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CORDIS Results Pack on

geothermal energy

A thematic collection of innovative EU-funded research results

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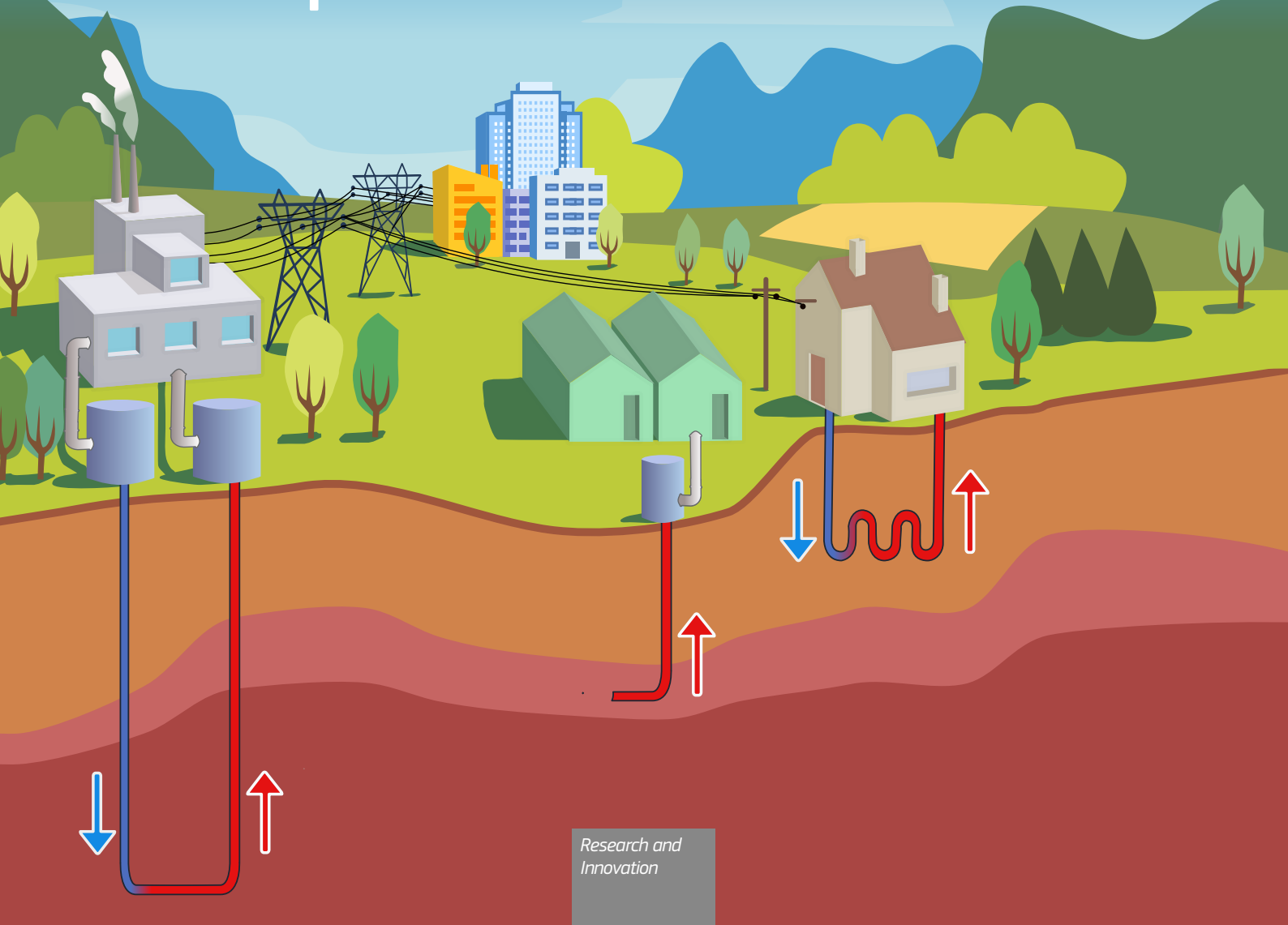
A new and viable alternative energy source to help achieve Europe's climate ambitions



Research and Innovation

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Editorial

A new and viable alternative energy source to help achieve Europe's climate ambitions

In the ongoing quest to combat climate change, new forms of carbon-neutral, environmentally friendly energy sources are being prioritised by the European Commission, especially following the unveiling of its Green Deal initiative. Geothermal energy is one such promising avenue, and in this CORDIS Results Pack we showcase the very latest innovative EU-funded research on both deep and shallow geothermal energy that will allow for a faster, wider and more efficient roll-out of this potentially game-changing alternative energy source.

Geothermal energy is a local source of energy that can cost-effectively provide baseload or dispatchable electricity, heat or a combination of both. It has already been used for thousands of years by humans (for example, bathing in hot springs and room heating in ancient Roman times) and today has the potential to provide a real alternative to conventional fossil fuel power plants and heating systems emitting considerable quantities of greenhouse gases. This would be not only in Europe but also globally, in particular developing countries. In addition to simply producing energy, geothermal reservoirs may also act as energy and CO_2 storage sites, providing another major benefit of the technology.

A strong policy framework

The European Commission fully supports research and development in geothermal technologies, funding research projects through its Horizon 2020 programme on both the direct use of heat and the use of extracted heat for electricity generation focussing on cost reductions and improved performance.

Historically, the funding levels for this form of renewable energy have been particularly low when compared to alternatives, such as wind, solar and biomass, but it has recently increased. For example, the EU's Innovation & Networks Executive Agency (INEA), which manages almost all of the projects in this specific Results Pack, has a total budget of EUR 172 million allocated towards geothermal energy.

