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CORDIS Results Pack on

geothermal energy

A thematic collection of innovative EU-funded research results

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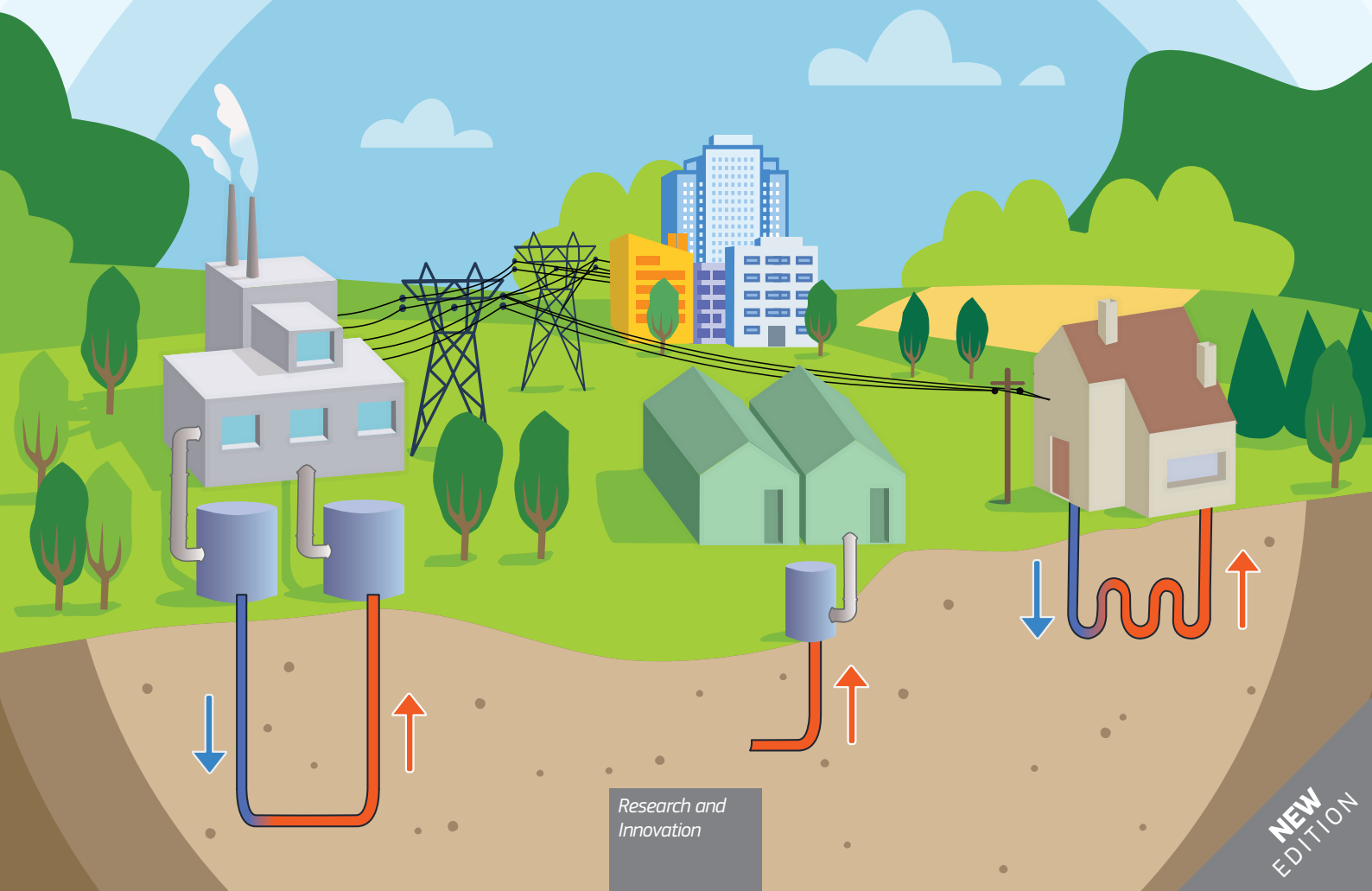
Supporting the development of Europe's geothermal energy sector



Research and Innovation

NEW EDITION

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Editorial

As a virtually unlimited source of renewable energy, geothermal is versatile, reliable and does not depend on weather patterns. As such, geothermal energy is a serious and viable contender to help lever Europe into first place as a carbon-neutral continent by 2050.

Radioactive decay generates continuous searing heat of more than 5 000 °C in the Earth's core. Radiating outwards, the heat warms rocks, water and gas in the geomaterial that makes up our planet. The resulting geysers and hot springs are sources of geothermal energy, but most accumulates as pockets of dry heat that must be accessed by drilling and released as steam by injection of water.

The European Green Deal targets a clean energy transition in which geothermal energy has the potential to play an important role. Geothermal energy is literally local and constantly available, making it an excellent contributor to the renewable energy mix.

Support for Europe's research initiatives to tap the heat beneath our feet

Geothermal is a viable renewable energy source for both heating and baseload electricity.

