FORGE Ahead - Roadmap Released for DOE’s Frontier Observatory for Research in Geothermal Energy

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Author’s Note: This article is a summary of key aspects of the FORGE Roadmap, developed and published by the IDA Science and Technology Policy Institute. The complete roadmap document can be found at https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2019/D-10474.pdf.

FORGE Background

The Frontier Observatory for Research in Geothermal Energy (FORGE) is a Department of Energy (DOE) effort to accelerate research and development (R&D) within the field of Enhanced Geothermal Systems (EGS) over the next 5 years at the a field site near Milford, Utah, operated by a team led by the University of Utah. FORGE’s mission is to enable cutting-edge research, drilling, and technology testing, underpinned by a comprehensive instrumentation and characterization effort and open data policy. Through this project, DOE endeavors to facilitate and spur transformative EGS research across the domestic and international geothermal community, with FORGE at the center, culminating in a set of rigorous and reproducible EGS technical solutions and a commercial pathway to successful EGS development.
The desired outcomes of the FORGE initiative are to:

- Allow the subsurface research community to develop, test, and improve new EGS technologies
- Gain fundamental understanding of key mechanisms controlling fracture generation, fluid flow, heat transfer, and sustainability of EGS reservoirs
- Enable rapid dissemination of technical data to the research community, developers, and other stakeholders
- Enable a pathway towards a rigorous and reproducible EGS development approach
- Reduce uncertainty and risk for industry

More information on the FORGE initiative, including previous phases of development and competition, can be found at https://www.energy.gov/eere/forge/. The 5-year implementation phase of the FORGE initiative will run from approximately mid-2019 to mid-2024. The research recommendations in this roadmap cover this 5-year implementation phase of FORGE at the Utah site.

**Scope and Purpose of FORGE Roadmap**

DOE’s Geothermal Technologies Office (GTO) tasked the IDA Science and Technology Policy Institute (STPI) to research, design, and develop a roadmap for the FORGE initiative. The objective of this roadmap is to provide technical research recommendations to DOE GTO, FORGE’s Science and Technology Analysis Team (STAT), and the broader research community for the 5 years of FORGE’s operation as an EGS research site operated by the Utah FORGE team at the Milford, Utah site. While the roadmap’s components are focused primarily on FORGE’s 5-year timeline and are appropriate for the geology of the FORGE test site, these activities will also contribute to the knowledge and understanding of how to build future large-scale, economically sustainable EGS systems beyond the FORGE site.

This roadmap is intended for an audience knowledgeable about geothermal technology and research, and EGS topics specifically. The roadmap focuses on describing high-priority research that can advance EGS technology development at FORGE. Non-technical challenges related to EGS commercialization, such as economic, social, and regulatory barriers are not included in the scope of the roadmap.

**Roadmap Development Methods**

STPI used several methods to generate the data and information needed to inform the FORGE Roadmap. This information collection focused on the following:

- The current state of EGS research, including recent successes, failures, and developments;
- The remaining technical challenges and research needs of the field, including unmet needs related to tools, data collection methods, specific data or information, modeling and predictive algorithms, and techniques for drilling and measurement; and
- How these needs and challenges could be addressed by research at the FORGE site, including furthering research in specific areas of EGS and special considerations for the FORGE site in Milford, Utah.

To ensure meaningful and relevant information was gathered on the topics above, STPI created an elicitation strategy that included stakeholder groups with subject matter expertise. This strategy was executed in stages (shown in Figure 1) that built off each other, so outputs from one stage could be used to inform the next stage. There were also reflective processing steps in between each stage to ensure the strategy was on-track towards procuring the data and information needed for roadmap development. The elicitation steps included:

1. Conducting a literature review of relevant EGS strategic planning documents and EGS technology review documents;
2. Holding a series of semi-structured, topical interviews with staff from DOE GTO;
3. Holding a series of semi-structured, topical interviews with a diverse selection of members of the EGS research community; and
4. Organizing and convening a facilitated workshop hosted by STPI in August 2018 that included EGS subject-matter experts from the research community.
The technical information derived from the elicitation process was provided to DOE GTO, which reviewed the research activities and identified those that represented core research to accomplish the objectives of FORGE. DOE GTO also determined which activities represented other supporting or enabling research. Clear focus areas emerged from DOE’s review of the research activities generated by the elicitation process, and those critical research areas are used to frame the FORGE research recommendations included in this roadmap. STPI then conducted a peer review of the roadmap prior to publication.

Key FORGE Roadmap Components

The FORGE Roadmap describes discrete actions that could be carried out at FORGE to overcome key technical challenges necessary for EGS to be reliable and reproducible. These actions are organized in the roadmap in three sections: critical research areas, enabling R&D, and implementation principles. Each section supports the research described in the previous section(s). See Figure 2 for a visual representation of the components of the roadmap.

The critical research areas represent the recommended primary foci of research in the FORGE Roadmap. They are:

- **Stimulation planning and design**: research that supports efforts to design and optimally stimulate a well in accordance with natural subsurface characteristics
- **Fracture control**: research that supports efforts to develop an optimal fracture network as well as increase understanding of the resulting fracture systems
- **Reservoir management**: research that supports efforts to sustain the long-term heat exchange in the system

Within each of these critical research areas, the roadmap describes 1) core research actions that are essential in furthering EGS development and 2) additional research that could play a supportive role in furthering EGS development. Core research actions aim to address ongoing technical challenges where there is no known technical solution in the current EGS research landscape or research that must be successfully addressed for FORGE to show progress towards a set of technical solutions that will enable a rigorous and reproducible EGS methodology (Figure 2). Core R&D actions are considered the highest priority research actions within this roadmap and are emphasized over the supporting R&D actions and other roadmap components.

In addition to the three critical research areas that are the central objective of this FORGE Roadmap, the roadmap contains a section titled “Enabling R&D,” which describes additional research areas that would facilitate the translation of FORGE’s research and results to other sites and contribute to increased EGS efficiency. While these areas are high impact research needs, the underlying tools and techniques are already more technologically advanced than those of the critical research areas and are therefore not central to this roadmap’s research priorities for FORGE. The Enabling R&D areas include subsurface characterization, drilling, well completions, and induced seismicity management.

While the roadmap focuses on recommending specific research actions that could be conducted at FORGE, it also recommends implementation principles that were emphasized by the research community as critical to the success of FORGE research endeavors. These principles provide an implementation framework for conducting and managing research at FORGE to facilitate advancement in the critical research areas. They include cross-cutting research recommendations that should underlie the technical foundations of all research conducted at FORGE as well as broad operational considerations for the management of the FORGE facility that are born from lessons learned in previous EGS research efforts.
Figure 2: Visual summary of the key components of the FORGE Roadmap, including the Critical Research Areas, the areas of Enabling R&D, and the categories of Implementation Principles.