Now, following the announcement of the Commission's dedicated Green Deal, where the Commission has set the ambition for Europe to become the first carbon-neutral continent by 2050, the impetus to further develop and eventually deploy geothermal technologies as a viable and serious contender as part of the EU's energy mix will only increase further.

Twelve truly trailblazing projects

In this Results Pack, we feature 11 full CORDIS Results in Brief articles on the most recent EU-funded geothermal energy projects, plus a short introduction to a still ongoing but very promising initiative, GEOTHERMICA. These 12 projects cover the full spectrum of geothermal energy research and provide a holistic overview of what the key priorities are for further development and investment in these technologies so they become a vital source of alternative energy for Europe.

Warming up to promising sustainable heating and cooling technology

European buildings are sitting on a gold mine – geothermal energy. Now, major cost reductions in technology together with decision support for experts and novices alike should encourage uptake with important benefits for the environment.

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Heating and cooling accounts for about half of the EU's overall energy consumption. About 75 % of that is still supplied by fossil fuels. Clearly, enhancing the sustainability of heating and cooling could significantly reduce greenhouse gas emissions and mitigate climate change.

The ground underneath buildings can provide heat in the winter and cooling in the summers. However, widespread adoption of geothermal heating and cooling has faced economic and technical challenges. The EU-funded Cheap-GSHPs project has overcome these barriers and simultaneously delivered a freely

available decision support tool to help prospective users evaluate options.

Technological advances lower cost and enhance utility

According to project coordinator Adriana Bernardi: "Cheap-GSHPs targeted a 20-30 % reduction in total cost through improved design and installation of more efficient and safe shallow geothermal systems." The team developed helicoidal ground source heat exchangers (GSHEs) with a smaller external diameter of the heat basket to facilitate drilling at greater depths. They complemented the design with a modified dry drilling methodology. Cheap-GSHPs also designed coaxial steel GSHEs and improved existing vertical borehole installation technology, the latter of which resulted in a patent application. Multiple pilots of both technologies across Europe demonstrated increases in thermal energy exchange of 20-40 % when compared to the state of the art.

Cheap-GSHPs has now made shallow geothermal energy solutions more affordable in soil regions with high drilling costs thanks to an investment cost reduction of 20-30 %.

A novel heat pump using CO_2 as a refrigerant for high-temperature terminals and piping was developed and a patent application submitted. It eliminates the need to replace conventional radiators and piping to accommodate the lower temperatures of typical GSHE heat pumps. Installed under the supervision of UNESCO in the Nikola Tesla Technical Museum, Zagreb, the heat pump will significantly reduce the costs for retrofitting buildings, particularly historical and cultural ones.

Equally accessible to novices and experts

Software and modelling tools developed to aid in design optimisation were also critical components of Cheap-GSHPs' decision support system (DSS). The DSS represents a first of its kind, end-to-end feasibility assessment for shallow geothermal installations that includes drillability assessment, climatic data, building loads, heat pump/exchanger sizing, and regulatory structures. According to Bernardi: "The databases and tools enable creation of EUR/kW maps comparing the Cheap-GSHPs borehole heat exchangers with traditional ones to assess the feasibility of shallow geothermal energy."

Shallow geothermal for a sustainable future

An important way to enhance the impact of the technology was raising public awareness. The project developed a technical brochure and a technical training manual in eight languages, as well as a technical handbook in three languages focused on historical buildings. Together with the DSS, all are freely available on the project website. In an innovative and highly unusual action, the project also offered free workshops and training courses in countries throughout Europe in the language of the country.

Bernardi summarises: "Cheap-GSHPs has now made shallow geothermal energy solutions more affordable in soil regions with high drilling costs thanks to an investment cost reduction of 20-30 %." The project also delivered the new heat pump for the retrofitting of existing and historical buildings and the DSS. Together, Cheap-GSHPs' innovative, cost-effective and energy-efficient technologies and tools could significantly enhance uptake and reduce CO_2 emissions associated with heating and cooling Europe's buildings, old and new.

PROJECT
Cheap-GSHPs – Cheap and efficient application of reliable Ground Source Heat Exchangers and Pumps

COORDINATED BY
National Research Council in Italy

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/657982

PROJECT WEBSITE
cheap-gshp.eu

Deep metal reserves deliver renewable heat and valuable raw materials to the Earth's surface

The Earth reliably and sustainably produces a tremendous amount of geothermal energy that can be used for power and heat. Innovative technology will extract the heat from deeper and hotter sites, bringing out valuable metals as well.

The total heat produced by Earth is immense, yet exploitation has to date been limited to shallow areas near the surface where the heat is carried up via groundwater transfers. Deeper in the Earth's crust, the temperature increases on average 25 °C per km.

The EU-funded CHPM2030 project has developed the technology to both harness this deep geothermal energy and extract valuable metals from the geothermal fluid, something that has never been done before.

A hot idea moves full steam ahead

Enhanced geothermal system (EGS) technology relies on injecting cold water through a drill hole down to 4-5 km at high pressure, 'enhancing' natural fractures. The water is heated as it passes through the fractures in the hot rock and comes to the surface through another drill hole where the hot vapour is used to produce heat and energy.

The key barriers to EGS adoption are the efficiency of the underground heat exchanger and the costs of investment and operation. Project coordinator Éva Hartai explains: "Combined heat, power and metal (CHPM) extraction from the geothermal fluid will make EGS more economically attractive. To accomplish it, we identified deep metal enrichments throughout Europe that are relevant for the CHPM technology, proved the applicability of the concept and delivered a roadmap for implementation."

Combined heat, power and metal (CHPM) extraction from the geothermal fluid will make EGS more economically attractive. To accomplish it, we identified deep metal enrichments throughout Europe that are relevant for the CHPM technology, proved the applicability of the concept and delivered a roadmap for implementation.