In May 2022, the European Commission presented the REPowerEU Plan, a roadmap for mitigating energy market disruption in Europe by reducing the dependence on imports of fossil fuels. With the RePowerEU plan, new initiatives and measures to support a faster green transition are being taken.

Geothermal energy will play an important role in this endeavour, as this renewable energy is expected to become integrated more widely in modernised district and communal heating systems. This will further drive innovation of the necessary equipment and processes, that require access to finance to demonstrate the developments in the field.

Ten earth-shaking projects

The 10 projects in this Results Pack demonstrate the European Commission's continued support for research and innovation to expand the geothermal sector. These projects present an overview of the different areas of development and potential solutions for a wider deployment of geothermal heating and power generation.

The operational efficiency of geothermal power plants is determined by the physical and chemical properties of geological fluids. The REFLECT project is studying these, and the GEOPRO project is amassing new data about geological fluid properties.

Environmental concerns for deploying geothermal energy in Europe are being tackled using a toolkit for life cycle impact assessment that highlights projects' benefits, developed by GEOENVI. In the same vein, GEORISK's blueprint will allow geothermal risk mitigation schemes to be established all over Europe in an approach tailored to national or EU level.

Aiming to reduce greenhouse gas emissions, the GECO project is developing a holistic solution for emission gas management in geothermal power plants.

Drilling is often the most capital-intensive part of project development, but innovations in drilling systems developed by Geo-Drill promise to decrease drilling costs. The space for the development of a drilling site is also an issue in many cities, particularly for Europe's historic buildings. The GEO4CIVHIC project has tailored geothermal solutions enabling operation in an urban environment.

Where geothermal sites already exist, MEET is maximising the use of installations and prospecting for resources in geological structures that are currently underexploited.

Collaboration is the key action of GEOTHERMICA, accelerating geothermal energy deployment whereby transnational projects receive both national funding topped up with Horizon 2020 financial support. Projects promote innovation, cooperation and synergy. The SU-DG-IWG project is coordinating European research efforts to accelerate geothermal uptake.

Study of fluid properties boosts geothermal's potential

For all its incredible promise, some aspects of geothermal energy present technical challenges: the hot fluid's extreme properties could impair power plant performance. An improved database on fluid properties will help to tackle these challenges.

Deep down, beneath our feet, there is a natural source of energy. Geothermal power plants use hot fluids from deep underground reservoirs. After being pumped to the surface, the fluid is either used directly to spin a turbine or it passes through a heat exchanger, where it releases heat to a transfer fluid, which then spins a turbine. The latter is connected to a generator to produce electricity.

"As pressure and temperature change, the fluid from the reservoir undergoes chemical or physical processes that alter the composition or characteristics of the fluid. This can cause mineral precipitation and thus clogging of pipes, corrosion of plant components or degassing, which negatively affect power plant operation and overall project economics," explains Simona Regenspurg, coordinator of the EU-funded REFLECT project.

Current model predictions suffer from numerous uncertainties because carrying out in situ fluid sampling and measurements at extreme conditions (i.e. in the presence of extremely hot or saline fluids) poses a great challenge for both equipment and analytical procedures.

Rising to the challenges of geothermal energy extraction

REFLECT chose to address the problem at its source by collecting high-quality chemical, physical and microbiological data at extreme salinity levels, pressures and temperatures from field measurements. Laboratory experiments and predictive models helped improve understanding of precipitation, corrosion and degassing processes.

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"Project partners have collected data from more than 3 000 fluid samples from geothermal sites within their countries or from literature research from freely accessible sources. We also collected 80 fluid samples from selected sites over the course of the project," notes Katrin Kieling, the manager of the project.

Project partners have collected data from more than 3 000 fluid samples from geothermal sites within their countries or from literature research from freely accessible sources.

All collected data served as input in the European Geothermal Fluid Atlas, a database that collates geothermal data including geographical, geological, depth range, physical, chemical and microbial properties of fluids. The data was also fed into predictive models that can serve as a guide on the optimal operation of geothermal systems. Filtering geothermal fluid

for microbiological analysis during sampling in the Bad Blumau geothermal site, Austria, is featured in the photo above.

"The Geothermal Fluid Atlas is the first collection of physical and chemical fluid data of geothermal wells across Europe. It facilitates the selection of new potential geothermal locations and enables effective design and layout of new geothermal power plants," remarks Regenspurg.

Better data through experiments and innovation

REFLECT researchers performed an extensive review of organic compounds and microbial life in deep geothermal fluids. The data could help better predict how microbial activity affects power plant operation. For example, microbes could induce mineral precipitation, thereby decreasing the plant's performance.

Researchers also developed the open-source software package porousMedia4Foam for simulating hydro-geochemical processes across scales. Geochemistry is handled by PHREEQC and coupled to the flow and transport solver of OpenFOAM®. The package has been fine-tuned to model the nature of fluid flow in geothermal production wells.

Many experiments were conducted in the laboratory. For example, CO_2 degassing experiments were carried out to determine the bubble point pressure and the bubble formation rate at various salinities and temperatures. Knowledge of these parameters is key to preventing the blocking of pathways in geothermal reservoirs.

