



The diagram illustrates an enhanced geothermal system (EGS). On the left, a large grey cooling tower stands on a sandy ground. A blue pipe leads from the ground down to a red and blue well. A red pipe leads from the well up to a grey power plant. Inside the power plant, a red and blue turbine is connected to a yellow generator. A red pipe leads from the generator to a power transformer and then to a power line tower. The background shows a blue sky with clouds and green hills. The ground is brown, and a red and orange heat source is visible in the lower part of the ground.

# Way Ahead for Enhanced Geothermal Systems

**The United States could generate more electric power with an enhanced geothermal system (EGS) that is able to extract geothermal energy from currently impermeable underground sources. But the high temperatures and high pressure at these locations make engineering fluid permeability particularly difficult. IDA's Science and Technology Policy Institute (STPI) worked with the Department of Energy (DOE) to foster successful development of EGS technologies and techniques.**

The DOE launched the FORGE (Frontier Observatory for Research in Geothermal Energy) initiative to encourage EGS development, testing, and breakthroughs by providing a site for scientists and engineers to collaborate and access the latest instrumentation and data. As such, FORGE aims to fill critical gaps in scientific knowledge and overcome challenges that have constrained commercial development of an EGS. The desired outcomes of the FORGE initiative are as follows:

- Enable the subsurface research community to develop, test, and improve new EGS technologies
- Understand key mechanisms controlling fracture generation, fluid flow, heat transfer, and sustainability of EGS reservoirs
- Disseminate technical data rapidly to the research community, developers, and other stakeholders
- Provide a path to rigorous and reproducible EGS development
- Reduce uncertainty, risk, and cost for industry

*(continued)*

STPI helped develop a FORGE roadmap that provides a framework for achieving these outcomes by describing three critical research areas (see table), enabling research and development (R&D), and supporting cross-cutting research principles and operational considerations. Research conducted at FORGE will address critical EGS challenges, while maintaining operational discipline and scientific rigor with respect to data collection and research implementation.

	Stimulation Planning and Design	Fracture Control	Reservoir Management
Definition	Research that supports efforts to design and optimally stimulate a well in accordance with natural subsurface characteristics	Research that supports efforts to develop an optimal fracture network as well as increase understanding of the resulting fracture system	Research that supports efforts to sustain long-term heat exchange in the system
Core R&D Actions	<ul style="list-style-type: none"> <li>Develop new <b>well configurations and well field designs</b> for optimal reservoir stimulation and operation</li> <li>Develop <b>new and adapt existing fracturing technologies and procedures</b> for EGS</li> </ul>	<ul style="list-style-type: none"> <li><b>Optimize design of fracture procedures</b> to reservoir conditions</li> <li>Develop <b>alternative injection practices and procedures</b></li> <li>Understand the effect of different <b>stimulation types</b> on the resulting fracture system</li> <li>Develop methods for successful <b>zonal isolation</b> during stimulation at high temperatures and pressures</li> </ul>	<ul style="list-style-type: none"> <li><b>Predict and monitor changes</b> in the fractures system over time</li> <li>Engineer <b>solutions to compromised or other unwanted changes</b> in reservoir permeability that can disrupt operation</li> </ul>

Three most critical research areas for FORGE

Before the FORGE roadmap was published in February 2019, the American Geophysical Union (AGU) hosted a town hall with panelists from STPI and DOE who talked about the roadmap. It was also part of a DOE webinar in February 2019 with Assistant Secretary for the Office of Energy Efficiency and Renewable Energy, Daniel R. Simmons. The roadmap was also featured in the Geothermal Resources Council’s *Bulletin* (Vol. 48, No. 2, March/April 2019).

If the FORGE initiative is successful in executing the core actions and principles that the roadmap identifies, a rigorous and reproducible EGS methodology can be developed in the next 5 years, bringing the United States closer to a more secure energy future.



For this project, **Alexis McKittrick** of IDA’s Science and Technology Policy Institute (STPI) led a team that included **Leslie Abrahams** ([labrahams@ida.org](mailto:labrahams@ida.org)) of STPI and others.

This summary is based on **IDA NS D-10474**, *Frontier Observatory for Research in Geothermal Energy: A Roadmap*, A. McKittrick, L. Abrahams, C. Clavin, R. Rozansky, and D. Bernstein, February 2019. See also “**Integrating Input to Forge Ahead in Geothermal Research**,” *Eos*, January 3, 2020. Research was sponsored by the Department of Energy.