2016 Working Group 13 Report – Emerging Geothermal Technologies

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1. Introduction

Working Group (WG) 13 – Emerging Geothermal Technologies was initiated on 21st April 2015 and started work at a kick-off meeting in Hanover, Germany, in September 2015. The working group covers a broad spectrum of activity including: exploration, drilling, reservoir creation and enhancement, corrosion and scaling in surface facilities, the use of tracers, and the mitigation of induced seismicity.

Work in WG 13 is currently carried out in five tasks:

A. Exploration, Measurement and Logging,
B. Drilling Technology,
C. Reservoir Creation and Enhancement
D. Induced Seismicity
E. Surface Technology (Heat and Electricity Production, Corrosion, Scaling, Tracer Technology).

Furthermore, it is planned to establish a sixth task on Geothermal Reservoir Management in the near future.

The goal of WG 13 is to provide quality information to facilitate and promote the utilization of geothermal energy worldwide. The development of innovative technologies is being pushed by expert collaboration between countries and the results made available in documents and through presentions at relevant conferences and workshops.

Current participants of WG 13 are Germany (among others the Leibniz Institute for Applied Geophysics as Operating Agent, with Josef Weber being WG leader), Switzerland (with Christian Minnig as WG co-leader), Norway (IFE), Korea (KIGAM), New Zealand (GNS Science), Japan, Australia, France, the United States and the European Commission.

2. Progress in 2016

2.1 Task A – Exploration, Measurement and Logging

Task A is targeted at sharing information on new and emerging technologies in exploration, measurement, and geophysical logging, and sharing experiences from case studies in various geothermal fields in different countries. By 2016, participating countries in Task A are Korea, Japan, Germany, and New Zealand.

2.2 Task B – Drilling Technology

Drilling can account for up to 50 % of the total costs of a geothermal project. Task B addresses the question of how to reduce drilling costs and what innovative drilling technologies may be alternatives to the rotary method that is predominantly used. For this purpose, Task B includes the compilation of geothermal well drilling performance and cost information. The aim is to identify problem areas, and discuss and suggest action points.

2.3 Task C – Reservoir Creation and Enhancement

Reservoir creation and enhancement technologies are of the utmost importance to exploit the enormous worldwide untapped geothermal energy potential. In most countries, there are no

naturally occurring hydrothermal reservoirs which can be used for energy production. Even in countries like New Zealand, Iceland and the Philippines such technologies are crucial, as the favourable hydrothermal conditions providing sufficient natural fluid flow for economic geothermal utilisation are limited to only a very few spatially restricted areas.

As a consequence, in most countries deeper geothermal energy is hardly developed. To utilise the vast quantity of energy stored in the earth, new and innovative technologies to create or enhance artificial reservoirs have to be developed and improved.

The objectives of Task C are to:

- establish a platform for international knowledge and information exchange,
- collate quality information with the overall goal of accelerating the development of these technologies, and
- mitigate the technical and non-technical barriers.

Task C was successfully started with a kick-off meeting in September 2016 in Munich. The work tasks have been defined and prioritised. A first publication is under preparation.

Current tasks are:

- Worldwide overview of the state of the art (first priority)
- Overview of worldwide research and development
- Ongoing exchange in the area of research and development, e. g. stimulation procedures, zonal isolation, modelling, characterisation, cost reduction
- Worldwide overview of country-specific challenges
- Development of a worldwide roadmap for EGS (considering country-specific challenges)

Furthermore, a project focussed on more general information about the potential of reservoir creation and enhancement is in the planning phase.

2.4 Task D – Induced Seismicity

Induced seismicity risk is an issue for a number of geothermal projects, particularly those involving deep EGS fracture stimulations, and those located in densely-populated regions, near fragile buildings, or surrounded by people not used to experiencing natural earthquakes. Collaborative research into this topic commenced in 2004 as a task in Annex 1 then switched to Annex 11, and in 2015 transferred to Task D under WG 13. The initial work focus was on developing a protocol to assist developers and regulators, as well as providing a forum for research collaboration and information exchange. Through collaboration with IPGT, efforts also focussed on establishing consistent data protocols, understanding mechanisms, and improving advanced forecasting methods using a modified ‘traffic-light’ approach for adaptive response to observed levels of seismicity based on modifying injection and stimulation parameters. Aspects of this work are continuing under this task. A new research focus is to better understand, through collaborative modelling and data sharing, the key mechanisms behind induced seismicity that sometimes accompanies long term injection.