To further improve data collection in the future, researchers developed a downhole sampling technique, which will significantly expand the range temperature and pressure conditions for sampling of hot and super-hot wells, thus enabling a more sustainable layout of installations for super-hot geothermal systems.

Recommendations for preventing problems before they arise

"REFLECT outcomes will have a major impact on the operational efficiency, project economics and viability of geothermal power plants," notes Regenspurg. "By redefining geothermal fluid properties and their geochemical reaction constants over a large range of salinity levels and temperatures, a huge knowledge gap will be closed, leading to more reliable predictions of geothermal power plant performances."

PROJECT

REFLECT – Redefining geothermal fluid properties at extreme conditions to optimize future geothermal energy extraction

COORDINATED BY

Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences in Germany

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/850626

New tools accurately predict properties of geological fluids

Operational efficiency is key to efficient system operations in geothermal power plants. EU researchers provide data on the heat-transfer behaviour of super-hot fluids to maximise the value of thermal energy.

Rigorous thermodynamic models are crucial to understanding the physical and chemical properties of geological fluids – hot groundwaters that circulate within the Earth's crust. However, geothermal power plants lack high-precision models that can be used to plan and test the efficiency of system operations. As a result, operators often resort to empirical in situ trials.

Modelling geological fluid characteristics

The EU-funded GEOPRO project has brought together 12 partners from seven countries to collect new data about geological fluid properties to better understand and improve operational problems in geothermal power plants.

"The physical and chemical properties of geothermal fluids are key to determining their heat-carrying potential over the lifetime of the well. Enhanced understanding of the fluid properties allows optimising site developments and operation," notes project coordinator Namrata Kale. "Furthermore, the development of novel geothermal technologies, namely enhanced geothermal systems and supercritical systems, is intimately tied to the properties of the reservoir fluids."

Now, two and a half years since the project began, GEOPRO is confident that its objectives will be reached. Researchers

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have been working on the development of a multiphase flow loop (laboratory instrument for investigating the fluid flow characteristics in pipes) and the generation of new accurate thermodynamic and kinetic data for geological fluids. Furthermore, the team has been working on new models that allow the prediction of complex solutions of CO_2 and multicomponent mineral salts.

"All this data served as input in the design of a set of new user-friendly, flexible decision-support tools that should allow optimisation of geothermal reservoir management, power and heat production, and reinjection strategies," notes Kale.

GEOPRO impact

Scale formation such as silica and calcium carbonate scaling, which occurs within boreholes, surface pipes and equipment, has serious economic consequences. It could cause energy and production losses, increase cleaning and other maintenance costs, or even lead to the shutdown of production/reinjection wells. Improved equations of state along with flow assurance simulations (which ensure that pipes do not clog up) and tests are expected to aid in predictive modelling of the causes of scaling.

Local corrosion phenomena caused by CO_2 outgassing can negatively affect the structural integrity and the service life of the pipes and equipment of geothermal power plants. Feeding CO_2 solubility models and equations of state for fluids containing H_2O, salt and CO_2 into flow assurance simulations will enable researchers to better assess the causes of outgassing and optimise pressure/outgassing control.

"Geothermal simulations coupled with knowledge-based decision-support tools can be used by geoscientists to help operators optimise well layout, pipe dimensions and coatings, and reduce maintenance costs," says Kale.

The use of the GEOPRO tools will optimise the production and exploitation of geothermal wells and enhance the operational efficiency of geothermal power plants, establishing geothermal energy as a secure and sustainable energy source.

GEOPRO's new models and tools will contribute to rendering geothermal energy generation more accessible and affordable. They should help reduce scaling formation and reinjection temperature, control CO_2 outgassing, slow material degradation, increase energy production and exploit super-hot resources (with temperatures up to 440 °C). Taken together, these will result in reduction of capital costs from equipment oversizing, pumping costs and equipment costs related to corrosion. There will be a corresponding increase in enthalpy extraction and efficiency in power generation.

In addition, the knowledge generated by GEOPRO will contribute to achieving Europe's new 2030 climate targets. The capacity factor of geothermal power exceeds 95 %. The use of the GEOPRO tools will optimise the production and exploitation of geothermal wells and enhance the operational efficiency of geothermal power plants, establishing geothermal energy as a secure and sustainable energy resource.

PROJECT
GEOPRO – Accurate Geofluid Properties as key to Geothermal Process Optimisation

COORDINATED BY
TWI Limited in the United Kingdom

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/851816

Toolbox counters geothermal energy's negative perception by focusing on potential

A toolkit for environmental life-cycle impact assessment addresses European concerns over risks of deep geothermal energy, highlighting its potential and benefits.

From buildings to greenhouses, geothermal energy is used to generate electricity and for heating and cooling.

As a virtually unlimited source of renewable energy that can be produced almost anywhere and is available 24/7, it is one of the most versatile and reliable renewable energy sources.

The EU reaps the benefits of this energy source, boasting the fourth largest geothermal power and heat capacity worldwide – enough to power about 2 million homes.

