Inventory of RD&D project highlights

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Abstract

This report shows highlights of ongoing or recently realised R&D, demonstration and deployment projects on geothermal energy in countries, participating in ERANET Geothermal energy. The projects are selected by the various agencies and research councils, because of their interesting impact on fundamental or practical knowledge about geothermal energy utilisation in their specific country.
Executive summary

This report shows highlights of ongoing or recently realised R&D, demonstration and deployment projects on geothermal energy in countries, participating in ERA-NET Geothermal energy. The projects are selected by the various agencies and research councils, because of their interesting impact on fundamental or practical knowledge about geothermal energy utilisation in their specific country.

The report is not a complete inventory. Our aim is to make a start in assessing the joint interests in research themes among the countries participating in ERA-NET Geothermal energy.

The participating countries in ERA-NET geothermal have many interests in common. However, each country has its own focal areas, as a result of the nature of its resources, the maturity of its market, its history and its policy on geothermal energy.

An indicative listing of common RDD&D interests includes topics related to the subsurface, and topics related to the utilisation of geothermal energy:

**Subsurface**

- Geological exploration and geological databases
- Advanced geological analysis and monitoring
- Extremely hot geothermal resources
- Advanced drilling techniques
- Operation of wells
- Enhanced geothermal systems and induced seismicity

**Utilisation**

- Direct utilisation of geothermal heat
- Electricity production
- New concepts/new combinations

With this report, we make a contribution to increased collaboration through European energy agencies and research councils on the topic of geothermal energy.
1 Methodology

This report shows highlights of ongoing or recently realised R&D, demonstration and deployment projects on geothermal energy in countries, participating in ERANET Geothermal energy. The projects are selected by the various agencies and research councils, because of their interesting impact on fundamental or practical knowledge about geothermal energy utilisation in their specific country.

The report is not a complete inventory. Our aim is to make a start in assessing the joint interests in research themes among the countries participating in ERA-NET Geothermal energy.

ERA-NET Geothermal Energy produced another report, on policies on geothermal energy, regulations, statistics and relevant support schemes for implementation of geothermal energy R&D, demonstration or deployment projects\(^1\).

2 Selected RDD&D projects by country

This chapter presents selected RDD&D projects by country.

2.1 Switzerland

Switzerland presents seven selected RDD&D projects. R&D topics include induced seismicity, innovative drilling techniques, mapping for geothermal resources, high-temperature geothermal systems (i.e. close to the magma). For Demonstration and Deployment, Switzerland presents an application in the agribusiness, and risk management; early detection of induced seismicity.

Table 1 List of RDD&D projects for Switzerland

<table>
<thead>
<tr>
<th>CH-a</th>
<th>GEOSIM</th>
<th>Real time assessment of seismic risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH-b</td>
<td>Thermal spallation drilling: rock-flame interaction</td>
<td>Revolutionary drilling technique;</td>
</tr>
<tr>
<td>CH-c</td>
<td>GeoMol - CH</td>
<td>Delineate the geothermal potential of the sedimentary basins of CH.</td>
</tr>
<tr>
<td>CH-d</td>
<td>COTHERM</td>
<td>Better understanding of high-temperature geothermal systems (i.e. close to the magma)</td>
</tr>
<tr>
<td>CH-e</td>
<td>GEOTHERM</td>
<td>Novel observation techniques for understanding induced seismicity</td>
</tr>
<tr>
<td>CH-f</td>
<td>Direct heat for Grob Agri-business in Schlattingen (Canton Thurgau)</td>
<td>Use of geothermal energy for agribusiness. 2nd deviated well to be drilled.</td>
</tr>
<tr>
<td>CH-g</td>
<td>GEOBEST</td>
<td>Risk management; early detection of induced seismicity</td>
</tr>
</tbody>
</table>

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\(^1\) Geothermal energy status and policies in the ERANET Geothermal Energy
2.2 Germany

Germany presents five selected R&D projects and three selected demonstration/deployment related projects. Topics include prediction of subsurface conditions while drilling and 3D seismic, advanced drilling, predicting and limiting induced seismicity, a study to improve knowledge of the Upper Rhine Graben, and three themes related to smooth operation: diagnosis for muck pumps, understanding corrosion in saline water, and preventing precipitation.