In the CHPM2030 concept, an efficient underground heat exchanger relies on the slow dissolution of metal-bearing minerals to further open natural fractures. According to Hartai: "No high-pressure stimulation is needed as it is accomplished via the leaching process itself. It also gradually increases the flow rate and thermal output of the wells over time. In addition, reverse power electrodialysis using the high-salinity geothermal brine generates additional power so the total energy output of a CHPM plant will be even higher than in a traditional EGS plant."

Amongst the most exciting results were experiments investigating metal recovery using patented gas-diffusion electroprecipitation and electrocrystallisation (GDEx). As Hartai explains, "GDEx is a novel way to recover metals from dilute solutions. It enabled nearly complete recovery of the relevant metals present. The GDEx experiments are upscalable and preliminary economic feasibility calculations show positive results."

Impact far and wide as well as deep

"A mathematical model of engineering subsystems enables stakeholders to simulate different scenarios and optimise systems," says Hartai. A decision support tool that assesses economic feasibility from both the energy and metal extraction revenue streams will remain available on the website of MinPol (Agency for International Minerals Policy), a private company that participated in the project.

As the project name suggests, CHPM2030 identified four pilot sites after screening Europe's mineral belts for their EGS potential, and created a 2030 CHPM roadmap for exploiting them. Actions, targets and milestones were also established for 2050. An ambitious outreach campaign spread the word through numerous multimedia materials, social media and the dissemination channels of project partner the European Federation of Geologists.

The innovative technology combined with extensive outreach and clear roadmaps should ensure widespread uptake. This will increase energy independence and enhance economic competitiveness with local extraction of strategic raw materials of industrial relevance.

PROJECT
CHPM2030 – Combined Heat, Power and Metal extraction from ultra-deep ore bodies

COORDINATED BY
University of Miskolc in Hungary

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/654100

PROJECT WEBSITE
chpm2030.eu

World-record drilling depth signals potential for carbon-neutral Europe

Enhanced geothermal systems could be the very thing that brings geothermal energy from the status of outsider to that of serious contributor to a carbon-neutral Europe. Successful drilling tests in the DEEPEGS project are a major step towards such a future.

Geothermal energy is green, infinite and available virtually everywhere. However, the full exploitation of its potential calls for new technologies able to exploit sites with naturally occurring heat, but lacking both water and sufficiently high rock permeability.

This is where enhanced geothermal systems (EGS), and more specifically the DEEPEGS project, come into play. Back in April 2017, DEEPEGS made the headlines for its successful 4659-metre-deep drilling into a geothermal field in Iceland. The

© Peter Petrov

first-of-its-kind venture offered a wealth of learning opportunities for the geothermal sector and is still a world record to this day.

"The very high permeability of the superhot site at Reykjanes below a 3-km depth came as a pleasant surprise," says Gudmundur Ómar Fridleifsson, coordinator of DEEPEGS. "No drill cuttings or drilling cooling fluids reached the surface below a depth of 3.2 km. The drilling to a 4 650-metre depth in high-temperature geothermal systems had never been achieved before in an environment where 600 °C reservoir temperatures have been confirmed."

Low permeability is one of the barriers to EGS market development which the DEEPEGS project aimed to overcome. The project team initially planned to conduct its permeability enhancement experiments in southern France, where temperatures above 200 °C were expected below 4-km depths. However, things there didn't exactly go to plan: delays accumulated in the three field tests that the project planned to use and "as time passed we realised that none of these three fields would be greenlighted," explains Sigurdur G. Bogason, Chief Project Officer of DEEPEGS.

The next milestone: winning continental Europe's hearts

To proceed with their work, the consortium had to substitute the three originally targeted fields with the geothermal site of Vendenheim, Alsace, where a multi-leg (multi-drain) enhancement for increased permeability is currently being tested. If successful, it could have an immediate impact on further utilisation of EGS in Europe. "Hot granites over 200 °C have already been drilled, while permeability enhancement is still ongoing," Bogason points out.

One of the main problems faced by the consortium in France was the sceptical attitude of French communities and authorities towards EGS, even though the technology is environmentally friendly. Huge communication efforts had to be deployed by the French energy company, Fonroche Géothermie, to obtain clearance in Vendenheim. As Fridleifsson points out, all projects close to urban areas in continental Europe will need a high level of communication to get citizens and local authorities on board.

The drilling to a 4 650-metre depth in high-temperature geothermal systems had never been achieved before in an environment where 600 °C reservoir temperatures have been confirmed.

Project partners expect the project's success in Iceland to impact the market within 10 years. Until then, they will keep disseminating the positive outcome of the DEEPEGS project in order to convince the geothermal industry to drill into superhot systems for increased power production. "The lessons learned are of great value and have already led to advanced technological breakthroughs such as deep casings and the testing of flexible couplings which are being planned, all based on the experience gained in DEEPEGS," Fridleifsson concludes.

PROJECT
DEEPEGS – Deployment of Deep Enhanced Geothermal Systems for Sustainable Energy Business

COORDINATED BY
HS Orka in Iceland

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/690771

PROJECT WEBSITE
deepegs.eu

New stimulation methods for more efficient EGS treatment

The DESTRESS project has been developing and testing new stimulation methods for enhanced geothermal systems. Their efforts should lead to reduced costs and increased environmental safety.

There is essentially one barrier that separates conventional techniques from enhanced geothermal systems (EGSs): the ability to produce affordable energy by pumping high-pressure water into a hot rock with low permeability. This process known as hydraulic stimulation would open a whole new world for society. Geothermal resources that have not been economically viable to exploit so far would suddenly become a no-brainer.