2.5 Task E – Surface Technology (Heat and Electricity Production, Corrosion, Scaling, Tracer Technology)

Task E has continued to focus on recent developments in surface technology for geothermal heat and electricity production, corrosion, scaling and tracer technologies. It is based on the following activities:

- Collecting and collating available information from IEA Geothermal members
- Technical presentations at international forums
- Increasing awareness of the IEA Geothermal work and knowledge to the international community
- Collaboration and joint actions with other international bodies dealing with similar aspects and issues
- Attracting new members from results presented and the benefits derived
- Commencing cooperation between countries, research organisations and industry

3. Outputs

3.1 Task A – Exploration, Measurement and Logging

As the first step of the Task, a list of developers and/or service companies has been compiled serving as an information source for geophysical well logging, especially for high temperature applications (see Table 1). The list is far from containing all service and development companies worldwide, but it will be extended and updated every year.

Table 1. List of organizations which provide tools and/or services for geophysical logging for geothermal applications

Nation	Company	homepage
Korea	Korea Institute of Geoscience and Mineral Resources (KIGAM)	http://www.kigam.re.kr/
Japan	Geothermal Energy Research and Development Co. (GERD)	http://www.gerd.co.jp/index-e.html
Germany	Antares	http://www.antares-geo.de/
	Karlsruhe Institute of Technology (KIT)	ZWERG project
New Zealand	Hades Systems	http://www.hadessystems.com/
USA	Schlumberger	http://www.slb.com/
	Bakers and Hughes	https://www.bakerhughes.com/
	GE Oil and Gas	https://www.geoilandgas.com/
	Tiger Energy services	http://tigerenergyservices.com/
Luxembourg	Advanced Logic Technology (ALT)	https://www.alt.lu/
UK	Robertson Geologging (RG)	http://www.geologging.com/
	Probe	https://www.probe1.com/
	Severn Subsea Technologies (Calidus Engineering)	http://www.severnst.com/ http://www.calidusengineering.com

3.2 Task B – Drilling Technology

In 2016, information collection and the preparation of short reports was started. In this context it was possible to attract new members for the task.

In April 2016, Task B organised a session on "Innovative Drilling Technologies" at the Central and South American Workshop on Geothermal Energy in Cuernavaca, Mexico. Experts from Germany and Japan presented about the development of various drilling technologies for different applications.

3.3 Task C – Reservoir Creation and Enhancement

The Task C activities started with a workshop session at the IEA Geothermal Workshop on "Innovations in Geothermal Energy" in Cuernavaca, Mexico in April 2016.

The kick-off meeting of Task C took place in Munich in September 2016 in conjunction with the Executive Committee Meeting of IEA Geothermal. Representatives from all IEA Geothermal member countries participated except from UK and Italy.

A first presentation is under preparation and will be made publicly available. It will give an overview of relevant projects and the state of the art of reservoir creation and enhancement in the different countries.

3.4 Task D – Induced Seismicity

During 2016, the primary effort of this task was to encourage collaboration of researchers and to share the results of the considerable amount of funded research undertaken by participants. Countries with a strong interest in this topic include: Germany, France, Switzerland, Iceland, Japan, USA and New Zealand. The reference list in section 6.2 provides most of the 2016 publications from these groups of researchers. Some outputs are specific to one project or one country, while others represent joint work of individuals from several collaborating organisations, with funding also coming from a variety of sources. The reference list is subdivided into topics that have attracted most interest and collaboration: induced seismicity observations, mechanisms and models, and EGS stimulations.

3.5 Task E – Surface Technology (Heat and Electricity Production, Corrosion, Scaling, Tracer Technology)

Task E was presented and discussed in several international forums. These included:

- European Geothermal Congress (EGC 2016)
- Workshop at the Munich Molasse Meeting, September 2016
- Central and South American Workshop on Geothermal Energy, Cuernavaca, Mexico, April 2016
- "ETIP" (European Technology & Innovation Platform for Deep Geothermal)
- "Geothermal ERA-NET"
- 11th Asian Geothermal Symposium (AGS11)
- "EERA JP Geothermal"

New members were recruited. The current members are Japan, Iceland, Italy, New Zealand, USA, Germany and Norway.

4. Highlights

4.1 Task A – Exploration, Measurement and Logging

The ZWERG Project:

The term “ZWERG” stands for the German translation of dwarf. This project has been running since 2010 at the Institute for Applied Computer Science, Karlsruhe Institute of Technology (KIT), Germany. The main purpose of the project is to provide standardized basic components that are commonly used in many probes, such as probe housing, thermal insulation, design parameters and materials, to those who are working on the design and development of many different kinds of logging probes and tools (Isele, 2015).