A complete inventory of R&D projects on geothermal energy can be found at [http://www.forschungsjahrbuch.de/](http://www.forschungsjahrbuch.de/)

<table>
<thead>
<tr>
<th>DE-a</th>
<th>Seismic prediction while drilling</th>
<th>New approach for seismic exploration in bore-holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE-b</td>
<td>Geothermal reservoir analogues for the northern Upper Rhine Graben (AuGE)</td>
<td>Conclusions on deep subsoil to be drawn from superficial rock analogues?</td>
</tr>
<tr>
<td>DE-c</td>
<td>Development and testing of an electric pulse method drill head for deep geothermal (EIV)</td>
<td>Develop and test a drillhead with impulse voltage source for deep geothermal.</td>
</tr>
<tr>
<td>DE-d</td>
<td>3D seismic in crystalline rocks in Saxony for geothermal project (SIK)</td>
<td>Develop 3D seismic for crystalline rocks. Map Saxony crystalline rocks / fault structures in this way.</td>
</tr>
<tr>
<td>DE-e</td>
<td>Microseismic Activity of Geothermal Systems (MAGS)</td>
<td>Understanding and limiting induced seismicity</td>
</tr>
<tr>
<td>DE-f</td>
<td>Strategies to avoid negative effects on the thermal water loop in geothermal systems (ContraPart)</td>
<td>Preventing precipitation of barium and strontium by inhibitors</td>
</tr>
<tr>
<td>DE-g</td>
<td>Diagnosis and monitoring system for muck pumps</td>
<td>Reliability of muck pumps</td>
</tr>
<tr>
<td>DE-h</td>
<td>Longterm corrosion analyses and monitoring in saline thermal water</td>
<td>Regional, fluid-specific catalogue of suitable construction materials</td>
</tr>
</tbody>
</table>

2.3 France

France presents 6 R&D and 3 demonstration/deployment projects. R&D themes include geological mapping, geology of hot subsurface in the West Indies/French overseas islands, fracture/fluid interaction, combination of geothermal energy and ATES (aquifer thermal storage) and EGS.

<table>
<thead>
<tr>
<th>FR-a</th>
<th>CLASTIC-2</th>
<th>3D geomodel of silico-clastic Trias</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-b</td>
<td>GHEMOD</td>
<td>Tools to understand the origin of geothermal resources in the French overseas islands</td>
</tr>
<tr>
<td>FR-c</td>
<td>GEO3BOU</td>
<td>Modeling and monitoring Bouillante geothermal field in French overseas islands</td>
</tr>
<tr>
<td>FR-d</td>
<td>GEFRAC3 EXP</td>
<td>Experimental study of fluid/rock interactions in fractures</td>
</tr>
</tbody>
</table>
FR-e  | GEFRAC3 MOD | Modeling study of fluid/rock interactions in fractures
FR-f  | THERMO2PRO | Web tool for geothermal potential estimation
FR-g  | GEOSTOCAL  | Aquifer thermal storage in combination with geothermal energy production, Paris area
FR-h  | Soultz III | First pilot EGS project in Europe. Exploitation and monitoring
FR-i  | ECOGI      | First application of EGS in private sector in France

### 2.4 Hungary

Hungary presents 4 R&D and 2 Demonstration/Deployment projects. Themes include geological mapping coupled to demand, transboundary management of geothermal resources, and direct use.

**Table 4 List of RDD&D projects for Hungary**

<table>
<thead>
<tr>
<th>HU-a</th>
<th>TRANSENERGY</th>
<th>Cross border harmonised utilisation strategy for western part of Pannonian basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>HU-b</td>
<td>Geo-DH</td>
<td>Within Geo-DH, HU is preparing an interactive web-map matching potential and demand</td>
</tr>
<tr>
<td>HU-c</td>
<td>Geothermal potential assessment</td>
<td>HIP, inferred resources and probable reserves; reliable numbers on geothermal potential</td>
</tr>
<tr>
<td>HU-d</td>
<td>Delineation of geothermal protection zone</td>
<td>Remove administrative barriers for geothermal energy</td>
</tr>
<tr>
<td>HU-e</td>
<td>Szentlőrinc</td>
<td>First 100% geothermal district heating system in Hungary</td>
</tr>
<tr>
<td>HU-f</td>
<td>Miskolc-Mányi</td>
<td>First large-scale district heating project in Hungary, capacity 55 MW.</td>
</tr>
</tbody>
</table>

### 2.5 Iceland

Iceland presents 7 R&D and 4 Demonstration/Deployment projects. Themes include interaction between magma and geothermal fluids, subsurface two-phase and supercritical behaviour, innovative methods for geological/geophysical mapping, mapping shallow resources, and applications of the CO₂ produced with geothermal energy: injection of CO₂ for fixation, CO₂ conversion to methanol and CO₂ for growth of algae.

