Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Status report: European Energy Research Alliance - Joint Programme Geothermal

Inga Berre[1,2,*], Paola Bombarda[3], David Bruhn[4], Philippe Calcagno[5], Justyna Ellis[4], Thomas Kohl[6], Charlotte Gannefors Krafft[2], Erlend Randeberg[2], Francesco Rizzi[7], Martin O. Saar[8], Jan Diedrik van Wees[9], Florian Wellmann[10]

[1]University of Bergen, Norway

[2]NORCE, Norway

[3]Politecnico Milano, Italy

[4]GFZ Potsdam, Germany

[5]BRGM, France

[6]Karlsruhe Institute of Technology, Germany

[7]Scoula Superiore Sant'Anna, Italy

[8]ETH Zurich, Switzerland

[9]TNO, Netherlands

[10]RWTH Aachen, Germany

*inga.berre@uib.no

Keywords: research cooperation, Europe, network, geothermal

ABSTRACT

The European Energy Research Alliance Joint Programme Geothermal (EERA Geothermal) was established in 2009 and formally started as one of the first four joint programmes of EERA in 2010. As of 2019, EERA Geothermal had 30 Full Participants and 6 Associate Participants. Over the last 10 years, EERA Geothermal has been central in establishing a number of European projects, contributing to crucial research for utilization of geothermal energy in Europe and beyond. It is estimated that more than 40% of the European public research capacity on geothermal energy is integrated into EERA Geothermal. The utilization of common capacity speeds up the implementation of new research ideas to matured developments. The participants of EERA Geothermal are active in geothermal energy research and have active international collaboration across sectors. The research of EERA Geothermal is structured into eight Sub-Programmes, representing topics that will provide important contributions to realize the aims of the European Strategic Energy Technology Plan (SET-Plan) Implementation Plan Deep Geothermal.

1. INTRODUCTION

Geothermal energy can provide base-load and dispatchable electricity, heat or a combination of both. In addition, geothermal reservoirs may act as sites for subsurface energy storage. With these features, geothermal energy has the potential to replace fossil energy as well as complement the increased deployment of fluctuating renewables.

Currently, deep geothermal heat is directly used in a number of sectors. Depending on the temperature of the resource, these range from balneology and greenhouse heating to industrial processes. In Europe, more than 300 geothermal district heating systems are in operation (Dumas et al., 2018). The potential for further utilization is large and includes many countries that currently rely on fossil fuels for their heating needs. There is also a potential for an increased use of geothermal heat in industry and agriculture.

The total installed capacity for geothermal electricity generation in Europe was about 3.1 GW_e in 2018, generated by 127 power plants (Dumas et al., 2018). This represents a doubling of the capacity in six years. Globally, the geothermal power market is particularly dynamic in Turkey, Indonesia, USA, Mexico and New Zealand. In the EU, geothermal power can be invigorated more if unconventional geothermal resources including EGS can achieve sustainable and commercial production rates in a wider range of geological settings. This target can be reached only through the application of new cost-effective technologies able to enhance the production of the already identified resources, by discovering new untapped hydrothermal systems and by developing non-hydrothermal systems; that is, EGS, geopressured systems, supercritical systems, magmatic systems, offshore hydrothermal etc.

While the potential for use of geothermal energy is large, further development faces barriers and obstacles, such as high upfront cost and risk associated with the resource assessment stage, insufficient production rates, low efficiency of power conversion technology, environmental acceptance and risk, and lead-time from discovery to production. Moreover, with current technology only a part of the huge thermal energy confined at accessible depths may be utilized for electricity generation and/or direct uses. Hence, research for the improvement of geothermal energy technologies and their incorporation into the energy system is crucial to enhance geothermal energy production in Europe and worldwide.

The European Energy Research Alliance Joint Programme Geothermal (EERA Geothermal) was established to coordinate European research capacity and join forces in tackling the research challenges of the geothermal sector.

2. EUROPEAN ENERGY RESEARCH ALLIANCE - JOINT PROGRAMME GEOTHERMAL

The European Energy Research Alliance (EERA) is an association of approximately 250 public research centres and universities active in low-carbon energy research as members. EERA's official mission is to catalyse European energy research for achieving a

climate-neutral society by 2050. The member organizations are from 30 countries across Europe and comprises more than 50 000 experts. EERA is organized in 17 Joint Research Programmes, of which EERA Geothermal was one of the first four. It is estimated that more than 40% of the European public research capacity on geothermal energy is integrated into EERA Geothermal. As of 2019, EERA Geothermal had 30 Full Participants and 6 Associate Participants from 13 countries across Europe. The participants are approved based on an application process that considers their research activities and capacity. All of them are active in European and national research projects ranging from low to high Technology Readiness Levels (TRLs) and have wide international and intersectoral collaboration.