Geothermal energy has a bit of a bad green reputation

But some citizens are opposed to deep geothermal energy production, mainly due to reservations about its environmental impact. For example, some of the extraction systems can raise environmental concerns, such as greenhouse gas emissions. The negative perception of geothermal energy production may hold back its market uptake.

The EU-funded GEOENVI project delivered a variety of solutions to address concerns about the environment, in terms of both impacts and risks.

"Dealing properly with environmental issues is a prerequisite for deploying deep geothermal resources," stresses project coordinator Philippe Dumas, secretary general of the European Geothermal Energy Council. "The best way to assess potential environmental impacts is by doing a life-cycle assessment (LCA), but methods to perform this analysis can vary widely, take a long time and are not tailored to energy systems."

The best way to assess potential environmental impacts is by doing a life-cycle assessment (LCA), but methods to perform this analysis can vary widely, take a long time and are not tailored to energy systems.

Life-cycle assessment tools for all situations

With a focus on Belgium, France, Hungary, Iceland, Italy and Turkey, the GEOENVI team developed an LCA method that assesses the environmental impacts of deep geothermal energy plants already operating or under construction.

The tool assists geothermal developers to evaluate the environmental performance of their planned project: they can quickly measure the resulting benefits. Such a reliable estimate of a given project's environmental impact can be used to support documents required by developers, like environmental impact assessments.

To help developers with little or no experience in LCA, GEOENVI has produced several new simplified models.

It is impractical for developers to carry out a full LCA of their geothermal project before investing because the project's

© GEOENVI

actual parameters are usually only known after the first well has been drilled. The simplified LCA tool helps developers evaluate the impact of their investments before construction, based on the best scientific knowledge available. It allows the life-cycle impact of different geothermal technologies, like power plants or district heating and cooling projects, to be estimated across a broad range of environmental aspects.

Decision-makers and key geothermal market actors will benefit from the project's practical recommendations explaining how to harmonise environmental regulations throughout Europe.

Bringing deep geothermal energy to the mainstream

GEOENVI's extensive dissemination and communication activities have boosted awareness of LCA in the geothermal sector. These efforts were also key to communicating geothermal projects and their benefits. They reached a diverse audience of over 150 000, including stakeholders in the scientific community and industry as well as policymakers and the general public.

The project's work is contributing to the REPowerEU Plan and the 2030 climate and energy framework, in support of the European Green Deal's plan to make the continent climate neutral by 2050.

PROJECT
GEOENVI – Tackling the environmental concerns for deploying geothermal energy in Europe

COORDINATED BY
European Geothermal Energy Council in Belgium

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/818242

Lowering the risk of investing in geothermal energy

The heat from the Earth's core can be exploited to generate electricity. Mitigating the risks of exploring different geothermal resources will protect prospective developers, including cities developing district heating systems.

Production of geothermal energy is associated with technical and economic risks. For example, there is the possibility of not finding, after drilling, the financially sustainable geothermal resource expected. Alternatively, the resource may be naturally depleted, thereby rendering its exploitation economically unprofitable after some years.

Exploring the subsurface is necessary to characterise the capacity for a specific region to serve as a geothermal energy resource. The resource risk often prohibits the development of geothermal projects across Europe due to the high cost and low funding availability for this development phase.

Integrated European efforts towards geothermal risk mitigation

The EU-funded GEORISK project proposed to record the risks associated with geothermal project development so as to attract investments for private capital. The project was led by the European Geothermal Energy Council (EGEC) and brought together key stakeholders involved in deep geothermal projects for power and/or heat. These include geothermal associations, companies, public entities involved in risk mitigation, such as geological surveys, and institutions involved in geological and geothermal activities, energy, and funding public institutions.

GEORISK focused on key countries in Europe with different deep geothermal potential, geological settings and market maturity. France, Germany and Turkey have rather mature markets for geothermal power or district heating plants, while the markets of Greece, Hungary, Poland and Switzerland are in a transitionary phase.

© EGEC

An online GEORISK tool

Partners generated a risk register that includes six categories of risk: external hazard risks due to natural or anthropogenic factors, risks due to uncertainties in the external context, risks due to internal deficiencies, risks due to subsurface uncertainties, technical issues, and environmental risks. The register can be downloaded as a spreadsheet alongside assessment information on the importance of each risk.

"GEORISK covered all the plausible risks faced by developers of geothermal projects as well as mitigation measures," explains Philippe Dumas. The overview of associated risks helped project developers and market actors analyse financial and risk insurance schemes for risk mitigation and compare directly geothermal sources versus other renewable energy sources.

Our blueprint will allow geothermal risk mitigation schemes to be established in a tailored approach at national or EU level.

Risk mitigation schemes

The new EU Renewable energy directive proposes the implementation of risk mitigation frameworks to reduce the cost of capital for renewable heating and cooling projects. GEORISK helped partner countries establish sustainable risk mitigation and insurance schemes covering geothermal resource and technical risks.