**Table 5 List of RDD&D projects for Iceland**

<table>
<thead>
<tr>
<th>IS-a</th>
<th>GEORG “Deep roots of Geothermal systems” project</th>
<th>Understanding interaction between magma and geothermal fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-b</td>
<td>HYDRORIFT</td>
<td>New method for exploration of supercritical geothermal systems</td>
</tr>
</tbody>
</table>
Advanced 3D Geophysical Imaging Technologies for Geothermal Resource Characterization
New geophysical exploration and interpretation methodologies

Sustainable Yield of Geothermal Resources and Renewability
Ensuring that the renewable energy society can be sustained for the generations to come

Properties of two phase flow of water and steam in geothermal reservoirs
Deepen understanding, improve modeling of such geothermal reservoirs

Predicting permeability in igneous formations
From igneous rock samples, improve modeling of permeability

ThermoMap
Web GIS application, using existing data for shallow geothermal potential (GSHP)

Deep Drilling Project
Economic feasibility of producing energy and chemicals from supercritical waters

Carbfix
Fix CO\textsubscript{2} in basaltic bedrock through carbonate formation

Carbon Recycling
Makes methanol – transport fuel - from CO\textsubscript{2} from geothermal waters, and H\textsubscript{2} from electrolysis

Geochem
X00.000 tons/a CO\textsubscript{2} released from geothermal sources; aim to utilise for growth of algae.

### 2.6 Italy

Italy presents 3 R&D and 4 Demonstration and Deployment projects. Themes include mapping of geothermal resources, deep drilling in a caldera/geothermal properties of supercritical fluids. Selected applications include district heating from “cold” subsurface reservoirs, and district heating and dairy production with steam from geothermal power plant.

<table>
<thead>
<tr>
<th>IT-a</th>
<th>Italian Geothermal Atlas of southern regions</th>
<th>Maps favourability of territories to host geothermal systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT-b</td>
<td>VIGOR Geothermal potential assessment of italian convergence regions</td>
<td>Feasibility studies for geothermal energy at 8 locations, all southern Italy</td>
</tr>
<tr>
<td>IT-c</td>
<td>Campi Flegrei Deep Drilling Project</td>
<td>Volcanological and geothermal study of Campi Flegrei caldera</td>
</tr>
<tr>
<td>IT-d</td>
<td>FORIO Project</td>
<td>2nd zero emissions geothermal power plant (5 MW) on Ischia island</td>
</tr>
<tr>
<td>IT-e</td>
<td>SCARFOGLIO Project</td>
<td>5 MW geothermal power plant in Campi Flegrei</td>
</tr>
</tbody>
</table>
2.7 The Netherlands

The Netherlands presents 6 R&D projects and 5 Deployment and Demonstration projects. R&D subjects include on geothermal mapping, drilling and fraccing techniques, and co-injection of CO₂. Demonstrations from the Netherlands concern applications for agriculture and district heating, in two cases combined with seasonal storage.

Table 7 List of RDD&D projects for the Netherlands

| NL-a | DIRT | Drilling with fiber reinforced composite material |
| NL-b | Heat atlas of the Netherlands | Mapping heat demand and availability |
| NL-c | ThermoGIS | Subsurface data to determine potential for geothermal |
| NL-d | Potential scan deep geothermal energy 2050 | Potential of deep geothermal by 2050 |
| NL-e | CO₂ injection in aquifers combined with geothermal energy | Co-injection of CO₂ for CO₂ sequestration |
| NL-f | "More pressure on geothermal energy" | Informing future owners of geothermal wells on stimulation techniques and consequences |
| NL-g | Heerlen heated with mine water | Water from former coal mines for district heating and cooling |
| NL-h | Geothermal heat for greenhouse, A+G van den Bosch | First project with deep geothermal heat in horticulture |
| NL-i | Californië, peppers with heat from the carboniferous limestone | First project in karstic/fracture aquifer |
| NL-j | Geothermal district heat The Hague | Second geothermal district heating project in the Netherlands |
| NL-k | Multi Energy Concept – Greenhouses “Vierpolders” - MEC-V | Application in horticulture, year-round heat supply and demand through seasonal storage. |
2.8 Slovakia