2.1 Objectives and activities

The overall goal of EERA Geothermal is to provide research to expand the type, number and size of geothermal resources suitable for increasing power and heat generation; improve efficiency, sustainability and flexibility in production of geothermal resources and improve integration of geothermal heat and power in the energy system.

In the framework of the SET-plan to accelerate technology development (European Commission, 2015), EERA Geothermal has identified the following objectives to direct its research:

- improve performance and sustainability of production and extend system lifetime
- explore, access and develop at a large scale
  - new untapped hydrothermal resources (up to 6 km deep and offshore)
  - Enhanced Geothermal Systems
  - "high-potential" resources such as supercritical resources, geopressured resources, and magmatic resources
- improve integration of geothermal heat and power in the energy system and increase the flexibility of grid supply,
- improve processes for co-generation (of heat, power, hydrocarbon, ore and materials), and hybrid production

EERA Geothermal incorporates experiences from several geothermal plants in operation under different geological environments. Combining the forces of the major European geothermal R&D institutions and considering the strategic goals of the SET-Plan (European Commission, 2015), EERA Geothermal aims at facilitating a significant acceleration of the development for providing reliable and highly efficient technology for the use of deep geothermal resources for heat and power. This is done through the following EERA Geothermal activities:

- contribution to the development of funding priorities
- exchange and sharing of knowledge
- dialogue with industry and European Technology & Innovation Platform on Deep Geothermal
- development of EERA Geothermal as the important network for shaping EU proposals
- joint use of research infrastructures
- fostering of mobility and training
- dissemination and communication

An example of one European research project that has resulted from the established cooperation within EERA Geothermal is the GEMex project, which is the result of an international collaboration between Europe and Mexico for the development of Enhanced Geothermal Systems and Superhot Geothermal Systems (Bruhn et al., 2019). The cooperation encompasses two partner projects, one funded within H2020 by the European Commission and one by the government of Mexico through the National Council of Science and Technology CONACyT.

Another example of the current involvement of EERA Geothermal is its active participation in a project that focuses on establishing collaboration on geothermal energy research and innovation partnership between Africa and Europe (PRE-LEAP-RE, 2019).

2.2 Organization and structure

The structure of EERA Geothermal is designed to meet the above-mentioned objectives and is targeted towards a comprehensive and coherent development of cost-effective geothermal technologies, which can successfully be applied under different practical conditions. Different thematic areas of focus are set out in eight Sub-Programmes (SPs): SP1 Assessment of Geothermal Resources, SP2 Exploration of Geothermal Reservoirs, SP3 Constructing Geothermal Wells, SP4 Resource Development, SP5 Energy Conversion Systems, SP6 Operation of Geothermal Systems, SP7 Sustainability, Environment and Regulatory Framework, and SP8 Computing and Data Management.

Together with the Joint Programme Coordinator and Scientific Secretary, the Sub-Programme Coordinators constitute the Management Board of the Programme. For running the activities of EERA Geothermal, the team is supported by a Secretariat. The governance structure and the subprogrammes are illustrated in Figure 1.

The Sub-Programmes are structured into several Actions that are proposed for the future or performed in ongoing joint projects, mostly funded through H2020. These Actions are subdivided into specific tasks and targets. An overview of the structure is given in Table 1.