We are not exactly there yet. EGS still has some way to go to prove its worth and attract investors, and efforts under the DESTRESS project are meant to clear the path. Since 2016, the project has been building upon advances in the oil and gas sector to develop new stimulation methods with a view to reducing cost, increasing reservoir transmissivity and minimising environmental impact. This notably involves preventing seismic events and pollution of groundwater reservoirs.

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"Inspiration came from hydrocarbon reservoir development, with one main difference: geothermal stimulation targets an environmental safe treatment of the reservoir," says Ernst Huenges, Head of the International Centre for Geothermal Research (GFZ) at Helmholtz Centre Potsdam, Germany, and coordinator of DESTRESS. The project consortium also base their concepts on extended risk assessment and recent scientific progress in fluid-rock interaction, enabling a soft stimulation approach, more accurate determination of the stress field and the analysis of induced seismicity.

Inspiration came from hydrocarbon reservoir development, with one main difference: geothermal stimulation targets an environmental safe treatment of the reservoir.

The DESTRESS concept is being applied at several sites. "Our stimulation treatments are being demonstrated in different geological environments and under different site-specific circumstances such as specific states of the well and various distances to cities. In each case, the required adaptations are related to the types of pathways for fluids. Pore space-type reservoirs require more chemical treatments to dissolve obstacles with acids, while fracture-type reservoirs react more to hydraulic-mechanical stimulation," Huenges explains.

DESTRESS was divided into seven work packages, two of which aimed to provide a demonstrator for innovative stimulation treatment: one for combined hydraulic-acidisation treatments in sandstones and other rocks; and one for cyclic hydraulic and multi-stage stimulation in granites and tight sandstones.

A source of inspiration for new sites

Although the project is due for completion at the end of November 2020, Huenges is confident that any stakeholder looking for similar treatments to solve productivity or injectivity problems at their own site could take DESTRESS as an example. "Surely, lessons learnt from DESTRESS operations, especially with regard to applied risk assessment and workflows, will positively influence treatments to be performed later at other sites (for example United Downs in the UK)," he says.

The potential for geothermal heat supply in Europe is huge and increasing demand for renewable energy supply makes EGS a tempting solution as long as potential environmental issues can be managed positively. The DESTRESS team will be focusing on a multi-stage stimulation over the next few months, which has yet to be demonstrated for geothermal systems with a sufficient reliability level, in order to keep closing the remaining gaps.

From that stage onwards, commercialisation should not be too far into the future. "We think we are close to commercialisation in newly developed wells," says Huenges. "However, we recently learned that there is still additional development required in older wells because of integrity issues. Several stakeholders involved in DESTRESS, along with a follow-up EU project, will continue to develop new treatment solutions."

PROJECT
DESTRESS – Demonstration of soft stimulation treatments of geothermal reservoirs

COORDINATED BY
GFZ German Research Centre for Geosciences in Germany

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/691728

PROJECT WEBSITE
destress-h2020.eu/en/home

Europe-Mexico collaboration tackles unconventional geothermal systems

To help geothermal energy fulfil its low-carbon potential, GEMex (collaborating with Mexican researchers) assessed and characterised two sites in the Trans-Mexican Volcanic Belt, to propose ways to tap them.

© Anna Jentsch

Geothermal energy is underutilised, despite offering a local energy source, available 24/7. It could be used for heating and cooling throughout Europe and for electricity generation in regions with higher geothermal temperatures such as Croatia, France, Germany, Greece, Hungary, Iceland, Italy, Romania and Serbia.

The EU-funded GEMex project was formed as a European consortium, in conjunction with a Mexican consortium, under the auspices of EERA joint programme of geothermal energy. Working at two geothermal project sites in Mexico, Acoculco and Los Humeros, it assessed their resources, characterising reservoirs and developing concepts for future site development.

Exploring unconventional geothermal reservoirs

While geothermal energy has been used in Europe and in Mexico for some time, both regions' consortium members were interested in unconventional geothermal systems: enhanced geothermal systems (EGSs) and superhot geothermal systems (SHGSs).

EGSs are geothermal reservoirs with promising high temperatures but without enough initial rock permeability or fluids in the rock to transfer sufficient heat to the surface.

SHGSs are geothermal reservoirs with very high reservoir temperatures (sometimes above 350 °C), higher than currently exploited anywhere. Such high temperatures would provide more energy per well than the standard geothermal installations. While ideal for geothermal electricity production, the harsh subsurface conditions challenge drilling and well completion methods and materials.

The Acoculco site is very hot (300 °C at 2-km depth), but two deep wells encountered hardly any fluids, necessitating an EGS – never before accomplished in Mexico. Los Humeros is an operating geothermal system where a superhot part of the geothermal field, with temperatures above 400 °C, remains undeveloped.

GEMex's proposals should speed up geothermal development in Mexico and Europe, and, with its predictive models, reduce the risk of wasted investment.

GEMex researchers applied geological, geochemical, geophysical, volcanological and hydrological tests (including passive seismic, magnetotellurics, gravimetry and soil gas) to characterise the reservoirs at depth and determined rock and fluid properties and their response to temperature and pressure changes in laboratory tests.

The results of this research were combined with updated regional and reservoir models as the basis for further development and exploitation.

A concept for EGS at Acoculco considers the existing fracture network and geological information, as well as the physical properties of the rocks at depth, to propose hydraulic fracturing measures in one or both of the deep wells.

The concept for Los Humeros proposes well locations for access to the deep, superhot fluids, and operational well designs (including suitable materials) for safe and successful operations.

"At Acoculco, a fracture zone was identified that could be connected to the borehole by hydraulic stimulation to make the reservoir more permeable and serve as a naturally water-bearing zone," explains David Bruhn, project coordinator. "In Los Humeros, work indicated a reservoir deeper than the one currently exploited – this has not been investigated before."

