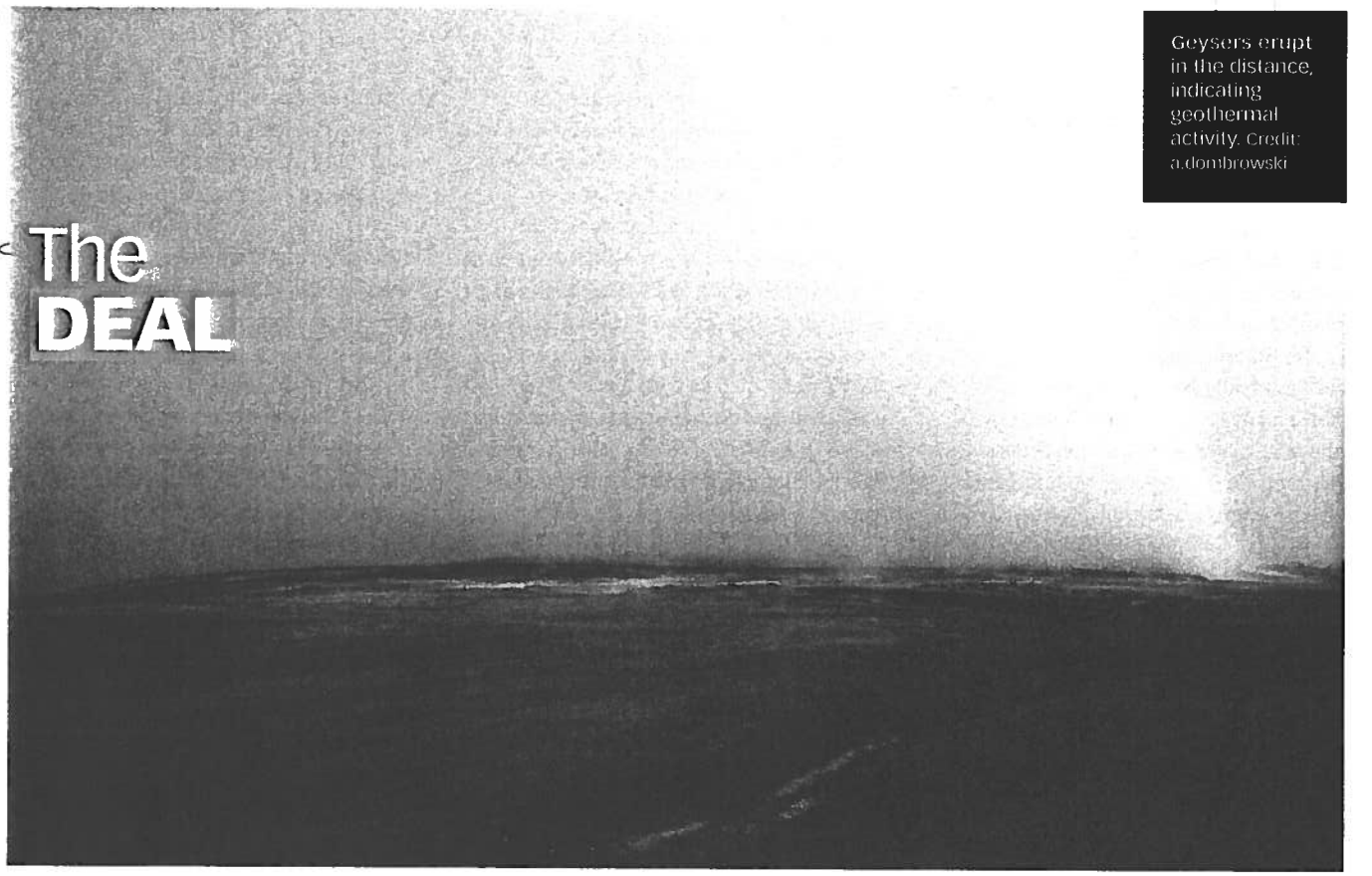
And there is still a need for more proven utility-scale geothermal power technology to convince private banks to finance the industry, even though they have long financed solar and wind projects. This is especially true for low-temperature reserves and for EGS, for which the industry is seeking to develop bankable standard risk analysis measurements. Smaller applications, like oil well associated flows being developed in Florida and Texas may be able to demonstrate the economic feasibility of low-temperature geothermal power over the nearer term.