Switzerland proposed a supplementary risk guarantee to complement the existing financial grants, while Germany will launch a new funding scheme for renewable heat networks with 40 % subsidies. France introduced a new risk mitigation scheme alongside an export fund, and Turkey launched two funding calls for geothermal energy projects. Poland proposed to include a risk insurance fund in its geothermal roadmap by 2040, while Hungary generated a geothermal platform with access to geological data for project development. Greece has submitted a proposal to the Ministry of Environment and Energy.

The experience acquired during GEORISK was replicated in other European target countries (Belgium, Croatia, Denmark, the Netherlands, Slovenia) and outside Europe (Canada, Chile, Kenya, Mexico). Regarding the future, Dumas emphasises: "Our blueprint will allow geothermal risk mitigation schemes to be established all over Europe in a tailored approach at national or EU level."

PROJECT
GEORISK – Developing geothermal and renewable energy projects by mitigating their risks

COORDINATED BY
European Geothermal Energy Council in Belgium

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/818232

The next big thing in the geothermal power industry

The most comprehensive up-to-date approach to tackle geothermal production emissions brings us one step closer to a low-carbon economy.

Although geothermal development and power generation are relatively clean, geothermal power plants remain a substantial source of sulfur dioxide, CO_2 and hydrogen sulfide (H_2S) emissions. Building upon the success of the recently completed CarbFix project, the EU-funded GECO initiative introduces a holistic solution for emission gas management in the geothermal industry.

Emissions reduced, captured, stored and transformed

GECO is implementing a promising technology for CO_2 mineral sequestration that enables reduction of CO_2 emissions from geothermal power plants in an enduring and secure way. Its aim is to capture the gases by dissolving them in water from the power plants and inject the gas-charged water back into the geothermal reservoir, where they are mineralised.

The team has created new and more accurate modelling tools to predict the reactions that occur in the subsurface in response to induced fluid flow.

The feasibility of gas capture for reuse was based on second-stage cleaning of the gas stream, through amine gas treatment and burn and scrub processes. This produces a CO_2 stream with H_2S levels below 1 ppm.

© Arni Saeberg

The results: a more cost-competitive geothermal energy with low environmental risk, an optimised production process, and a 'how-to' guide for commercialising the by-products of the stored emissions – ideal materials to be used in the construction materials sector.

Making the most out of the challenge

The GECO approach was designed to be applied in four distinct reservoirs in different European countries: a high-temperature basaltic reservoir in Iceland, a high-temperature gneiss reservoir in Italy, a high-temperature metamorphic reservoir in Turkey, and a low-temperature sedimentary reservoir in Germany.

A stone's throw from quality control and market launch

The project's high multidisciplinarity, with 18 partners across Europe and diverse expert teams, seems to have been the secret to its success.

The partners' high collaborative spirit and resilience throughout the challenges and their openness to share knowledge within and outside the consortium were key elements for the progress of GECO.

"The partners' high collaborative spirit and resilience throughout the challenges and their openness to share knowledge within and outside the consortium were key elements for the progress of GECO," says the project's communications officer and manager Amel Barich.

This year the GECO team are starting the demonstration campaigns at the designated sites. "It is an important year for the project where we will test the solutions developed over the past few years," explains Barich. "We are also tackling the business aspect by developing the exploitation strategy of the results and creating a business case for GECO."

PROJECT
GECO - Geothermal Emission Control

COORDINATED BY
ORKUVEITA REYKJAVIKUR SF in Iceland

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/818169

Holistic technology cuts the cost of geothermal drilling

The cost of deep geothermal drilling is spiking. New optimised equipment and technologies are set to drastically slash overall costs.

Geothermal energy is a low-carbon resource that could meet the heating, cooling and electricity demands of the future. Despite its potential, geothermal energy is prevented from making a bigger impact due to the perceived costs associated with drilling operations and its long development cycle.

"The process of geothermal drilling itself is capital intensive, often accounting for up to 50 % of total costs for a planned geothermal project. Associated costs are exponentially higher in enhanced geothermal systems (EGSs) owing to increased drilling distances, tripping times and harsh environments," explains Namrata Kale, coordinator of the EU-funded Geo-Drill project.

EGS technology is a process used to enhance permeability in geological formations, by increasing fracture networks and fluid pathways, allowing injected water to be heated naturally, as it passes through the fractures.

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A reliable, low-cost down-the-hole hammer

Geo-Drill developed a down-the-hole (DTH) hammer that operates with an innovative valve system that is more durable and has longer-lasting performance. Unlike traditional fluid hammers, Geo-Drill's DTH hammer is driven by bistable fluidic oscillators that allow much greater tolerances in the percussion mechanism. "Our new hammer demonstrates increased reliability, overcoming a number of issues associated with conventional air/fluid hammers, through the reduction of internal parts subject to high rates of wear/failure," remarks Kale.

Improved monitoring sensors and material engineering

Researchers developed robust, low-cost 3D-printed sensors that provide real-time data on drilling operations – e.g. bit/rock interaction, impact energy and blow frequencies. Flow assurance simulations combined with the sensor readings and a knowledge-based system aid in the optimisation of drilling parameters and of the cuttings transport performance.

