DeepU

DELIVERABLE D6.6

Final technical brochure

Production

Lead Beneficiary: CNR

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Dissemination Level

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SEN	Sensitive - limited under the conditions of the Grant Agreement	
CI	EU classified - RESTREINT-UE/EU-RESTRICTED, CONFIDENTIEL-UE/EU-CONFIDENTIAL, SECRET-UE/EU-SECRET under Decision 2015/444	

DeepU

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Document History

Version	Date	Authors	Description
1	2/09/2025	A. Manzella	First draft of the text
2	20/09/2025	All partners	Review and comments
3	23/09/2025	A. Manzella	Final draft
4	25/09/2025	All partners	Review and comments
5	29/10/2025	A. Manzella	Final document

Disclaimer

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EXECUTIVE SUMMARY

This report describes the activities carried out to complete the final brochure outlining the DeepU project's main results. The activities included a survey to gather opinions on the primary innovations and to collect feedback from partners, as well as the editorial process of preparing the brochure, which involved drafting the main text and formatting it visually.

The brochure is shown in this report and is available on the project website. It can be downloaded at this link.

1. INTRODUCTION

A final brochure summarizes a project's achievements compared to its initial goals. For DeepU, since most results are documented in sensitive files, the brochure mainly acts as a descriptive overview. This report includes the final brochure itself, along with details on how it was prepared, organized, and distributed.

2. THE BROCHURE PREPARATION

The preparation of the brochure involved multiple activities that could only begin once the final project results were almost available. The first step began in early July 2025, when a survey was sent out to project partners to summarize their key innovations and provide material and ideas for visual representation. The survey questions are outlined in Table 1.

Table 1: Questions asked in the survey

#	**Question**	Ch**oice of multiple answer** *Requests from the activity coordination after the slash*
1	Please briefly describe what you consider the main innovation(s) in your DeepU-related activity	NA
2	Have you a visual representation (e.g. graphic, video, photo) of your innovation(s)?	
		Yes */ Please send it to me asap or upload it on the VRE, with a clear reference to the innovation title*
		Partially */ Does it take long to complete it? Can we work on this together? Please insert this answer in the "Other notes"*
		No, I have no idea */ I will try to suggest something and we will need to be in contact for this before our interview*
		No but it could be created / I have an idea */ Could you please send me the idea or organise a chat to discuss it so I can assist with it? Please insert this answer in the "Other notes";*
3	Other notes (e.g., regarding visual products)	NA
4	Please indicate your availability for a short interview between August 18 and September 10 (suggest one or more days, and we will contact you to arrange the time)	NA

After gathering all the requested information, CNR began preparing the textual and graphic design. Given that the graphical material and picture ideas provided by partners were somewhat limited, CNR decided to design the brochure with only a few images, focusing mainly on concepts and visual design. The text was finalized in late August 2025 and refined through direct discussions with partners during interviews and recordings conducted for a video. After completing the semi-final draft of the brochure on September 2, the text was shared with partners, and CNR initiated the editorial and graphical formatting phase in Adobe Illustrator. The fully edited version, which circulated in late September, received final suggestions, enabling CNR to prepare a complete document for printing.

3. THE BROCHURE

The final version of the brochure is shown in Annex 1. It is designed to be an A3 sheet that folds into an A5 size (Fig. 1). Instead of replicating content from the original brochure — such as partner descriptions, concept, and targets — the new brochure is intended to complement it. The "original" brochure (Annex 2), provided at the start of the project and updated after the consortium expanded, has only been minimally revised from the version published on the DeepU website, with the addition of the title "The Beginning." Together, the brochures clearly illustrate the achievements in relation to the initial goals.

Approximately 80 printed copies of the combined brochures were distributed at the DeepU Final Conference and the European Geothermal Conference in Zurich, Switzerland, from October 6-9, 2025. The remaining printed copies have been distributed among partners for personal sharing.

The final brochure is available on the project website at this link.

Figure 1: A photo of the two brochures distributed in October 2025. On the right, the original brochure titled "The Beginning," A3 in size, folded to fit into an A4. In the center and on the left, the new brochure, folded to nearly A5 size.