Perhaps the greatest limit to growth is the unpredictability of political will in Washington to invest in geothermal during the pre-election period. But rising energy demand and the volatile price of oil may benefit efforts like the GTP. "There will be a double-whammy to our economy if renewable resources like geothermal do not continue growing," said Gawell.



The Desert Peak Geothermal Project is in the Hot Springs Mountains, near Fernley, Nev. Credit: DOE.

Charles W. Thurston is a journalist who specializes in renewable energy, from finance to technological processes. He has been active in the industry for over 25 years, living and working in locations ranging from Brazil to Papua New Guinea.



Geysers erupt in the distance, indicating geothermal activity. Credit: a.dombrowski

The DEAL

Geothermal Heating Up in Nevada Despite Frigid Industry Climate

Gradient Resources has started construction on the 60-MW first phase of its Patua project, with plans for vast expansion in the next few years.

Meg Cichon,
Associate Editor

Amidst a year of frustrating inactivity in the geothermal industry, many are holding hope for a brighter 2012. The industry holds more than 700 MW of projects in its pipeline to be completed before the federal tax credit expires in 2013. One project that has the upper hand in this race is Gradient Resource's 60-MW Patua project, about 38 miles east of Reno, Nev., set to go online in late 2012. Gradient has partnered with TAS Energy Inc., a technology provider, and SAIC Inc., a technology applications company.

Rocky Industry Climate

Though the past few years for the geothermal industry have been agonizingly slow, developers and financers are boldly moving forward, with many motivated by the federal tax credit. But industry experts argue that these short-term credits only hamper the industry's future.

"We need the market to be told that is the direction we will be going in. All the uncertainty and on-again off-again credits and policy cause people to sit back and wait. We need a national clean energy standard or national tax credits that will drive all renewables forward. That's what we need out of Congress. But with the debacle we have right now, we might not get it right away," said Karl Gawell, director of the Geothermal Energy Association (GEA).

Though the Patua project has started construction, it was not an easy process. Projects take years to develop due to long lines and red tape. "We also need less bureaucracy," said Gawell. "Projects are taking too long. We need to cut project times in half without short-circuiting any environmental safeguards. The government has taken a commitment to do that, and we need to push it through so projects can get done in half the time."

According to Íslandsbanki's 2011 Annual Geothermal Market Report, 2010 and 2011 served as slower planning years due to the financial crisis in 2008 and 2009. But by the end of 2012 and into 2013, the report predicts larger projects will come online — the Patua project appears to be following this trend.

Ideal Location, Lengthy Project Preparation

Nevada is a hotbed of geothermal potential, with some of the most favorable EGS (Enhanced Geothermal Systems) conditions in the U.S., according to an assessment by NREL. Recognizing this potential, Gradient has six geothermal power projects in advanced development near the Nevada towns of Fernley, Fallon, Hawthorne and Lovelock. And it even recently moved its headquarters to Reno in 2010. According to the GEA, Gradient holds leases on about 170,000 acres of federal and private land in five states surrounding this area, which makes up one of the largest portfolios of geothermal properties in the nation.

During a press conference, Gradient CEO Craig Mataczynski read a letter from Senate Majority Leader Harry Reid, a Democrat from Nevada, who emphasized the importance of geothermal in his state: "I am confident that together we can power Nevada and the United States with clean renewable energy, bolster a growing local industry, and create thousands of new jobs if we invest in our geothermal energy resources."

Gradient assessed the Patua location with an extensive exploration program that included over two decades of research. This investigation consisted of geological, geochemical, and geophysical surveys, core hole drilling, well drilling, and well discharge testing. The research indicated that Patua has ideal geothermal potential with 13 hot springs that range in temperature from 82 degrees to 240 degrees Fahrenheit. According to Gradient's website, in 1962 Magma Power Company drilled three shallow exploration wells at Patua ranging in depth from 300 to 750 feet with a reported maximum temperature of about 270 degrees, further proving the site's potential.