The development of graphene coatings added to the overall improvement and lifetime of the drill components, giving them enhanced substrate adhesion and dispersion properties and improved resistance to abrasion, erosion, corrosion and impact.

Rigorous testing of technologies

Technologies developed throughout the course of Geo-Drill were subjected to full-scale laboratory testing under realistic reservoir conditions using the in situ Borehole and Geofluid Simulator at the International Geothermal Centre in Germany.

"We have developed a holistic technology that offers a safe, economic and efficient methodology for high-performance geothermal drilling. The project's overall goal is to reduce drilling costs by up to 60 %," notes Kale.

"Unlike most drilling systems, our holistic approach to in-hole tooling simplifies the procurement/logistics aspects for both developers and contractors. Ensuring that all equipment shipped to a drill site is fully compatible is a major bonus, resulting in reduced operational times," concludes Kale.

We have developed a holistic technology that offers a safe, economic and efficient methodology for high-performance geothermal drilling.

PROJECT
Geo-Drill - Development of novel and cost-effective drilling technology for Geothermal Systems

COORDINATED BY
TWI Limited in the United Kingdom

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/815319

Mobilising the heat below our feet to energise historic buildings

Europe has a wealth of historic buildings that need an energy retrofit. Special innovations to extract geothermal heat mean this totally fossil fuel-free energy resource can do the job.

Shallow geothermal heating and cooling systems are beginning to look more like attractive contenders for upgrading Europe's ageing building stock. EU initiatives, including the Renovation Wave, and policy measures such as the revision of the Energy Performance of Buildings Directive are spearheading this change.

However, historic buildings have their own restrictions limiting them from using this completely renewable energy source. The EU-funded GEO4CIVHIC project has developed and modified existing technologies to accelerate the deployment of shallow geothermal heating and cooling in such buildings located in built-up areas.

"On average, a geothermal system can supply 4 kW of thermal energy to the building by using 1 kW of electrical energy and extracting 3 kW of free energy from underground," notes Adriana Bernardi, project coordinator, physicist, research director and head of the National Research Council's Institute of Atmospheric Sciences and Climate, Padua, Italy.

Drilling and operating in a restricted space

A borehole heat exchanger coupled to a heat pump extracts the Earth's inexhaustible heat and supplies this energy to the emission units or radiators. Heat exchangers extract energy from the soil up to 8 °C, and the heat pump 'lifts' this energy to temperatures of up to 50 °C to supply the heating system. In summer, the heat pump reverses and draws heat from the building, recharging the soil.

"Radically new approaches to drilling the borehole, heat pump efficiency and types of refrigerants used are required," Bernardi explains.

Radically new approaches to drilling the borehole, heat pump efficiency and types of refrigerants used are required.

The historic city of Mechelen in Belgium boasts some 300 listed buildings. GEO4CIVHIC developed a compact and reduced-weight drill rig with a very small footprint that could be hoisted into gardens with a crane around these quaint narrow streets.

GEO4CIVHIC optimised and installed several co-axial steel heat exchangers with up to 20-30 % higher energy extraction rates, reducing the total length of heat exchangers needed. These heat exchangers were patented in the Cheap-GSHPs Horizon 2020 project.

Variations across the demo sites Europe-wide

Three pilot and four demonstration sites show the extent of GEO4CIVHIC's success across a range of rocks in the Earth's crust and different building designs.

Five heat pump solutions were developed to cope with low efficiency due to high-temperature emission systems. Compact plug-and-play heat pumps were integrated into the test facilities at the University of Padua and at Tecnalia, Bilbao, Spain, to develop energy management apps.

© Adriana Bernardi

Bernardi points out: "These developments include the use of new refrigerants with low global warming potential to respond to the upcoming legislation."

For drilling in hard rock, GEO4CIVHIC developed a compact, powerful roto-vibrating drill head. In Ireland, the demo case at Greystones is on compacted rock, so the team used compressed air as the drilling fluid, whereas in softer rock on Malta, at the Msida Bastion Historic Garden, water was used.

The future for geothermal energy

GEO4CIVHIC comprehensive drillability maps will characterise sites according to geological properties, complete with duration and costs. "For integration of geothermal plants with other renewable sources, we are developing a decision-support system. This will help users improve overall energy efficiency and accelerate the return on investment," Bernardi emphasises.

Bernardi's vision for Europe's historic building stock involves "demonstrating to all stakeholders the long-term economic returns of shallow geothermal heating and cooling. Activities we plan for training, guidelines and workshops will contribute to increasing the awareness and confidence in this technology amongst the stakeholders," she concludes.

PROJECT
GEO4CIVHIC – Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings

COORDINATED BY
The National Research Council in Italy

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/792355

Awakening the sleeping giant of geothermal energy

Rising energy costs and dependence on fossil fuels necessitate cleaner alternatives. MEET explored different geological environments as unconventional reservoirs of geothermal energy.

