Dixie Valley Bottoming Binary Plant: Terra-Gen was funded by the American Recovery and Reinvestment Act of 2009 to demonstrate the technical and economic feasibility of electricity generation from nonconventional geothermal resources of 223°F, employing the first commercial use of a supercritical cycle at a geothermal power plant inlet temperature of less than 300°F. Since September 2012, the plant has been online and producing 6 MW gross.

# Geothermal Value-Added Technologies

The U.S. Department of Energy's (DOE) Geothermal Technologies Office (GTO), in partnership with DOE's national laboratories, universities, and small businesses, conducts research, development, and demonstration projects throughout the United States on low-temperature and coproduced geothermal resources. Recent funding opportunities have enabled GTO to support work that extends into sedimentary basins, including geothermal resources colocated within oil and natural gas fields. GTO strives to demonstrate innovative technologies that will lead to advanced geothermal energy use and electricity production in these currently underutilized resource areas.

In the power generation cycle, low-temperature geothermal resources can be challenging because the highest temperature has a very strong effect on overall efficiency. However, these resources are widely available, and with newer technologies, unit installations have doubled in the United States in the last 15 years.

In addition, there are numerous applications for low-temperature geothermal energy beyond power generation, including space heating and cooling, water purification, and radiant heating. The Office is also looking at the potential for mineral recovery from geothermal fluids. These and other direct use low-temperature activities continue to gain ground in the United States.

Because they are so plentiful, low-temperature resources have the potential to make a significant contribution to the national geothermal portfolio. The U.S. Geological Survey is currently in the process of updating their assessment of untapped low-temperature geothermal resources in the United States and should have results in fiscal year 2015.

## Low-Temperature and Coproduced Resources

Low-temperature and coproduced resources represent a growing sector of hydrothermal development in the geothermal industry. Considered nonconventional geothermal resources below 150°C (300°F), these applications are bringing valuable returns on investment in the near-term, using unique power production and resource optimization methods.

### Low-Temperature Resources

Increasingly, low-temperature resources—once used predominantly for direct-use applications such as heating, fisheries, and industrial processes—can now also be used for power generation in suitable conditions. Low-temperature technologies have the potential to utilize geothermal resources from across the nation, expanding geothermal power potential beyond the western United States.

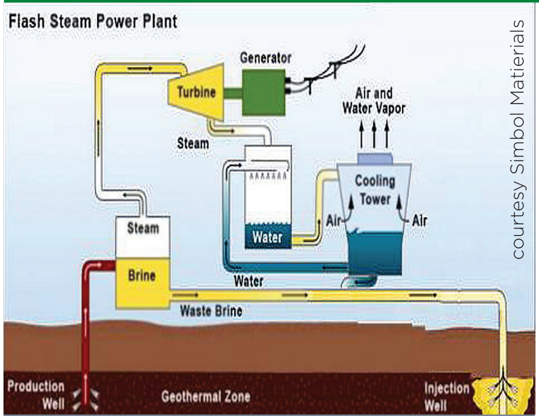
### Coproduced Resources

Coproduced resources use hot fluid—a by-product of oil, gas, and other material harvesting processes—to generate electricity. While the quality of the resource depends on water volume and temperature, these technologies have the potential to extend the economic life of oil and gas fields.

### Geothermal Power/ Oil & Gas Coproduction Resource Capacity

- 823,000 oil and gas wells in the U.S. produce hot water concurrent with oil and gas production.
- The water produced annually by oil and gas fields could generate up to 3 GW of clean, base-load power using binary geothermal units.
- U.S. oil and gas industry already invests beyond hydrocarbons—these technologies offer an opportunity to expand into renewable energy.