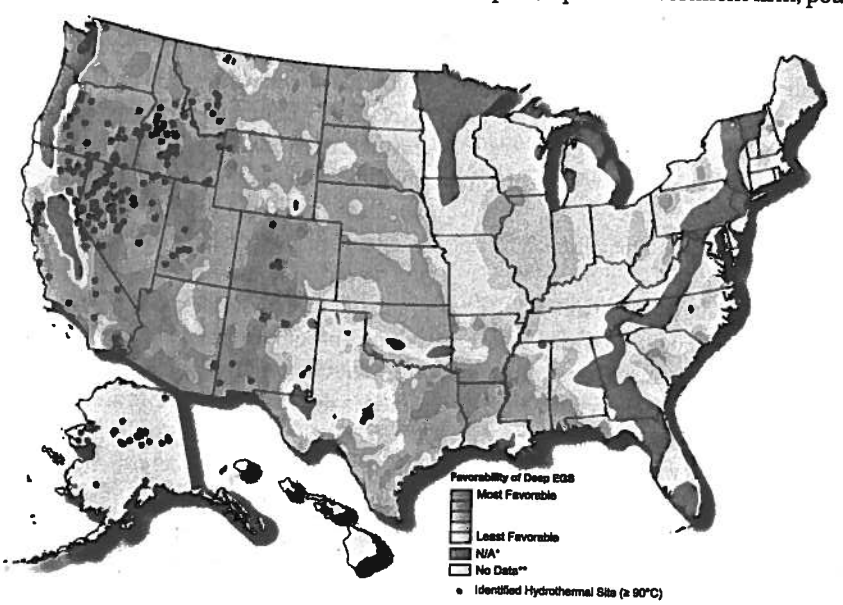
"The state of Nevada has a tremendous geothermal resource and access to attractive energy markets where there is a strong demand for electricity produced from geothermal resources" said Mataczynski. "Its leaders and communities have taken great steps to encourage the industry's growth."

Not only has Gradient conducted years of research, but it also completed an extensive environmental assessment with the Bureau of Land Management. The BLM confirmed drilling, the use of geothermal well pads, fluid pipelines, transmission lines, and the construction of the plant. Gradient also gained permission from nearby landowners to construct the plant and produce geothermal energy.

These exhaustive research and planning efforts were key factors in landing funding for the $300 million project. Denham Capital, a private investment firm, poured $108 million in the project, which allowed production well drilling to start in 2010. BNP Paribas, Dexia Credit Local and Scotia Capital provided further investment.