Sustainable site development

GEMex supports the EU's Strategic Energy Technology Plan to develop and deploy low-carbon technologies. To help promote European research, the project developed both an Open Access Database for sharing and publishing project data and results and a Virtual Research Environment for knowledge sharing internally.

"GEMex's proposals should speed up geothermal development in Mexico and Europe, and with its predictive models reduce the risk of wasted investment," says Bruhn. "We are now discussing potential follow-up projects to include new wells targeting the superhot zone in Los Humeros and perhaps to connect a permeable zone in Acoculco. As a scientist I would greatly welcome and support a Mexican deep drilling project."

PROJECT
GEMex – Cooperation in Geothermal energy research Europe-Mexico for development of Enhanced Geothermal Systems and Superhot Geothermal Systems

COORDINATED BY
GFZ German Research Centre for Geosciences in Germany

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727550

PROJECT WEBSITE
gemex-h2020.eu

New materials for (cost-) efficient geothermal energy systems in buildings

Forget about the wind and sun. In the future, your house could very well be pumping heat directly from the ground below, thanks to EU-funded efforts aiming to decrease the cost of shallow geothermal energy systems.

Photovoltaic panels are easily the first power sources coming to mind when considering renewable energy options. But there is an outsider that's increasingly making noise in the sector: geothermal energy.

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With almost EUR 4 million of EU support, GEOCOND aims to turn this potential into reality. The project Consortium has been working on shallow geothermal energy systems (SGESs) for buildings since May 2017, which is easily understandable in light of their tantalising promises.

The companies in the Consortium are interested in pursuing the exploitation of the GEOCOND technologies which are at quite a high TRL level, especially the grouts and the plastics.

"SGESs have very interesting features. They are electric-driven (heat pump), boast the highest possible efficiency (most convenient thermal source) and can serve heating, cooling and hot water simultaneously. Besides, they are highly integrable into buildings, can be combined with other RES thermal or electric sources, and are a proven and robust technology with the lowest maintenance costs," says Javier Urchueguia, Professor at the Polytechnic University of Valencia, GEOCOND coordinator.

There is only one issue. So far, SGESs have been struggling to attract end users, one of the reasons being its high initial cost. GEOCOND is one of several projects aiming to overcome that obstacle, specifically by formulating new materials for future SGES installation.

"SGE has traditionally used materials such as PE-100 that were not specifically aimed at this application. This implies that their use for SGE is far from optimal. Big plastic suppliers were not interested in producing new compounds, probably because the scale of the market is still too narrow. This is why an initiative such as GEOCOND was required," Urchueguia explains.

GEOCOND's research covers four key elements at the heart of SGESs: plastic pipes with improved conductivity, grouts with enhanced characteristics in different sizes, new materials to store heat, and new materials increasing the capacity of the surrounding ground to transfer heat.

The project is now in its final year, and the list of outcomes is already promising. Among other things, the Consortium has proposed a new geometry to improve thermal efficiency, as well as a new algorithm for material optimisation considering thermal, energetic and economic variables.

Higher conductivity at lower cost

The project's new plastic compounds multiply the conductivity of PE-100 by a factor of three, all this while maintaining mechanical properties and other critical specifications related to weldability and manageability.

"New plastics have been also developed for other geometries like coaxials," says Urchueguia. "Moreover, we have managed to produce a new family of grouting compounds with improved specifications that have been tested in real-world conditions with excellent control of their properties; and we have developed an improved system of grout and phase change material mixtures to enable underground thermal storage at different temperature levels."

The project team is now focusing on its three pilot plants which should soon be in operation. To be considered successful, these pilots must provide critical information to confirm the benefits brought by GEOCOND to improve SGESs with regards to lower cost and higher efficiency.

"The companies in the Consortium are interested in pursuing the exploitation of the GEOCOND technologies which are at quite a high TRL level, especially the grouts and the plastics. A 1 or 1.5-year follow-up and upscale project could be enough to reach the requested market maturity for these products," Urchueguia concludes.

Together with other projects aiming to solve other problems affecting SGESs – such as the lack of training, appropriate legislation and other technological limitations – GEOCOND is well on track to play a key role in democratising geothermal energy for future buildings in Europe.

PROJECT
GEOCOND – Advanced materials and processes to improve performance and cost-efficiency of Shallow Geothermal systems and Underground Thermal Storage

COORDINATED BY
Polytechnic University of Valencia in Spain

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/727583

PROJECT WEBSITE
geocond-project.eu

Geothermal system innovations benefit buildings large and small

If geothermal energy is to become widespread, it will have to become cheaper and more efficient for everyday buildings. GEOTeCH has made innovations in drilling and extraction technology that could help further release the power of these underground energy resources for buildings.

© GEOTeCH coordination, Solintel

Compared to fossil fuels, geothermal energy emits very little CO_2 or other greenhouse gases. But to harness this heat-carrying fluid near the Earth's surface, its temperature must be raised by heat pumps (usually borehole heat exchangers). However, typical drilling technologies have a number of challenges that can be mitigated, including: expensive equipment, specialist teams, compressor noise, dangers from pressurised air (12-20 bars), potential borehole instability, the significant quantities of drinking-quality water required and poor working conditions.

Our foundation heat exchangers have the same heat exchange capacity as borehole heat exchangers, but the implementation costs are 82 % lower.

The EU-supported GEOTeCH project designed, built and tested a drill-rig which has already been commercially released by Conrad (a project partner) with hollow stem auger (HSA) drilling for shallow borehole heat exchangers (BHXs). The rig can drill quickly in loose soils (sand, gravel, clays), with minimal water usage. The costs of those units, designed for small-scale buildings, are 70 % of those for a comparable mud rotary rig, reducing barriers to entry for newcomers to the geothermal market.