The project developed many different modules or “bricks” as parts of logging probes, such as housing modules for uncooled space and for the electronics, Dewar flasks (a vacuum insulation) and so on. It provides details of the design parameters and information on the materials, and eventually blueprints for each of the bricks.

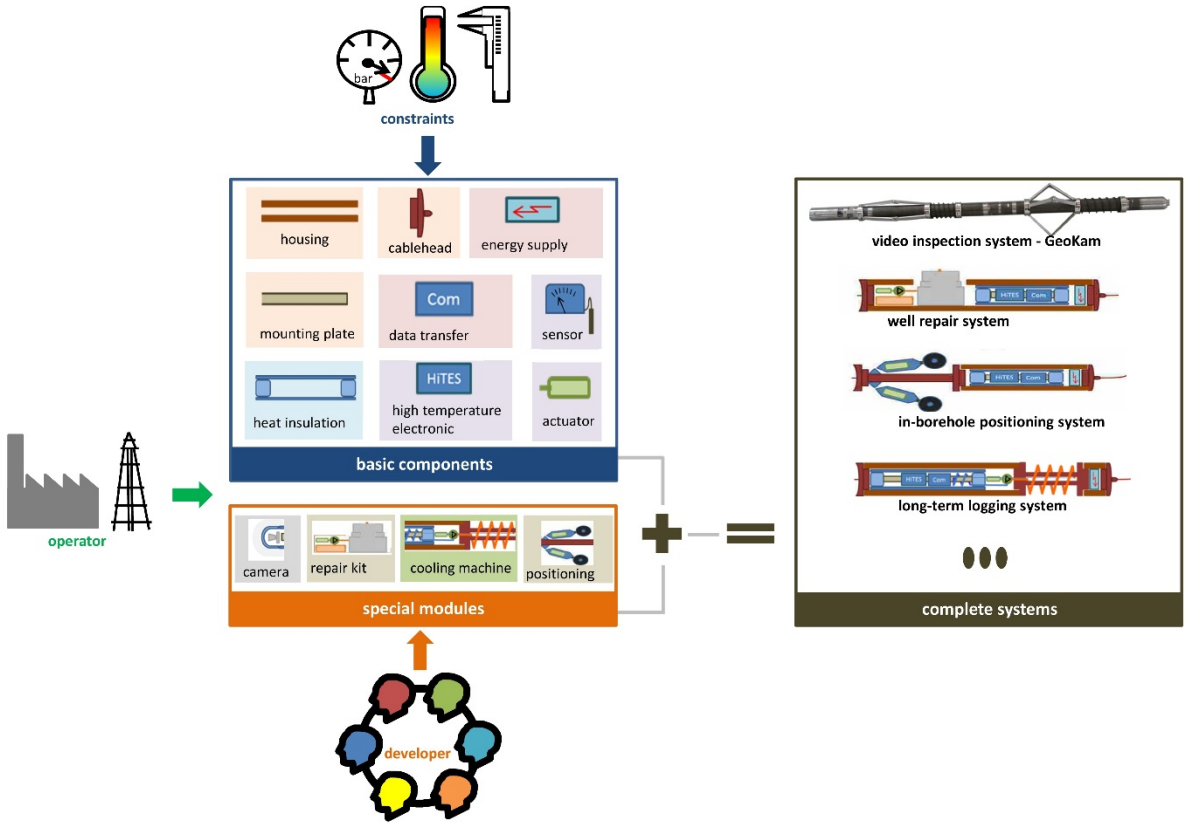

Fig. 1 Schematic diagram for the strategy and workflows of the ZWERG project (Figures provided by Benedict Holbein (KIT), personal communication).

As of 2016, development of the first tool GeoKam, a video inspection tool for deep geothermal boreholes, was almost completed (Spatafora et al., 2016). A laboratory evaluation test will be performed in an autoclave simulating borehole conditions. The autoclave at the Karlsruhe Institute of Technology can simulate pressures up to 80 MPa and temperatures higher than 200 °C.