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Geothermal energy is a renewable and untapped source of natural energy that comes from the Earth's subsurface. Despite its many advantages, exploitation has not reached maximum potential. The main reasons are related to the risks and upfront costs associated with exploration and drilling for reservoirs.

Exploiting enhanced geothermal systems for unlimited power and heat generation

To address this challenge, the EU-funded MEET project proposed to exploit deep reservoirs and enhanced geothermal systems (EGSs) as a more cost-effective approach. EGSs are geothermal reservoirs made more available through hydraulic, chemical and/or thermal well stimulation. This reactivates natural fractures that are initially poorly permeable as viable reservoirs. The produced water is then used at the surface for power generation and/or heat application.

"The mission of MEET was to demonstrate that it is feasible and financially viable to generate electric and thermal power from EGSs and deep reservoirs in different geological settings," explains Albert Genter, project coordinator and deputy general manager at ÉS-Géothermie. Researchers explored the potential of sedimentary (oil fields), volcanic, granitic and metamorphic environments by taking advantage of various sites in Europe and other parts of the world.

Generating EGSs in different geological settings

The consortium was interested in testing mature or abandoned oil wells for their potential as geothermal reservoirs. Using existing oil wells whose production has peaked was shown to significantly reduce costs of new drilling for geothermal energy exploitation.

Researchers also explored the possibility of using technologies based on organic compounds as a working fluid, a process known as the organic Rankine cycle. Implementation of this process at two sites in Iceland showed the potential to convert low-flow and/or low-temperature heat to power in volcanic environments.

Fieldwork in the Ardennes in Belgium and in the Harz mountains in Germany allowed the characterisation of the permeability of the metamorphic basement and demonstrated its potential to serve as an EGS site.

In EGS plants in granitic settings, the team demonstrated that lower-temperature water reinjection could valorise up to 45 % of additional heat. In addition, innovative chemical treatment of granitic reservoirs in Cornwall in the United Kingdom is under development to improve production.

There is still a lot of room for manoeuvre to exploit deep geothermal energy, by maximising the use of existing installations and by seeking resources in geological structures that are currently underexploited.

Tools to support deep geothermal energy projects

According to Genter: "There is still a lot of room for manoeuvre to exploit deep geothermal energy, by maximising the use of existing installations and by seeking resources in geological structures that are currently underexploited."

MEET generated a map viewer as a one-stop solution for future projects of deep geothermal exploration. In addition, the Decision Making Support Tool for Optimal Usage of Geothermal Energy (DMS-TOUGE) was developed as an open-access stand-alone application to estimate different important economic indices for a defined geothermal scenario and provide multicriteria decision-making analysis.

Currently, the main focus of the project is on promoting and disseminating results about the value of different geological structures in geothermal energy production. Activities include articles published in a special issue of the *Geosciences* journal as well as various events organised by the geothermal community. The consortium also established exploitation plans, including a market analysis and identified key actors who will help implement MEET results and move geothermal energy exploitation forward.

PROJECT
MEET - Multidisciplinary and multi-context demonstration of EGS exploration and Exploitation Techniques and potentials

COORDINATED BY
ÉS-Géothermie in France

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/792037

Research and innovation bringing geothermal technology closer to market

Networking, know-how and financial resources are a winning combination in speeding up the deployment of geothermal energy in Europe.

Geothermal energy is only used in a few market sectors and regions, despite the fact that it is a widely distributed, clean and continuously available energy resource. These benefits make it uniquely positioned to contribute towards Europe's transition to secure, clean and efficient energy.

The EU-funded GEOTHERMICA project is accelerating geothermal energy deployment by promoting research projects, innovation and collaboration. It exchanges information, knowledge and good practices related to geothermal energy research and innovation (R&I) policies between national and regional funding

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bodies. "In doing so, geothermal energy will be able to fulfil its true potential for a climate-neutral Europe," comments Alicja Wiktoria Stokłosa, a geothermal energy expert who works as an office manager for GEOTHERMICA.

Joining forces to finance innovation in geothermal energy

The project began by identifying national and regional barriers to and opportunities for developing geothermal energy, as well as national and regional R&D needs. This has resulted in clusters, or common areas of interest, and cooperation partnerships.

Countries can quickly find others with similar needs, or countries that have already reached the next level in developing geothermal energy and are attractive partners to learn from. The results fed into strategic recommendations on short- and medium-term priorities in R&I.

Mobilising knowledge networks on geothermal energy

The consortium is pooling the resources and know-how of 20 geothermal energy R&I programme owners and managers from 18 EU Member States and Associated Countries. Acting as a collaboration platform for R&I funding organisations, the network makes funds available for R&I actions related to geothermal energy. "The support has provided countries with less developed geothermal sectors invaluable access to the skills and experience of peers and colleagues," adds Stokłosa.

This extensive network has made much progress in key areas of policy, regulations and decision-making. Through joint calls, it has developed and implemented a strategy to build a durable and long-lasting European R&I cooperative to expand geothermal energy use.