Slovakia presents two R&D projects and 5 Deployment and Demonstration projects. R&D focuses on advanced drilling. Deployment and demonstration is mainly district heating, one combination with heat pumps, and a combination with electricity generation under construction.

Table 8 List of RDD&D projects for Slovakia

<table>
<thead>
<tr>
<th>SK-a</th>
<th>Applied research and development of innovative drilling technology for ultra-deep geothermal wells</th>
<th>Innovative water jet generating system, based on electric-discharge plasma</th>
</tr>
</thead>
<tbody>
<tr>
<td>SK-b</td>
<td>Robust autonomous mechatronic systems for ultra-deep geothermal wells</td>
<td>Innovative mechatronic systems for ultra deep geothermal wells</td>
</tr>
<tr>
<td>SK-c</td>
<td>Geothermal District Heating in Sala</td>
<td>Base-load heat source, single well, 1,6 kton/year CO₂ reduction,</td>
</tr>
<tr>
<td>SK-d</td>
<td>Geothermal District Heating in Sered</td>
<td>Combination deep geothermal and heat pump for district heating. 1,1 kton/year CO₂ reduction</td>
</tr>
<tr>
<td>SK-e</td>
<td>Geothermal District Heating in Galanta</td>
<td>90% heat delivered by geothermal, 7 MW system</td>
</tr>
<tr>
<td>SK-f</td>
<td>Geothermal District Heating in Svinica-Durkov</td>
<td>Combination 3,5 MWe and 100 MWt, under construction</td>
</tr>
<tr>
<td>SK-g</td>
<td>Geothermal District Heating in Podhajska</td>
<td>10,5 MWt project, only operating Slovak project with reinjection instead of single well.</td>
</tr>
</tbody>
</table>

2.9 Slovenia

[Slovenia has been invited to contribute to this report]

2.10 Turkey

Turkey presents six R&D project focal areas. These include mapping of geothermal resources, materials research, and applied research for specific applications.

Table 9 List of RDD&D focal areas for Turkey

<table>
<thead>
<tr>
<th>TR-a</th>
<th>Searching for geothermal energy in pilot areas of Turkey</th>
<th>Searching for geothermal energy in pilot areas of Turkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR-b</td>
<td>Software for geothermal-solar hybrid system</td>
<td>Software for geothermal-solar hybrid system</td>
</tr>
<tr>
<td>TR-c</td>
<td>Traditional food production by utilisation of geothermal energy</td>
<td>Traditional food production by utilisation of geothermal energy</td>
</tr>
<tr>
<td>TR-d</td>
<td>Water leakage monitoring at geothermal fluid transport systems</td>
<td>Water leakage monitoring at geothermal fluid transport systems</td>
</tr>
<tr>
<td>TR-e</td>
<td>Geothermal energy based food drying oven equipment</td>
<td>Geothermal energy based food drying oven equipment</td>
</tr>
<tr>
<td>TR-f</td>
<td>Materials for geothermal wells</td>
<td>Materials for geothermal wells</td>
</tr>
</tbody>
</table>
3  Common interests

This chapter presents indicative conglomeration of the selected RDD&D projects. Special focus is on common interests among the participating countries. The interests can be subdivided in projects focusing on the subsurface, and projects focusing on utilisation, the successful coupling of the characteristics of the subsurface and energy demand above ground.

3.1  Subsurface

3.1.1  Geological exploration and geological databases

Obviously, mapping the subsurface is a formidable task with important implications for the increase of the use of geothermal energy. In Switzerland (CH-c), Germany (DE-b) France (FR-a), The Netherlands (NL-d) and Turkey (TR-a) there are projects aimed at better understanding the nature of the geothermal resources. Other projects, in France (FR-f), Hungary (HU-a/d), Italy (IT-a/b), and the Netherlands (NL-b/c), focus on facilitating access to estimation of the potential, and at coupling heat demand and heat supply.