Gradient signed a 20- year power purchase agreement (PPA) with Sacramento Municipal Utility District for up to 132 MW of electricity, and is in the process of seeking out additional PPAs.

The geothermal resource potential map for the United States shows locations of identified hydrothermal sites and favorability of deep enhanced geothermal systems (EGS). Credit: NREL



Community Revitalization

The 60-MW plant is expected to generate baseload power as well as inject money back into the surrounding communities.

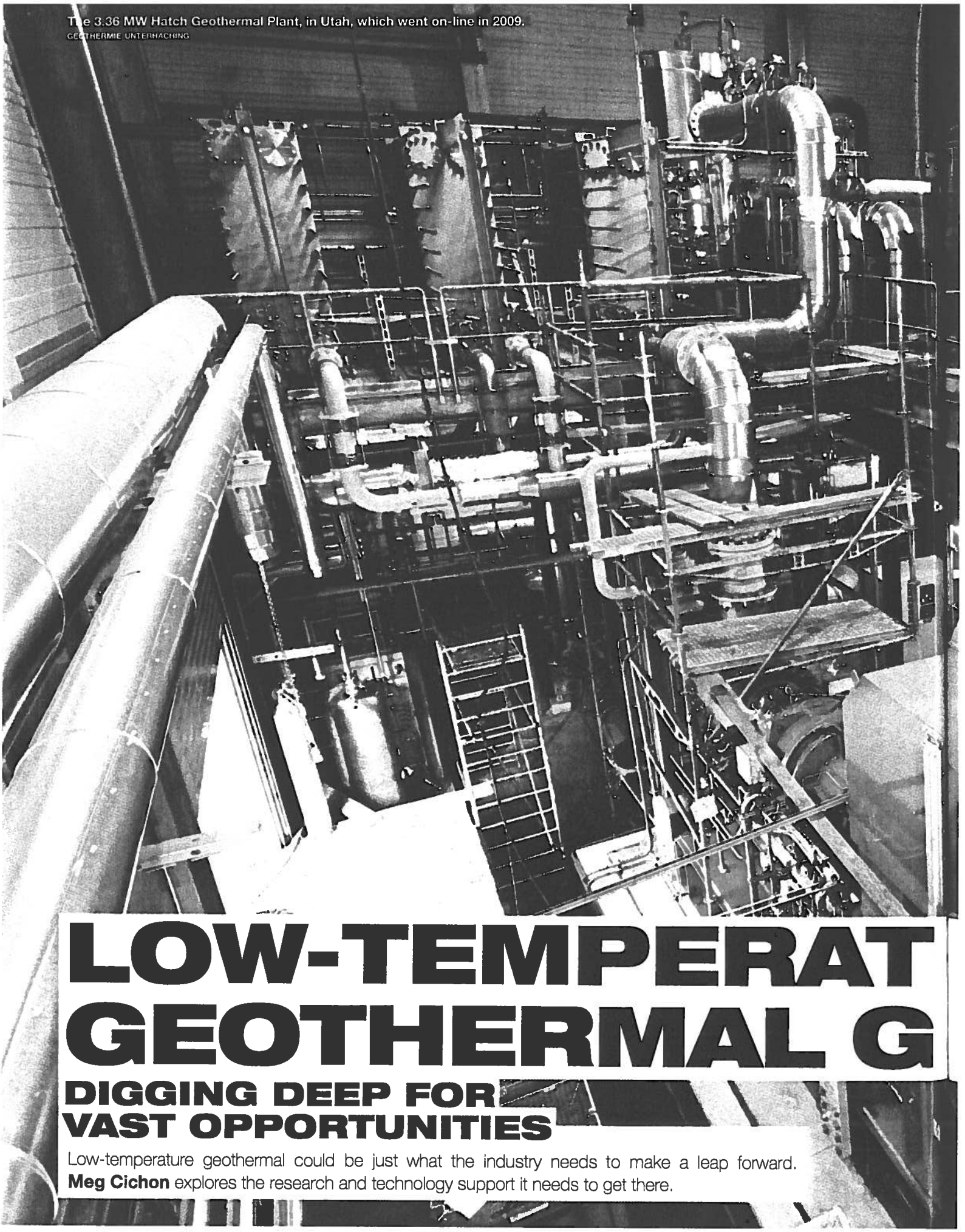
"When this project is complete, we will have erected approximately $300 million in steel, concrete and equipment, including the cost of labor. Of this $300 million, approximately $50 to $60 million will be filtered back into the local economy. This is, in my view, a big deal and will have a positive impact on the City of Fernley, Churchill County and surrounding areas," said Mataczynski in a statement.