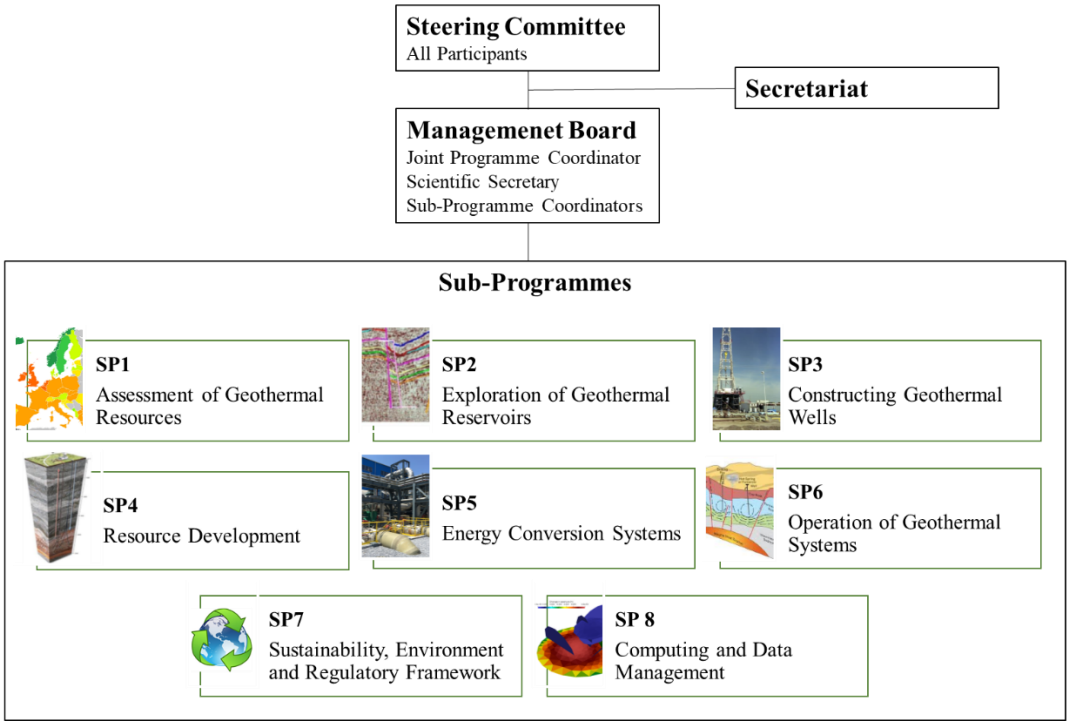

Figure 1: EERA Geothermal Governance structure and Sub-Programmes.

Table 1: EERA Geothermal Sub-Programme Actions.

SP1 Assessment of Geothermal Resources 1. Interdisciplinary 3D geothermal knowledge 2. Performance estimates 3. Implementation of European Geothermal Information System/Platform
SP2 Exploration of Geothermal Reservoirs 1. Conceptual models 2. Imaging 3. Natural laboratories
SP3 Construction of Geothermal Wells 1. Improvement of conventional drilling and horizontal drilling for geothermal scenarios 2. Development of novel drilling methods 3. Development of novel well completion/logging concept
SP4 Reservoir Development 1. Hydraulic, Thermal and/or Chemical Stimulation 2. Effect of engineering operations in superheated and supercritical water systems 3. Induced microseismicity 4. Alternative engineered geothermal systems 5. Numerical Simulators
SP5 Energy Conversion Systems 1. Component improvement 2. Underground thermal energy storage 3. System and network integration, modelling and optimization
SP6 Operation of Geothermal Systems 1. Sustainability of reservoir and environmental risk 2. Longevity of materials 3. Socio-economics
SP7 Sustainability, Environment and Regulatory Framework 1. Business models. 2. Socio-economic and environmental evaluations 3. Social acceptance
SP8 Computing and Data Management 1. Sustainable data management 2. Data Science in Geothermal Energy applications 3. Numerical simulation, parameter estimation and inversion 4. Geothermal HPC

3. SET-PLAN IMPLEMENTATION

EERA Geothermal is a key stakeholder of the SET-Plan Implementation Working Group Deep Geothermal (IWG-DG), who initiates and monitors measures to promote the targets of the SET-Plan Deep Geothermal Implementation Plan (DGIP) (SET-Plan Temporary Working Group, 2018). The work of the IWG-DG is based on the coordination work of a number of SET Plan countries as well as geothermal industry and research stakeholders who are already cooperating in platforms. In addition to EERA Geothermal, this includes the European Technology and Innovation Platform (ETIP) on Deep Geothermal and the European Geothermal Energy Council (EGEC); see Figure 2. The work of IWG-DG is supported by a H2020 funded project SU-IWG-DG (2019-2022), to which EERA Geothermal actively contributes.

Within DGIP, eight research and innovation (R&I) activities have been identified to promote the targets. The activities on a low TRL correspond well with the identified actions of EERA Geothermal (Table 1). Table 2 shows the results of a 2018 EERA Geothermal survey on how the research efforts within EERA, quantified as annual person months, currently support DGIP R&I activities. The results show that EERA Geothermal currently has significant capacity to support DGIP R&I activities.