Connected to this is also the project from Iceland (IS-d) aimed at exploring the sustainable yield of geothermal for the generations to come.

3.1.2  Advanced geologic analysis and monitoring

Analysing the subsurface requires analysis techniques. Advances presented by the participating countries include observation techniques for seismic prediction while drilling (DE-a), advanced 3D imaging (De-d) (IS-c) and improving modeling of permeability of igneous formations through analysis of rock samples (IS-f).

3.1.3  Extremely hot geothermal systems

Our understanding of extremely hot geothermal systems, where there is a significant potential for electricity generation, needs to be improved. This is the reason that countries that have such reservoirs, or specific knowledge connected to this research topic consider ongoing research in this area as crucial. Switzerland (CH-d), France (West Indies) (FR-b/c), Iceland (IS-a/b, IS-e, IS-h) and Italy (IT-c) have interesting research projects on this topic.

3.1.4  Advanced drilling techniques

Advancing drilling technique is relevant for geothermal energy, since the cost of a project are very closely related to drilling cost. Switzerland (CH-b), Germany (DE-c), Netherlands (NL-a) and Slovakia (SK-a/b) present research on drilling.

3.1.5  Operation of wells

Research into practical issues concerning operation of wells may enhance performance and reduce cost. This may be related to corrosion, scaling and injectivity problems. Germany presents very hands-on research into such issues (DE-f/h) concerning operation of wells.

3.1.6  Enhanced geothermal systems, well stimulation, induced seismicity

Enhanced geothermal systems, well stimulation and induced seismicity are related topics, most relevant for electricity production from the deep subsurface. France (FR-h) has the Soulz-III project in this category. Switzerland (CH-a, CH-e, CH-g) and Germany (DE-e) share a focus on induced
seismicity. France (FR-d/e) and the Netherlands (NL-f) present projects on fractures and the fluid flow inside them.

3.2 Utilisation

3.2.1 Direct utilisation of geothermal heat

The direct use projects which have been selected by the country representatives are projects that have a showcase value for the specific country.

This showcase value comes from scale (HU-f) or high percentage of geothermal heat in the district heating system (HU-e, SK-e), being the first-ever application of geothermal district heating (NL-g, -j), or the first-ever with a re-injection well (SK-g).

Apart from district heating, there are other applications or innovative combinations. Switzerland (CH-f) and the Netherlands (NL-h/i, k) show application of geothermal heat in the horticultural sector. France (FR-i), Italy (IT-h) and Turkey (TR-c, -e) have applications in food industry. There are also combinations with seasonal storage, in France (FR-g) and the Netherlands (NL-g, -k). And there are combinations with heat pumps or solar energy, as mentioned by Slovakia (SK-d) and Turkey (TR-b).

Additionally, there is the combination of electricity production and heat utilisation from geothermal resources. These are showcases in Italy (IT-g/h) and Slovakia (SK-f).

3.2.2 Electricity production

There is a handful of countries within the ERA-NET geothermal energy with geothermal power plants in operation or under construction. Selected projects include the Soulz III and from France (FR-h), the deep drilling project from Iceland (IS-h), the FORIO and SCARFOGLIO projects from Italy (IT-d/e) and the Svinica-Durkov project in Slovakia (SK-f).

This is not a complete inventory of electricity production projects throughout ERANET Geothermal energy, but rather a “showcase” approach. For an inventory of electricity production, see D2.1 from the ERA-NET Geothermal Energy.

3.2.3 New concepts/ new combinations

The enhanced greenhouse effect challenges the world to convert to a new energy system with a fraction of the current CO\textsubscript{2} emissions. There are several strategies: avoiding formation of CO\textsubscript{2}, re-utilisation of CO\textsubscript{2} from point sources and storage of CO\textsubscript{2} underground. Iceland (IS-i/k) and the Netherlands (NL-e) are both working on projects to explore the potential to join production of geothermal energy to limiting CO\textsubscript{2} emissions, by utilising co-produced CO\textsubscript{2} for mineralisation, conversion to methanol or as a feedstock for algae, or by co-injection of CO\textsubscript{2} in the injection well of a geothermal project.

4 APPENDIXES

Powerpoints, prepared by the partcipant countries.