ANNEX 1

FINAL BROCHURE

Innovation in laser drilling technology

to unlock the Earth's Limitless Energy

www.deepu.eu

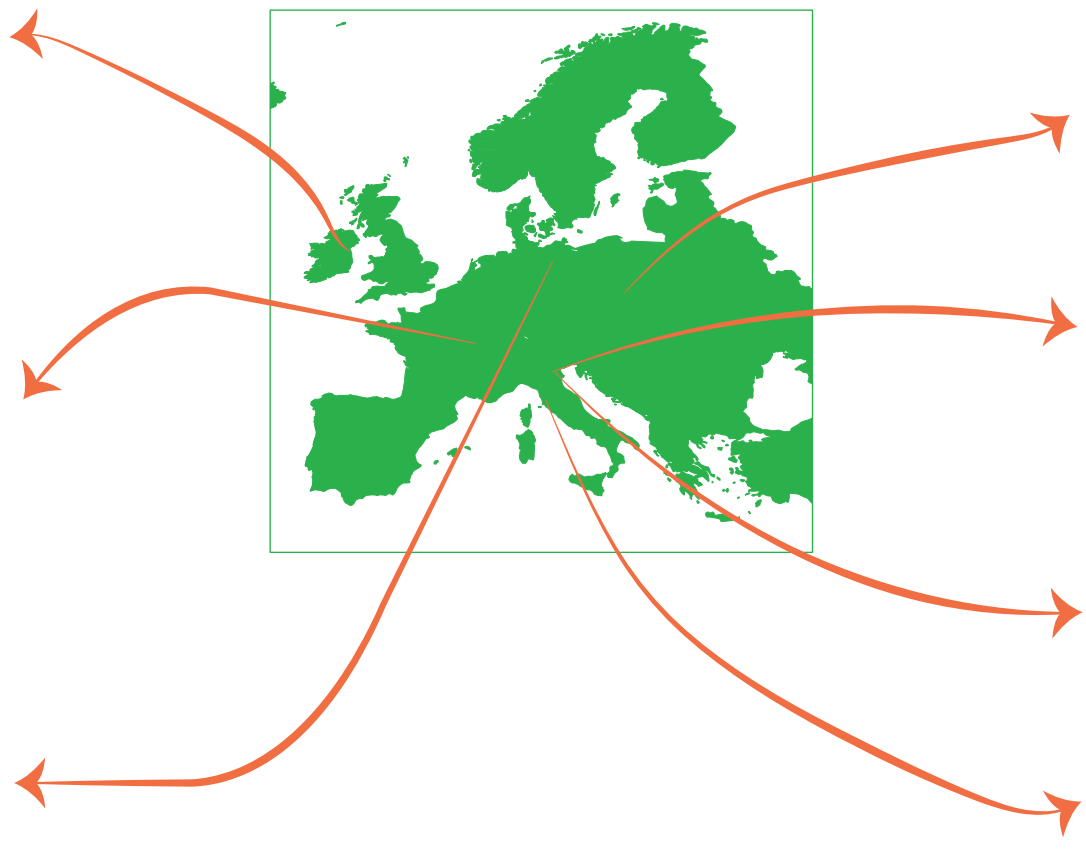
Imagine tapping into the clean, constant heat beneath our feet, anywhere on Earth. DeepU makes this possible with a game-changing breakthrough in laser drilling technology that overcomes the limitations of conventional drilling methods in developing deep closed-loop heat exchangers.

DeepU

Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

7 partners, 4 countries for a multidisciplinary geothermal challenge: innovate drilling technology for developing deep heat exchangers

Geoserv
IRELAND



Wrocław University of Science and Technology
POLAND

Prevent CO_2
GERMANY

Fraunhofer IAPT

Università degli Studi di Padova

Dipartimento di Geoscienze

RED
ITALY

Consiglio Nazionale delle Ricerche
Institute of Geosciences and Earth Resources
igg

DeepU is a Research Project funded by the European Union (G.A. 101046937) under the EIC Pathfinder, which supports early-stage projects (TRL 1-4) having the potential to create new markets and address global changes, making a real difference for our lives.