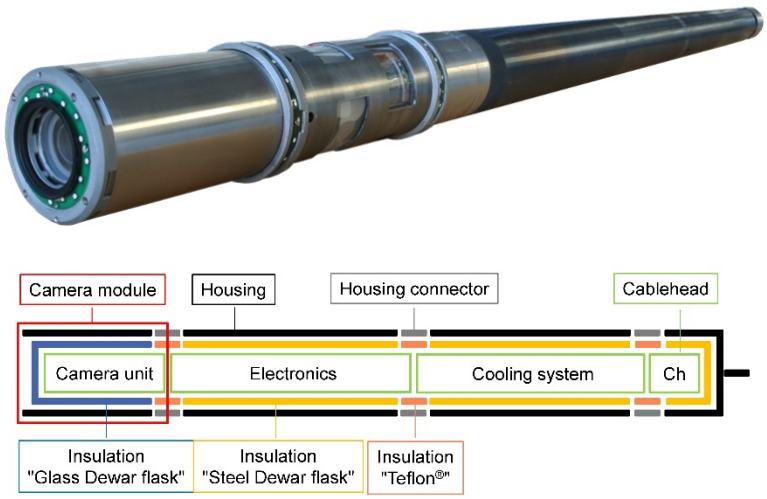

Fig. 2: Schematic design of video Inspection probe, GeoKam, function model for 48 MPa and 165 °C (Figures provided by Benedict Holbein (KIT), personal communication).

Details on the description of each module can also be found in Spatafora et al. (2016). GeoKam provides many important components, which can be universally used for the development of probes.

The reason why this project is special is that it is basically an open source (open hardware) project. It provides open sources or platforms, bricks, which can be used universally for downhole tool developments. The platform allows a cost effective and faster integration of additional modules, which in turn can form another unit (brick) of the platform.

4.2 Task C – Reservoir Creation and Enhancement

The highlight of Task C was the workshop session at the IEA Geothermal Workshop on “Innovations in Geothermal Energy” for Central and Latin American Countries. About 180 experts participated in the event.

Experts in the field of reservoir creation and enhancement joined Task C as national team leaders or active members. Almost all relevant countries are now actively participating in Task C.

5. Future Activities

5.1 Task A – Exploration, Measurement and Logging

In 2016, a list with several representative organizations which can provide downhole measurements and logging for geothermal applications was compiled. It not only includes member countries of Task A but also countries who have major service companies for oil and gas development. Participation of experts and researchers from those countries is expected in the future.

In the next two years, the list will be updated and more details about the services and tools of those organizations will be collected; e.g. types of services and tools, and their limits with regard

to temperature, pressure, and so on. A review of existing best practice manuals and white papers, such as the IFC-IGA best practice and IPGT white papers will be undertaken. Work scope of the task can be expanded by discussion among the member countries, and by accepting proposals from participating countries and specific experts on new technology for exploration, downhole tools/measurements, and monitoring including 4D imaging in geothermal fields.

5.2 Task B – Drilling Technology

First results of Task B will be a brief summary of innovative drilling technologies and a short report comparing alternative (drill bit) and innovative (plasma, laser, electric pulse) methods. These reports will be available in the middle of 2017.

Also in 2017, Task B will be presented at GEOTHERM in Offenburg, the largest European trade fair for geothermal energy.

Task B will go on with collecting and summarising data related to geothermal drilling and publish further short reports. The information will be collected mainly from published papers as industry data is difficult to access. It is planned to use the publicly available information to prepare a geothermal well drilling learning curve. A further step will be the organisation of a workshop in 2018 for exchanging information and know-how and gaining new task members.

5.3 Task C – Reservoir Creation and Enhancement

The next working group meeting of Task C will take place in conjunction with the May 2017 ExCo Meeting in Florence, Italy.

To boost international information and knowledge exchange, a workshop is planned in conjunction with the Geothermal Resources Council (GRC) in Salt Lake City, USA in October 2017. Furthermore, workshop sessions will be conducted at the two-day IEA Geothermal Workshop in November 2017 in Hanoi, Vietnam.

At least one presentation about current and past projects and the state of the art of stimulation technologies will be published in 2017 and a list of experts in the field of reservoir creation and enhancement will be compiled.

5.4 Task D – Induced Seismicity

Efforts to strengthen international collaboration will continue, and lessons learnt will be compiled into a summary document to assist developers, policy makers and the general public to make informed opinions about the risks involved. Outcomes will include improved and informed decisions about protocols and recommended monitoring schemes required for new or expanded geothermal projects.

5.5 Task E – Surface Technology (Heat and Electricity Production, Corrosion, Scaling, Tracer Technology)

We expect to collect and collate available information according to the already specified action plan in section 2.5 by giving technical presentations at international forums, increasing awareness of the IEA Geothermal work and knowledge to the international community, collaborating and initiating joint actions with other international bodies dealing with similar aspects and issues, and

attracting new members through results presented and the benefits derived from research organisations and industry.

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