Lyon County, where the project is being constructed, has embraced the project with open arms. With a 17.3 percent unemployment rate, many hope that the project will aid in revitalizing the community. "Projects like this are exactly what we had in mind when we passed the Economic Recovery Act," said Reid in a statement.

At the peak of construction, up to 170 people will be employed on the project. Once construction is complete, 32 people will work in operations and maintenance positions, and the plant's total payroll is estimated at $2.5 million. Gradient has further plans for expansion in nearby communities. Said Mataczynski, "Over the next five years, Gradient will bring some 300 MW of clean geothermal energy and create more than 1,000 construction and drilling jobs and an additional 80 permanent jobs."

Gradient hopes to expand the Patua project to up to 120 MW with additional financing and PPAs.

"In the next couple of years we will see a lot of growth, a lot of production, and a lot of business. The real question is what happens at the end of 2013 into 2014. Will the tax credit be extended? That is the question for all renewables," said Gawell, "Building a geothermal project is a struggle, but we're doing it."

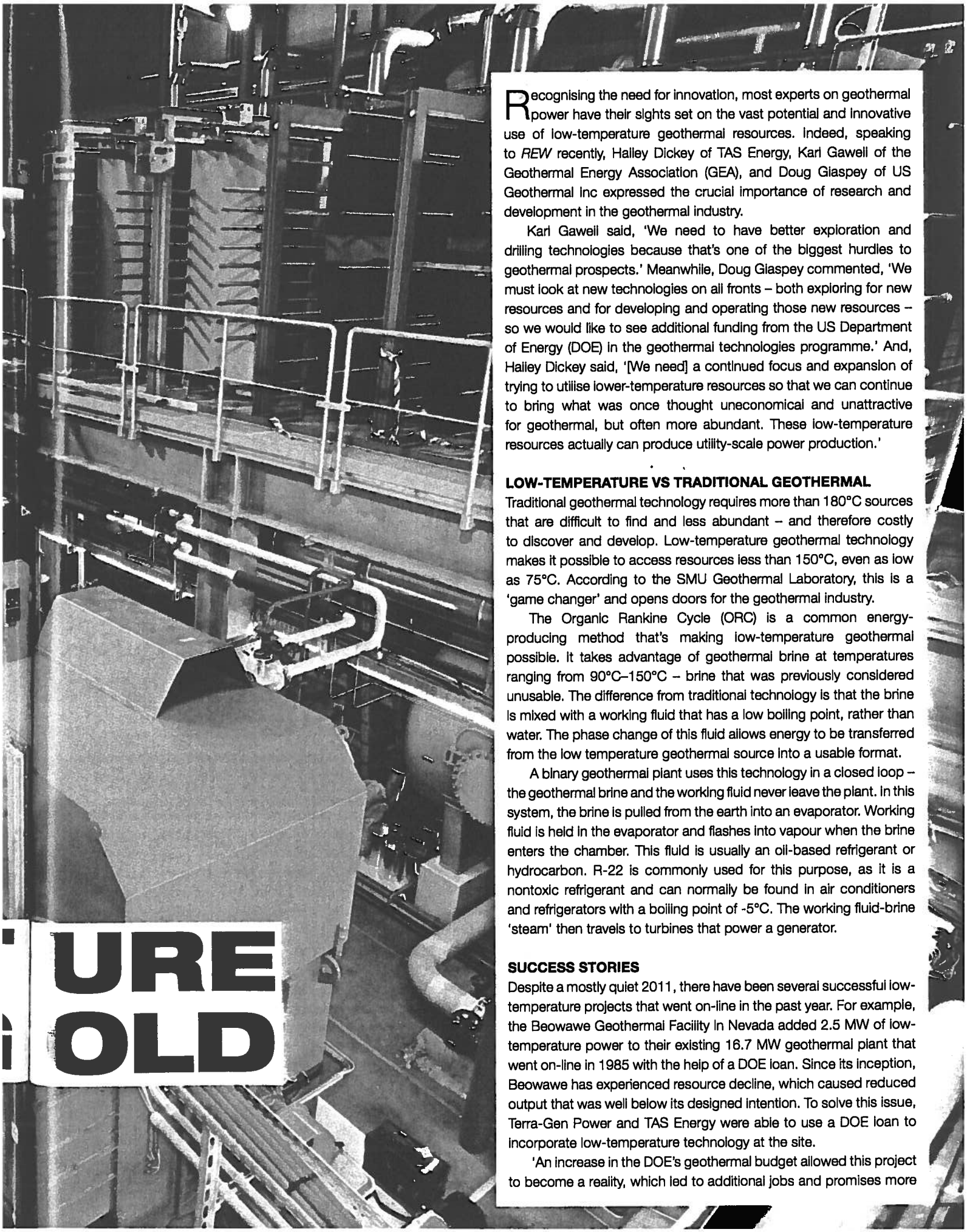


The 3.36 MW Hatch Geothermal Plant, in Utah, which went on-line in 2009.
GEOTHERMIE UNTERHACHING

LOW-TEMPERAT GEOTHERMAL G

DIGGING DEEP FOR VAST OPPORTUNITIES

Low-temperature geothermal could be just what the industry needs to make a leap forward. **Meg Cichon** explores the research and technology support it needs to get there.



URE OLD

Recognising the need for innovation, most experts on geothermal power have their sights set on the vast potential and innovative use of low-temperature geothermal resources. Indeed, speaking to *REW* recently, Hailey Dickey of TAS Energy, Karl Gawell of the Geothermal Energy Association (GEA), and Doug Glaspey of US Geothermal Inc expressed the crucial importance of research and development in the geothermal industry.

Karl Gawell said, 'We need to have better exploration and drilling technologies because that's one of the biggest hurdles to geothermal prospects.' Meanwhile, Doug Glaspey commented, 'We must look at new technologies on all fronts – both exploring for new resources and for developing and operating those new resources – so we would like to see additional funding from the US Department of Energy (DOE) in the geothermal technologies programme.' And, Hailey Dickey said, '[We need] a continued focus and expansion of trying to utilise lower-temperature resources so that we can continue to bring what was once thought uneconomical and unattractive for geothermal, but often more abundant. These low-temperature resources actually can produce utility-scale power production.'

LOW-TEMPERATURE VS TRADITIONAL GEOTHERMAL

Traditional geothermal technology requires more than 180°C sources that are difficult to find and less abundant – and therefore costly to discover and develop. Low-temperature geothermal technology makes it possible to access resources less than 150°C, even as low as 75°C. According to the SMU Geothermal Laboratory, this is a 'game changer' and opens doors for the geothermal industry.

The Organic Rankine Cycle (ORC) is a common energy-producing method that's making low-temperature geothermal possible. It takes advantage of geothermal brine at temperatures ranging from 90°C–150°C – brine that was previously considered unusable. The difference from traditional technology is that the brine is mixed with a working fluid that has a low boiling point, rather than water. The phase change of this fluid allows energy to be transferred from the low temperature geothermal source into a usable format.

