



Inventory of RD&D project highlights



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Gerdi Breembroek, Paul Ramsak

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Coordination Office, Geothermal ERA NET

Orkustofnun, Grensásvegi 9, 108 Reykjavík

Tel: +-354-569 6000,

Email: os@os.is

Website: <http://www.geothermaleranet.is>

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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 projects¹.

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

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

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

<http://www.forschungsjahrbuch.de/>

Table 2 List of RDD&D projects for Germany

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

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 3 List of RDD&D projects for France

FR-a	CLASTIC-2	3D geomodel of silico-clastic Trias
FR-b	GHEMOD	Tools to understand the origin of geothermal resources in the French overseas islands
FR-c	GEO3BOU	Modeling and monitoring Bouillante geothermal field in French overseas islands
FR-d	GEFRAC3 EXP	Experimental study of fluid/rock interactions in fractures

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

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

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

IS-a	GEORG “Deep roots of Geothermal systems” project	Understanding interaction between magma and geothermal fluids
IS-b	HYDRORIFT	New method for exploration of supercritical geothermal systems

IS-c	Advanced 3D Geophysical Imaging Technologies for Geothermal Resource Characterization	New geophysical exploration and interpretation methodologies
IS-d	Sustainable Yield of Geothermal Resources and Renewability	Ensuring that the renewable energy society can be sustained for the generations to come
IS-e	Properties of two phase flow of water and steam in geothermal reservoirs	Deepen understanding, improve modeling of such geothermal reservoirs
IS-f	Predicting permeability in igneous formations	From igneous rock samples, improve modeling of permeability
IS-g	ThermoMap	Web GIS application, using existing data for shallow geothermal potential (GSHP)
IS-h	Deep Drilling Project	Economic feasibility of producing energy and chemicals from supercritical waters
IS-i	Carbfix	Fix CO ₂ in basaltic bedrock through carbonate formation
IS-j	Carbon Recycling	Makes methanol – transport fuel - from CO ₂ from geothermal waters, and H ₂ from electrolysis
IS-k	Geochem	X00.000 tons/a CO 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 6 List of RDD&D projects for Italy

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

		caldera (under evaluation)
IT-f	Grado District Heating	2 MW district heating project in “cold” sedimentary basins.
IT-g	Monteverdi Marittimo District Heating System	Novel district heating, using steam from power generation.
IT-h	Dairy – Podere Paterno	Dairy plant, using heat coming from a geothermal power plant.

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 fracking 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	CO ₂ injection in aquifers combined with geothermal energy	Co-injection of CO ₂ for CO ₂ 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

SK-a	Applied research and development of innovative drilling technology for ultra-deep geothermal wells	Innovative water jet generating system, based on electric-discharge plasma
SK-b	Robust autonomous mechatronic systems for ultra-deep geothermal wells	Innovative mechatronic systems for ultra deep geothermal wells
SK-c	Geothermal District Heating in Sala	Base-load heat source, single well, 1,6 kton/year CO ₂ reduction,
SK-d	Geothermal District Heating in Sered	Combination deep geothermal and heat pump for district heating. 1,1 kton/year CO ₂ reduction
SK-e	Geothermal District Heating in Galanta	90% heat delivered by geothermal, 7 MW system
SK-f	Geothermal District Heating in Svinica-Durkov	Combination 3,5 MWe and 100 MWt, under construction
SK-g	Geothermal District Heating in Podhajska	10,5 MWt project, only operating Slovak project with reinjection instead of single well.

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

TR-a	Searching for geothermal energy in pilot areas of Turkey	Searching for geothermal energy in pilot areas of Turkey
TR-b	Software for geothermal-solar hybrid system	Software for geothermal-solar hybrid system
TR-c	Traditional food production by utilisation of geothermal energy	Traditional food production by utilisation of geothermal energy
TR-d	Water leakage monitoring at geothermal fluid transport systems	Water leakage monitoring at geothermal fluid transport systems
TR-e	Geothermal energy based food drying oven equipment	Geothermal energy based food drying oven equipment
TR-f	Materials for geothermal wells	Materials for geothermal wells

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 Soultz-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 Soult 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 CO₂ emissions. There are several strategies: avoiding formation of CO₂, re-utilisation of CO₂ from point sources and storage of CO₂ 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 CO₂ emissions, by utilising co-produced CO₂ for mineralisation, conversion to methanol or as a feedstock for algae, or by co-injection of CO₂ in the injection well of a geothermal project.

4 APPENDIXES

Powerpoints, prepared by the participant countries.



Geothermal ERA-NET

Orkugarður - Grensásvegur 9 - 108 Reykjavík - Iceland - Tel. +354 569 6000 - Fax: +354 568 8896
www.geothermaleranet.is, os@os.is