The project also developed a foundation heat exchanger (FHX) for use in larger buildings where it can be integrated with existing heating, ventilation and air conditioning (HVAC) systems, bringing down overall costs.

A geothermal solution for small and large buildings

A 'plug and play' BHX solution was developed for smaller buildings based on a coaxial spiral heat exchanger, which can tap energy from a shallower depth than usual. While this design has been available for a number of years, the project's prototype updated it with a coextrusion of the internal spiralled pipe. This innovation allowed more cost-efficient performance at depths of 20-50 metres, when compared to conventional U-loop heat exchangers.

GEOTeCH also developed an FHX for larger tertiary buildings, where a pipe is embedded into foundation structures, (e.g., walls). This approach avoids the drilling, pipe laying and grouting necessary for BHXs.

Testing of the drilling technology and the heat exchangers was conducted at four buildings around Europe. The BHX system was demonstrated in small-scale office buildings in Amsterdam, Leicester and Padova. The FHX technology was demonstrated in a large-scale office building in Barcelona, where it was also integrated with the HVAC system.

A fitting solution

The Barcelona demonstration showed that GEOTeCH could be especially useful for larger new buildings to significantly reduce their energy consumption. "Our foundation heat exchangers have the same heat exchange capacity as borehole heat exchangers but the implementation costs are 82 % lower," says Dery Torres, project coordinator.

To run the full system for larger buildings, which involves managing a geothermal heat pump for heating and cooling conditions where other thermal energy resources may be available, two energy management systems (EMSs) were developed based on machine learning techniques. Both used open-source interfaces to work with existing building management systems, and their functionalities were validated in two buildings: the BTEK Museum building, Derio, Spain and the Hollandsch Huys campus building, Hasselt, Belgium.

To bring the technology to market, the team are working to improve the performance of both the borehole and foundation heat exchangers, by optimising fluid content, flow rate, materials and the spiralling pitch for the borehole heat exchanger.

PROJECT
GEOTeCH – Geothermal Technology for €conomic Cooling and Heating

COORDINATED BY
Solintel M&P SL in Spain

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/656889

PROJECT WEBSITE
geotech-project.eu

EU research helps extend working life of geothermal wells

Fresh concepts for high-temperature geothermal wells will speed up the development of geothermal resources both in Europe and around the world.

The EU's revised Renewable Energy Directive establishes a new binding renewable energy target of at least 32 % by 2030, with a clause for a possible upwards revision by 2023. This will help address uncertainty in energy supplies and reduce fears of global warming. One part of this strategy is the growth of the geothermal sector.

The GeoWell project developed and tested new reliable, economical and environmentally safe technologies for the design, completion and monitoring of high-temperature geothermal wells (HTGWs). Researchers addressed all relevant steps in the geothermal well completion process, including cement and sealing technologies, material selection and casing couplings to extend the lifetime of HTGWs.

Consortium members comprised experienced geothermal developers, leading academic institutions, major oil and gas research institutions, and SMEs with access to world-class research facilities. These included test wells for validation of innovative technologies and laboratories for material testing.

New technologies tested

Project partners focused on both traditional production wells and deeper wells where the pressure is as high as 150 bar and temperatures exceed 400 °C, testing the technologies under in situ conditions in laboratories and existing geothermal environments. They also tackled major bottlenecks like high investment and maintenance costs by developing and validating innovative materials and designs that exceed current concepts.

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Researchers investigated novel cement and sealing technologies, casing materials and flexible couplings to minimise thermo-mechanical loadings. In addition, fibre optic cable technology and applications for measuring temperature and strain in wells were developed and successfully trialled at different temperatures and depths in wells located in Germany and Iceland.

Innovative materials

Cement samples were exposed to temperatures up to 450 °C in the Iceland Deep Drilling Project (IDDP-1) well. Following laboratory analysis at ambient temperature, results showed that Portland cement mixtures including silica are suitable for use in geothermal applications. However, water pockets can lead to critical pressure build-up in cement sheaths. "These findings resulted in the development of 'pumpable' cement with reduced water content without diminishing its sealing properties," says project coordinator Arni Ragnarsson.

The results will enhance the construction and operations of HTGWs, especially targeting well integrity improvement to offer new business opportunities for industry that will help Europe maintain its position as a world leader in geothermal energy.

The team also devised a ductile intermediate layer between cement and casing to take up the strains generated by temperature change and evaluated nanomaterials in small-scale tests for their potential to reduce friction. "The developed formulation has promising properties and a thin layer and is able to reduce the friction forces by more than a factor of 10," Ragnarsson explains.

Large temperature differences in geothermal wells regularly result in casing failures. Researchers therefore developed a flexible coupling that allows axial movement of casing segments and tested several full-scale prototypes. Tensile tests were also conducted on casing material using a dedicated high temperature rig, while corrosion tests were carried out in an autoclave. On-site testing of the flexible coupling is currently ongoing in the EU-funded DEEPEGS project to make the technology available for the geothermal industry.

Major benefits

The design and monitoring technologies developed by GeoWell will provide significant economic benefits by reducing the risk of casing failure and improving monitoring methods and risk assessment. Furthermore, the development of new materials and innovative solutions will help improve the integrity and safety of HTGWs, reduce the need for maintenance work, and extend the working life of HTGWs.

GeoWell technologies can be applied at a wide range of temperatures in deep geothermal wells throughout Europe. "The results will enhance the construction and operations of HTGWs, especially by targeting integrity improvement to offer new business opportunities for industries. This will definitely help Europe maintain its position as a world leader in geothermal energy," concludes Ragnarsson.