A binary geothermal plant uses this technology in a closed loop – the geothermal brine and the working fluid never leave the plant. In this system, the brine is pulled from the earth into an evaporator. Working fluid is held in the evaporator and flashes into vapour when the brine enters the chamber. This fluid is usually an oil-based refrigerant or hydrocarbon. R-22 is commonly used for this purpose, as it is a nontoxic refrigerant and can normally be found in air conditioners and refrigerators with a boiling point of -5°C. The working fluid-brine 'steam' then travels to turbines that power a generator.

SUCCESS STORIES

Despite a mostly quiet 2011, there have been several successful low-temperature projects that went on-line in the past year. For example, the Beowawe Geothermal Facility in Nevada added 2.5 MW of low-temperature power to their existing 16.7 MW geothermal plant that went on-line in 1985 with the help of a DOE loan. Since its inception, Beowawe has experienced resource decline, which caused reduced output that was well below its designed intention. To solve this issue, Terra-Gen Power and TAS Energy were able to use a DOE loan to incorporate low-temperature technology at the site.

'An increase in the DOE's geothermal budget allowed this project to become a reality, which led to additional jobs and promises more

clean renewable energy for the future,' said Jim Pagano, CEO of Terra-Gen Power. 'This project paves the way for additional low temperature binary projects in Nevada and elsewhere,' he added.

With energy created from a 95°C resource, Beowawe confirms the technical and economic feasibility of low-temperature electricity generation. It uses new binary expanders that allow the use of lower resource temperatures for geothermal and waste heat applications. An axial turbine using R134a and R245fa as the primary working fluid, covers gross power output from 500 kW–5.0 MW with temperatures from 97°C–260°C). And in 2006, the Chena Hot Springs plant in Alaska set the record for the lowest-temperature production at 74°C. The 400 kW plant was the first low-temperature geothermal plant in the world and uses United Technologies Company (UTC) ORC generators to produce power. Chena Hot Springs has reduced the cost of power from US$0.30/kWh to $0.5/kWh and has helped to lift the veil on Alaska's geothermal potential.

NOT SO SUCCESSFUL

The Hatch Geothermal Power Plant in Beaver County, Utah, has been on-line since 2009. Developed by Raser Technologies, the 14 MW plant generates energy from temperatures ranging from 70°C–80°C. However, its UTC-built generators, the same company that produces air conditioners, are able to generate power at 74°C.

Though expectations were high, the plant has underperformed over the years. According to reports, the geothermal resource temperatures were unexpectedly low, and Hatch was producing 5 MW – less than half of its capacity, and it takes 4 MW to run its operations. Raser has continued drilling to uncover higher-temperature resources and rework its current wells, but has incurred more debt. The DOE granted Raser a $33 million loan in 2010 to help the project along, but its prospects are still uncertain.

A DIFFERENT APPROACH

A similar, but innovative, method of power generation is gaining interest in the geothermal industry – the Kalina cycle. Developed by Global Geothermal, its major difference when compared with the ORC is that it uses an ammonia-water working fluid – 82% ammonia by weight – that condenses and boils at a wider temperature range. According to the Kalina Cycle website, these attributes can improve the efficiency of the power process by 10%–50%. Henry Micak, Mark Mirolli, Hreinn Hjartarson, and Marshall Ralph explain the advantage in a *POWER Engineers* article: 'The conspicuous efficiency advantage characteristic of the Kalina cycle is realised from the heat-exchange processes of the heat acquisition in the evaporator and the heat rejection in the condenser. Additional efficiency is achieved by the recuperator exchangers. These gains are made possible by the variable boiling and condensing characteristics of the ammonia-water mixture working fluid as it varies in concentration at different points in the cycle.'

This technology was first put to the test in Húsavík, Iceland, in 2000. The Orkuveita Húsavíkur plant uses geothermal resources with a typical temperature of 120°C. The plant, still in operation today, produces 1.6 MW and powers 80% of the town, according to the *POWER Engineers* article. Among other benefits, the hot fluid that leaves the plant is used in the town's heating system, to heat greenhouses and the town's swimming pool and assist in melting snow. These benefits have an Oregon community hoping for the same results. In the Klamath Basin Wildlife Refuge experts are testing for Kalina geothermal potential. The refuge has a water-shortage problem, and energy price hikes have made water pumping too costly. When drilling for water in 2002, experts discovered a 90°C geothermal resource – which is perfect for the Kalina cycle.