Financial resources to commercialise cutting-edge geothermal energy solutions

EUR 90 million has been made available for three calls for innovative projects. The network funds about half of this amount. Each call involves between 12 and 18 geothermal energy R&I programme owners and managers. All the calls emphasise the need for research projects that significantly contribute to making the climate transition a reality.

Two of the three joint calls have been completed with strong participation from industry. As of June 2022, 15 high-quality, transnational projects have demonstrated and validated novel concepts for geothermal energy use within the energy system and identified commercial opportunities. They covered all stages in the development cycle of secure, sustainable, competitive and affordable geothermal installations.

The third joint call was launched in 2021 to accelerate the heating and cooling transition. It will bring together national programmes to integrate the energy system and programmes to advance the various heating and/or cooling technologies, with a strong focus on geothermal energy. The funded projects will start in September 2022 and end within 3 years.

End users will benefit from more secure, sustainable, competitive and affordable energy.

"Outcomes are leading to cost reductions, improved safety and better possibilities to carry out geothermal energy projects," concludes Stokłosa. "End users will benefit from more secure, sustainable, competitive and affordable energy."

PROJECT
GEOTHERMICA – ERA NET Cofund Geothermal

COORDINATED BY
National Energy Authority in Iceland

FUNDED UNDER
H2020

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Strengthening the coordination of geothermal energy initiatives

Strategic research is accelerating climate-neutral geothermal energy initiatives to meet Europe's energy demands locally and sustainably.

The Earth continuously generates heat, or geothermal energy. Harnessing this sustainable distributed energy supply that can be both 'extracted' and used locally will yield a climate-neutral and independent energy supply for Europe.

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The EU-funded SU-DG-IWG project is providing instrumental support to the Geothermal Implementation Working Group (IWG) in the context of Europe's Strategic Energy Technology Plan (SET Plan).

Mobilised community collaboration drives progress

The Geothermal IWG is a strategic platform bringing together EU Member States, researchers and the geothermal industry, coordinating their efforts to accelerate geothermal uptake. The SU-DG-IWG provided administrative assistance, synergies and strategy support, and information and data to support decision-making and implementation.

However, perhaps the most exciting project outcomes – and those surpassing the original goals – were achieved in the mobilisation of the geothermal community. "The fact that geothermal is still a niche in many European countries makes knowledge sharing and nurturing of nascent geothermal projects essential. One of the hallmarks of geothermal development in Europe is how much it has been driven by voluntary partnerships and collaboration. There are now many flourishing collaborations, with GEOTHERMICA and the Transition Initiative IV of the European Clean Energy Transition Partnership among the most prominent," explains Steinar Jonsson, legal and policy advisor at geothermal research cluster GEORG and SU-DG-IWG project partner.

Compelling messaging raises geothermal's profile

Despite its clear capability for heating and cooling, geothermal energy has traditionally been associated with electricity production. Further, the lines between 'deep' and 'shallow' geothermal have become increasingly blurred by recent technological advances, resulting in legislative issues in many European countries.

The SU-DG-IWG project has been instrumental in increasing the clarity of messaging to foster public and private support. Since October 2021, the Deep Geothermal IWG has been rebranded as the Geothermal IWG, endorsed by the SET Plan Secretariat.

The Geothermal IWG has formally adopted the designation of four key geothermal areas: heating and cooling, power production, thermal storage and geothermal minerals, which has helped structure the research domain and identify priorities within the SET Plan.

"We have succeeded, in close collaboration with our partners in GEOTHERMICA, in putting geothermal on the map in Europe. The overall awareness of geothermal and its potential has grown immensely in the past few years. The SU-DG-IWG and the Geothermal IWG have, without a doubt, been part of that transformation," Jonsson concludes.

We have succeeded ... in putting geothermal on the map in Europe.

PROJECT
SU-DG-IWG – Support Unit for the Deep Geothermal Implementation Working Group

COORDINATED BY
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CINEA – Horizon project manager

All projects featured in this Results Pack are managed by CINEA, the European Climate, Infrastructure and Environment Executive Agency, established by the European Commission under the motto 'Funding a Green Future for Europe'. CINEA contributes to the European Green Deal by implementing parts of EU funding programmes for transport, energy, climate action, environment, and maritime fisheries and aquaculture. CINEA now manages the Connecting Europe Facility 2 (Transport and Energy), the Climate, Energy and Mobility Cluster of Horizon Europe, the LIFE programme, the Innovation Fund, the European Maritime, Fisheries and Aquaculture Fund, the Renewable Energy Financing Mechanism and the Public Sector Loan Facility under the Just Transition Mechanism and seeks to promote synergies between the programmes in order to benefit EU citizens and promote economic growth.

CINEA also implements two societal challenges of the Horizon 2020 programme: Secure, clean and efficient energy, and Smart, green and integrated transport. CINEA provides technical and financial management services at all stages of the programme and project life cycle – from the calls for proposals, evaluation of projects and the award of financial support, to the follow-up of project implementation and control of the use of funds allocated.

CINEA provides visibility for EU funding opportunities and project results – and supports potential applicants and beneficiaries, allowing them to benefit from the Agency's long-standing experience of programme implementation with a high level of performance.

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