PROJECT
GeoWell – Innovative materials and designs for long-life high-temperature geothermal wells

COORDINATED BY
Iceland GeoSurvey in Iceland

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/654497

PROJECT WEBSITE
geowell-h2020.eu

Generating electricity without sapping Europe's water supplies

Innovative technologies will enable Europe's electricity sector to power the continent without depleting water reserves, and one EU-funded project has been leading the way.

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Water is an invaluable resource for humanity, and one that will become increasingly important to preserve as the global climate continues to change. Power generation is one of the most water-dependent industries, requiring vast amounts to cool generating systems.

In Europe, energy production accounts for 45 % of all water extracted from natural sources; even with water returned to the environment considered, this still accounts for a fifth of water used. Reducing the impact of this industry on water reserves is therefore a simple and promising route towards a sustainable future.

The Horizon 2020-funded MATChING project, consisting of a consortium from six EU countries, is spearheading the European effort to reduce the demand for cooling water through

state-of-the-art technologies in thermoelectric and geothermal power plants.

"MATChING aimed to reduce the water demand and improve energy efficiency for cooling systems in the energy sector through the use of advanced and nano-technology-based materials and innovative configurations applied to both geothermal and fossil-fuelled power plants," comments Daniela Galla, MATChING Programme Manager at Enel.

In high-temperature geothermal sources, the results showed an average reduction in evaporated water of around 10 % in hybrid operations compared to traditional wet operations, incurring only a small energy penalty. Galla says this is "one of the best results of the project."

The future of cooling

The MATChING project trialled a series of technological solutions, involving every single area of power plant cooling systems, including cooling towers, cooling water circuits, water conditioning systems, groundwater cooling and steam condensers.

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Innovative membranes – some based on nano-technology – and advanced materials were tested to see how they could improve water conditioning and recovery. This boosts water supplies through the use of lower-quality waters – wastewaters from power stations or from cooling tower blow-down.

The results suggest that water intake can be reduced by over 30 % in thermal power plants with wet cooling. "Reductions are site-specific, depending on climate and water quality, and the net impact on cooling costs varies among technologies," Galla says.

Newly developed laser texturing techniques and nano-coatings were used to promote condensation on the outside of condenser tubes, increasing cooling efficiency. The project used hybrid cooling systems in geothermal power production, based on advanced fillings for more efficient cooling in high-temperature sources, and closed-loop groundwater use in low-temperature sources. New anti-corrosion materials were developed to ensure financially viable techniques, and sustainable production for many years.

"Many of the tests gave surprising results," concludes Galla. "Elsewhere, the potential yearly gain in certain geothermal plants using groundwater as a heat sink instead of air coolers ranged from 4 % to 14 %. In this case, higher heat demands result in higher relative gains in power plant efficiency."

Powering on

Technologies and techniques have been tested at six test sites across the EU, in Belgium, France, Italy and Spain.

The MATChING team is now analysing the results and using them to improve the systems further. Some of the results are being merged into other research projects or proposals for future developments.

"The results achieved in the project are now in an exploitation phase, which includes technical feasibility and cost-benefit analysis for specific applications," says Galla.

PROJECT
MATChING – Materials Technologies for performance improvement of Cooling Systems in Power Plants

COORDINATED BY
Enel Produzione SpA in Italy

FUNDED UNDER
H2020-LEIT-ADVMAT

CORDIS FACTSHEET
cordis.europa.eu/project/id/686031

PROJECT WEBSITE
matching-project.eu

Increasing the productivity of insufficiently producing geothermal wells

Researchers with the EU-funded SURE project are testing the use of radial water jet drilling as a means of improving the performance and economic viability of geothermal wells.

Geothermal energy offers incredible potential. Not only is it a renewable energy, it's also clean energy, meaning it does not produce harmful greenhouse gases. As such, geothermal has the potential to be a key component in Europe's renewable energy strategy, one that could eventually provide Europeans with a reliable source of baseload energy.

However, before this happens, the production process needs to be improved so that it is economically viable – which is where the SURE project comes in.

"The technology we're developing will improve the productivity of existing wells by providing an economically viable method for controlling the enhanced flow paths around a geothermal well," says Thomas Reinsch, a researcher at the German Research Centre for Geosciences and SURE project coordinator.

The RJD advantage

At the heart of the project is radial water jet drilling (RJD). RJD uses the power of a focused jet of fluids applied to a reservoir rock through a coil that is inserted directly into an existing geothermal well. This creates several small diameter holes running nearly 100 metres from the existing well to the reservoir, allowing the initially unconnected permeable zone to drain into the main well.

The SURE project contributed to significantly advancing our knowledge about RJD technology for geothermal energy purposes beyond the state of the art.

"Because RJD does not involve the amount of fluid used in conventional hydraulic fracturing, it reduces the environmental impact of stimulation technologies," explains Reinsch. "Furthermore, when used to access and connect a geothermal reservoir's highly permeable zones to the main well, RJD provides a higher degree of control and thus an increase in performance compared to conventional stimulation technologies."

Advancing the state of the art

Within the SURE project, researchers set out to determine the benefits and disadvantages of water jet drilling technology in comparison to more well-established stimulation processes. "Our focus was on understanding the drilling process, optimising it, and improving the performance – and predictability – of the technology," says Reinsch.

To do this, the project team conducted a range of experiments. This included studying the physical properties of various potential geothermal reservoir rock types and their reaction to various RJD processes. "The objective of this experiment was to achieve a complete understanding of the water jet/tooling-rock-interaction for a large variety of sedimentary and crystalline rocks," comments Reinsch.

From these experiments, researchers created several tools, including patent-pending components that can be used to improve the water jetting technology. They also developed numerical models that can be used to, for example, determine the rock destruction process and estimate improvement to a well's performance following RJD stimulation.