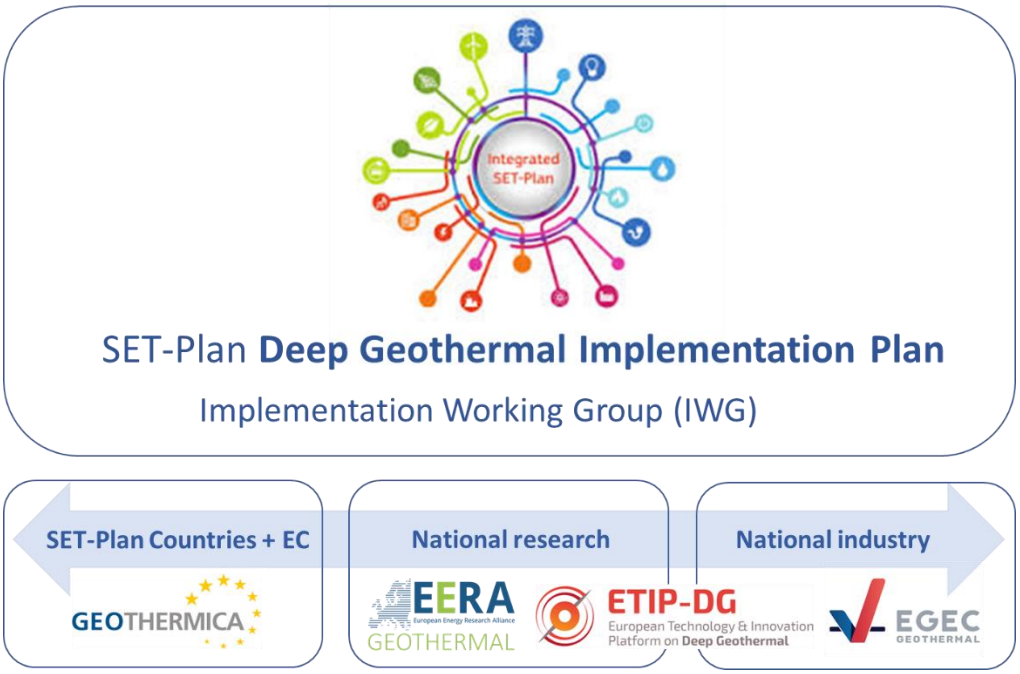

Figure 2: EERA Geothermal represents the interests of the research community in the SET-Plan Implementation Working Group Deep Geothermal.

Table 2: Reported annual Person Months (PMs) in EERA Geothermal to Implementation Plan Deep Geothermal R&I Activities.

SET Plan - Implementation Plan Deep Geothermal R&I Activities	PM / year
Geothermal heat in urban areas	346
Materials, methods and equipment to improve operational availability (high temperatures, corrosion, scaling)	240
Enhancement of conventional reservoirs and deployment of unconventional reservoirs	410
Improvement of performance (conversion to electricity and direct use of heat)	203
Exploration techniques (including resource prediction and exploratory drilling)	469
Advanced drilling/well completion techniques	319
Integration of geothermal heat and power in the energy system and grid flexibility	216
Zero emissions power plants	32

4. CONCLUDING REMARKS

EERA Geothermal has the potential to provide an outstanding contribution to the growth of geothermal energy utilization in Europe and worldwide, bringing together all major European research organizations in a strategically oriented endeavour. The participants of EERA Geothermal are active in geothermal energy research ranging from low to high TRLs and have active international collaboration across sectors. The eight Sub-Programmes of EERA Geothermal represent research capacities that will provide important contributions to realize the targets of the SET-plan Deep Geothermal Implementation Plan.

REFERENCES

Bruhn, D., Jolie, E., Kieling, K., Trumpy, E., Bonte, D., Liotta, D., Hersir, G.P., Deb, P., van Wees, J.D, and Huenges, E.: GEMex: Cooperation in Geothermal energy research Europe-Mexico for development of Enhanced Geothermal Systems and Superhot Geothermal Systems, *Proceedings*, European Geothermal Congress, The Hauge, Netherlands (2019)

Dumas, P., Garabetian, T., Serrano, C., and Pinzuti, V. (Eds).: EGEC Geothermal Market Report, Eighth Edition, June 2019, EGEC - European Geothermal Energy Council (2019)

European Commission: Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation, Communication from the Commission, European Commission, C(2015) 6317 final (2015). Accessed 24 June 2019, https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8_0.pdf

PRE-LEAP-RE: EU-AU collaboration on Renewable Energy (2019). Accessed 24 June 2019, http://www.leap-re.eu/

SET-Plan Temporary Working Group: Deep Geothermal Implementation Plan (2018). Accessed 24 June 2019, https://setis.ec.europa.eu/system/files/setplan_geoth_ip.pdf