Visit the Geothermal Technologies Office (GTO) website at **geothermal.energy.gov** for more information, or contact **geothermal@ee.doe.gov**.



courtesy Simbol Materials

Through funding provided by the American Recovery and Reinvestment Act and support from EERE's Geothermal Technologies Office, the Energy Department helped develop a first-of-its-kind technology to produce lithium carbonate from geothermal brine. California-based Simbol, Inc. successfully demonstrated this novel process – further refined from research initially developed at Lawrence Livermore National laboratory – to extract useful materials like lithium and manganese from geothermal fluids. As part of the Geothermal Technologies Office Low-Temperature Mineral Recovery Program, Simbol is exploring ways to cost-effectively extract valuable and strategically important minerals from U.S. geothermal brines. The company, with an annual production capacity of 15,000 tons, announced plans to begin building its first commercial plant in 2015. Its Salton Sea plant will create an additional revenue stream from geothermal power production in the near-term, and a replicable model for mineral extraction at other sites going forward.

## Technology Benefits of Low Temperature Power Production Units

- Capacity range from 50 kW to more than 10 MW
- Design flexibility and reduced construction lead times
- Scalable plant sizes based on local geothermal resource and demand
- Ability to utilize off-the-shelf units, easily adaptable to higher output when more generation

# Project Highlights

In February 2014, DOE issued a funding opportunity announcement to evaluate the feasibility and assess the technical and economic potential of energy production in conjunction with mineral extraction. These projects will be getting underway in early FY15. In addition, there are many other projects in the Low Temperature portfolio that are advancing toward completion. Together, these include:

***Southern Research Institute (Southern)***
Working to develop an innovative Geothermal Thermoelectric Generation (G-TEG) system specially designed to both generate electricity and extract high-value lithium from low-temperature geothermal brines. The proposed system will provide large quantities of previously inaccessible baseload renewable electricity to the grid, with a disruptively low-power, generation-specific capital cost of < $2,000/kWe, as well as a high-value lithium recovery system that could decrease costs 20-50% over current state-of-the-art.

***SRI International***
Preparing new advanced ion-exchange resins chemically designed to selectively bind lithium and manganese ions. The resins will be based on ion-imprinted polymers chemically designed to mimic the recognition properties of biological receptors. The objective of this project is to develop a new generation of highly selective low-cost ion-exchange resins that will separate metals from geothermal fluids more efficiently than current processes.

***Lawrence Berkeley National Laboratory***
Combining emerging capabilities in synthetic biology and materials science with expertise in geothermal systems to innovate a new technology that could address the most critical aspect of material extraction from geothermal brine: the ability to selectively bind the strategic metal of interest. This approach has the potential to overcome previous limitations by using engineered microbes as a low-cost, selective, and reversible metal adsorbent. More broadly, if the technical goals of this proposal are successfully achieved, this technology will have broad-ranging implications including extraction of critical materials from on-shore fields and remediation of contaminated sites.

***University of California***
Providing critically needed, quality data quantifying the concentration and chemical speciation of REE in fluids from a range of U.S. geothermal fields. The research focuses on sampling sites within distinctive end-member geothermal systems (e.g., basin and range type, sediment-hosted, volcanic associated, magmatic) to elucidate the dominant controls on REE concentration in geothermal fluids (i.e. temperature, pH, salinity, complexing agents, and phase separation history). This will allow industry to better target geothermal systems for pilot plant development and will stimulate investment by reducing risk and quantifying reward.

***Pacific Northwest National Laboratory***
Developing a new type of biphasic working fluid for subcritical geothermal systems that utilizes microporous metal-organic solids as the primary heat carrier and heat transfer medium to support an Organic Rankine Cycle (ORC). This technology could increase the efficiency of binary-cycle plants and consequently increase geothermal power output.

***Oak Ridge National Laboratory***
Increasing brine effectiveness in binary geothermal plants to lower the cost of geothermal power generation. This project aims to advance the state of the art in heat exchanger structures for geothermal applications, through breakthrough designs in additive manufacturing and the use of carbon foam to reduce the footprint of heat exchangers and ultimately, the cost of electricity from geothermal power plants.

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