"The SURE project has significantly advanced our knowledge about RJD technology beyond the state of the art and across different spatial and temporal scales," Reinsch concludes. "By increasing the productivity of insufficiently producing geothermal wells, we are making the supply of geothermal energy economically viable and environmentally sound."

PROJECT
SURE – Novel Productivity Enhancement Concept for a Sustainable Utilization of a Geothermal Resource

COORDINATED BY
GFZ German Research Centre for Geosciences in Germany

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/654662

PROJECT WEBSITE
sure-h2020.eu

Alternative drilling technology for deep geothermal applications

Enhanced geothermal systems have the potential to become a cornerstone of Europe's renewable energy strategy. To tap this potential, EU researchers have developed a revolutionary water-jet-assisted roller-cone drilling system.

Europe's dependence on non-EU sources of gas creates risks for the EU's energy security. One possible solution for easing this dependence is the use of geothermal energy for heat and electricity.

"The use of geothermal energy as a renewable resource is a fundamental prerequisite for ensuring a secure and sustainable energy supply in Europe," says Karin Rehatschek from Montanuniversität Leoben in Austria. Rehatschek is the coordinator of the EU-funded ThermoDrill project, which developed an innovative deep drilling technology for accessing geothermal energy.

Breaking through strong rock formations

Enhanced geothermal systems (EGSs) have the potential to become a cornerstone of Europe's future renewable energy strategy, providing baseload energy 24 hours a day with near-zero carbon emissions. Already, the 24 MWth geothermal plant in Rittershoffen, France supplies process heat to a nearby industrial site, while a plant in Insheim, Germany, supplies 8 000 households with electrical power.

But before EGSs can be scaled up, the cost of drilling must come down. "Most geothermal sources lie at depths ranging from 3 000 to 5 000 metres below the surface and typically under hard rock formations," explains Rehatschek. "As drilling costs rise exponentially with increasing depth, they represent the main cost drivers of geothermal plants – often accounting for more than half of all investment costs."

To overcome this potential roadblock to harnessing the potential of EGSs, the ThermoDrill project developed a hybrid drilling technique that combines standard rotary drilling with water jet cutting. The high-pressure water jet, which is placed directly above the drill bit, pre-damages the rock on impact. This makes it significantly easier for the drill to penetrate the rock, thus increasing the overall efficiency of the drilling process.

Enormous potential

Final field tests, which were conducted in a 1.3 km deep borehole in Austria, confirmed that the ThermoDrill technique can at least double drilling speed.

"ThermoDrill's enhanced effectiveness will lower drilling costs considerably, which in turn will lead to a reduced overall capital expenditure and thus much-improved economics of the entire geothermal project," says Rehatschek.

The ThermoDrill system can be fully integrated with existing drilling infrastructure and technology, thereby boosting acceptance of its deployment as a market-ready system in the future. With the ThermoDrill system, the consortium estimates that cost savings of approximately 20 % can be achieved for one deep borehole (5 000 m). This amounts to around EUR 3 million.

The use of geothermal energy as a renewable resource is a fundamental prerequisite for ensuring a secure and sustainable energy supply in Europe.

"Future advancements will bring this drilling technology to market-readiness, thereby paving the way for intensified utilisation of geothermal as an environmentally friendly alternative energy source throughout Europe – and even globally," concludes Rehatschek.

PROJECT
ThermoDrill – Fast track innovative drilling system for deep geothermal challenges in Europe

COORDINATED BY
Montanuniversität Leoben in Austria

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/641202

PROJECT WEBSITE
thermodrill-h2020.org

Introducing GEOTHERMICA, an umbrella initiative to help focus and target resources for the uptake and commercialisation of innovative geothermal technologies

Europe aims to increase the share of renewable energy for direct heating and cooling, industrial processes, power generation and energy storage. Geothermal energy today is only utilised in a few niche market sectors and a few regions but has the potential to be much more widely utilised. The EU-funded GEOTHERMICA project promises to play a big role in making this a reality.

GEOTHERMICA's ambitious objective is to combine the financial resources and know-how of 16 geothermal energy research and innovation programme owners and managers from 13 countries and to launch joint actions that demonstrate and validate novel concepts of geothermal energy utilisation within the energy system that can be further developed with a view to full-scale commercialisation in mind.

In particular, the initiative aims at the direct use and power generation from geothermal resources in an optimised way, which includes integrated and combined systems (e.g. heat pumps and using the underground as a heating and cooling energy storage site).

Now GEOTHERMICA has moved to embark on the next step: to combine forces at the European level and realise significant developments on a big scale through a platform of jointly funded European research and development (R&D) projects. For a first call through the project, EUR 30 million was made available for a small number of major demonstration projects, with strong industry participation. Overall, the European approach gathers together national funding efforts and provides the opportunity to unite the geothermal knowledge of all participating countries.

GEOTHERMICA's second call was launched at the end of 2019 with an indicative budget of around EUR 20 million.

The Horizon 2020 programme contributes directly to GEOTHERMICA with nearly EUR 8 million, with the rest of its budget coming from the EU Member States. The project is due to end in December 2021. For more information, visit the dedicated GEOTHERMICA website.

PROJECT
GEOTHERMICA – ERA NET Cofund Geothermal

COORDINATED BY
the National Energy Authority in Iceland

FUNDED UNDER
H2020-ENERGY

CORDIS FACTSHEET
cordis.europa.eu/project/id/731117

PROJECT WEBSITE
geothermica.eu

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RESULTS PACK ON PHOTONICS

From hyper-powerful scanning electron microscopes to ultra-efficient photovoltaic plants, quantum communication to wearable smart materials where the colours do the work, photonics – generating, controlling and detecting light – is the key. The latest Results Pack highlights how 10 EU-funded projects harness the power of light to propel technology by quantum leaps into the future.

Check out the pack here:
cordis.europa.eu/article/id/413590

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