'We had a need for cheaper power – they wanted to put this technology to work,' said Ron Cole, refuge manager at Sustainable Oregon. The $10 million project is said to have investors ready to move forward once the environmental regulations are cleared – construction could start by the end of 2012. If the project is a success, it may influence four other sites in the area.

IS SUPPORT FOR GEOTHERMAL POWER WANING?

With low-temperature technology advancements, successful projects and a vast resource map, what's next for the geothermal industry? Many argue that despite technology advancements, much more needs to be done. Experts argue that the geothermal industry has got this far due to strong support from the DOE, and this leads them to question what will happen if this support goes away.

'We need to have better exploration and drilling technologies because that's one of the biggest hurdles to geothermal prospects,' said Gawell. 'Our hope is that we see a sustained programme built upon that stimulus funding and that it's not just a one-shot deal.'

Many hope that programmes like the DOE's will be able to generate technology in the same way that drove the discovery and exploitation of oil and gas resources. According to Gawell, there are some similar promising technologies under development that he believes will significantly help the industry move forward. And many of these improvements focus on low-temperature sources.

Dickey agrees that the DOE programme, and others like it, have helped the industry along. But said that the public–private partnerships have also made projects make sense for investors when they might have been on the fence. 'We hope that DOE will continue to be supported by the government with dollars to work on exploration and risk-reduction and reservoir development in finding the resource and then helping support the difficulty in bringing those resources to the surface,' said Dickey.

Meanwhile, the global geothermal project pipeline suggests that in the next couple of years we'll see significant capacity added to the grid. California alone has more than 2000 MW in development. How much of that will be low-temperature? It's difficult to determine. With long project-development times and uncertain resources, implementing this fairly new technology has its challenges – but the future looks bright. 'Dr David Blackwell from SMU spoke at a national science foundation briefing on Capitol Hill [recently] and once again pointed out his estimates – there's something in the range of three million MW [of geothermal energy] that theoretically can be recovered. This industry has a long way to go, and technology is going to be a big part of making that happen,' said Gawell.

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ENHANCED GEOTHERMAL SYSTEMS: HAVE A LITTLE FAITH

EGS technology opens a hotbed of potential, but can it secure enough funding – and confidence – to move forward?

Meg Cichon, Associate Editor

Geothermal resource hot spots: Nevada, Arizona, California, and... Pennsylvania? Yes, even the east coast looks like a viable location for geothermal energy. Why? Enhanced geothermal systems (EGS) are making it possible.

Widening the Door of Potential

Traditional geothermal energy harvesting involves drilling into natural hot pockets of steam and water. These pockets can be difficult to find and locations vary widely, while the power produced depends on their size and temperature. The U.S. currently harnesses more than 2,800 MW of geothermal energy, about 30 percent of the world's geothermal energy capacity, which is more than 9,000 MW installed in 24 countries.

EGS technology significantly broadens U.S. geothermal potential to a whopping 2,980,295 MW, according to Google.org. This represents a near 40-fold increase compared to traditional geothermal technology potential because EGS taps into heat located under the Earth's crust that was previously unreachable — it can create power anywhere there is rock that is more than 150 degrees Celsius.

Okay, So How Does it Work?

The exciting aspect about EGS is that it can create geothermal potential in locations that were previously thought to be too dry or too cool. Creating this system requires improving the natural permeability of rock that is caused by fractures and pore spaces between mineral grains. Simply put, EGS is a loop-cycle system that pumps water into bedrock to re-open and create fractures. The naturally heated water is then pumped back to the surface, which creates steam that is then converted into energy.

"It is providing baseload continuous power with high availability. It's essentially emission-free and therefore carbon neutral. It has a distributed indigenous nature, so it's not just available in the southwestern parts of the U.S. — it is extendable and scalable on a national scale," said Dr. Jefferson Tester, professor of chemical engineering at Massachusetts Institute of Technology in a video on Google.org.

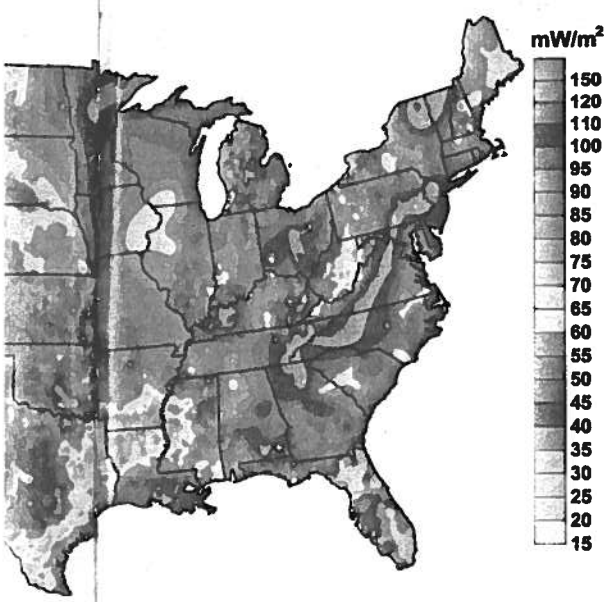
Fracturing rock may sound like it can create some disturbance or damage, but according to the U.S. Department of Energy, induced microseismic activity helps identify the extent of the fracture network in the reservoir — and in almost all cases cannot be felt at the surface due to its extremely low magnitude.

The first step in creating a successful EGS system is to identify a viable site. This is done by using heat maps and conducting extensive field exploration. Exploratory wells are then drilled to determine the extent of the resource, and if successful, an injection well is planned at the site. Water is then pumped through the injection well to create and reopen fissures in the rock — essentially creating a viable reservoir. Production wells are then drilled at key intersecting points in the reservoir to pick up the now-hot water pumped from the injection well. Once the water reaches the surface again, it heats a fluid that creates vapor to drive turbines that generate electricity. The now-cool injection water then flows back through the system again, creating a continuous loop and 24-hour energy production.

Encouraging Investment

Though the technology potential sounds great, it can't be done without significant investment. Fortunately, EGS is not being ignored.

Google has pioneered EGS advancement, and in 2008 invested more than $10 million in the technology. Funding went to two companies, AltaRock Energy and Potter Drilling, and two universities, Southern Methodist University's Geothermal Lab and Stanford University. The money went toward developing innovative EGS technology to reduce costs and expand range, and to create mapping to understand the size and extent of the energy resource.



The Google-funded SMU geothermal map identifies all viable EGS locations in the United States. Credit: Southern Methodist University

"EGS could be the 'killer app' of the energy world. It has the potential to deliver vast quantities of power 24/7 and be captured nearly anywhere on the planet. And it would be a perfect complement to intermittent sources like solar and wind," said Dan Reicher, director of climate and energy initiatives for Google.org in a written statement.

Google isn't the only one zeroing in on EGS; the U.S. government sees its potential, as well. The President recently released the U.S. FY2013 budget request, which included $65 million for geothermal and enhanced geothermal systems — a 71 percent increase. According to the DOE:

> *By 2020, the Program seeks to demonstrate that Enhanced Geothermal Systems are technically feasible by advancing critical technologies in reservoir creation, reservoir monitoring, and sustainability of sub-surface geothermal reservoirs. The Program focus is establishing EGS field sites, user test facilities, and developing game-changing reservoir creation and management technologies to expand the geothermal capacity more than 10 times from the current geothermal installed capacity of 3 GWe. The program will also aim to pursue technological innovation in finding, accessing, and developing 'blind' geothermal resources.*

Investment will focus on EGS technology, resource location technology, and resource assessment mapping in all 50 U.S. states.

Who's First Place in the EGS Race?

While much of EGS is still in research and development, there have been several successful commercial projects. A 2.5-MW EGS plant in Landau, Germany went online in 2007. Despite some minor seismic activity in 2009, the plant has been running smoothly. Australia has committed to finding and developing its vast geothermal potential. According to Primary Industries and Resources SA (PIRSA), an Australian government agency, investments between 2002 and 2014 may reach $2.7 billion, with 72 percent focused on EGS. Geodynamics has been developing a 50-MW EGS system in the Cooper Basin for years, which recently secured an additional $16.8 million in funding to drill a fourth well with hopes to establish a constant, viable source of energy at the location.

In the U.S., AltaRock is preparing a demonstration project in the Deschutes National Forest, about 30 miles south of Bend, Ore. And EGS is also improving current geothermal projects, like the Coso facility in Southern California. The 260-MW plant added another 20-MW of capacity by using EGS technology.

Said Karl Gawell, director of the Geothermal Energy Association, "You'll see EGS technology being applied in conventional plants in the next few years. The ultimate goal will be to have a project where you can literally engineer geothermal in many different areas than you can today. But it's going to take us 10-20 years to get there. All the tools developed for EGS technology will be applied to projects coming online in the next few decades to make them more efficient, more productive and lower risk."