Why It Matters

Geothermal energy is a renewable, sustainable, and reliable source of energy - yet accessing it remains a challenge. DeepU's laser drilling technology changes that, opening the door to affordable, zero-emission energy for homes, industries, and entire communities

How It Works

- **Laser precision**: Our innovative laser drill bit melts and evaporates rocks or breaks them down into tiny particles (spalls), without the mechanical interactions of conventional drill bits
- **Smart flushing**: A stream of supercritical cryogenic gas clears debris and keeps the borehole clean
- **Extreme resilience**: The process works at any rock's temperature, any hardness, or water content, even in the most challenging conditions found deep underground
- **Energy production anywhere**: With DeepU technology, we laser-drill deep, closed-loop heat exchangers, efficiently transporting energy from deep underground to the surface

What We Have Achieved

- Proven efficiency, non-contact laser drilling of a closed-loop heat exchanger in the lab
- Built a drill string prototype ready for field testing
- Identified optimal laser settings for varying rock types
- Assessed environmental and safety standards to ensure responsible deployment
- Explored the drilling cost reduction potential

In more detail

Laser drilling and cryogenic gas flushing:

Studies demonstrated that combining laser drilling with cryogenic gas flushing is highly effective. Rock fragments (spalled or evaporated particles) are removed via the borehole annulus, using supercritical nitrogen as the flushing and cooling medium. A model was developed to simulate and analyse particle transport, cryogenic gas fluid flow, and pressure–temperature variations

Efficient drill string:

Our full-scale drill string prototype is now ready for field testing trials. Experiments fine-tuned the drill string while adjusting the layout in terms of laser energy and gas flushing. Novel insulated, quick, and secure drill pipe connections ensure smooth and efficient operation

Fast drilling speed:

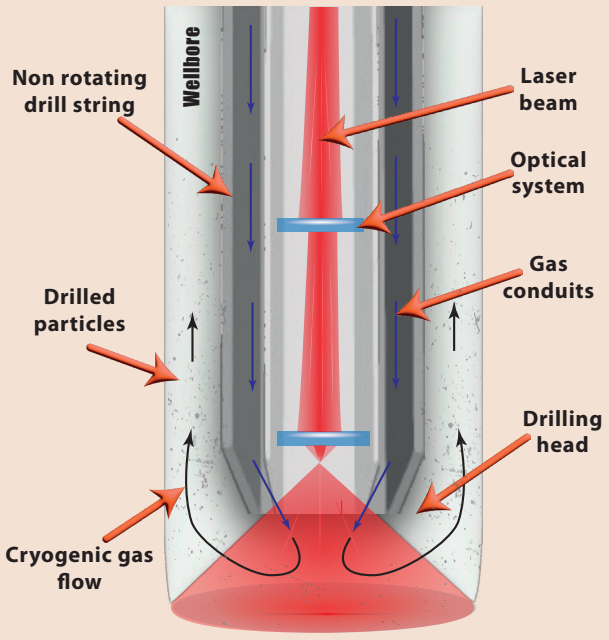
Boreholes were drilled with the DeepU laser drilling technology in various rock types, achieving a drilling speed (ROP) of 20-25 m/h in hard rocks

Laser-rock interaction:

By studying how rock responds to lasers, we identified the energy thresholds for spallation, melting, and evaporation, and determined the optimal settings for different lithologies and conditions

What Is Next

We are preparing to bring DeepU to the field—paving the way for large-scale, cost-effective geothermal energy. With the DeepU technology, the Earth's heat can power a cleaner, more resilient future.



Path to improvements:

Analyses of spalled particles and vitrified layers provided insights that will guide future enhancements of the DeepU technology

Economic comparison:

System-level simulations compared deep closed-loop with conventional open-loop systems. The Levelized Cost of Energy (LCOE) for electricity and heat, including investment and operating costs, was calculated for both conventional mechanically driven technologies and the non-contact DeepU technique. The results emphasise the opportunities that DeepU can offer over conventional approaches

Safety and regulation:

Using methods like Failure Mode and Effects Analysis and Environmental Risk Assessment, we benchmarked DeepU against conventional drilling. We also anticipated regulatory requirements for Health, Safety, and Environmental compliance

ANNEX 2

ORIGINAL BROCHURE

A printed copy of this brochure accompanied the final brochure for distribution at events, to highlight the achievements with respect to the expected targets and to avoid useless replication of information.

THE PROJECT TEAM

Seven partners from four European countries have joined forces to develop a technology that has the potential to implement the share of geothermal energy worldwide

R.E.D. SRL

RED SRL is a spin-off Company of the Italian CNR that designs and installs heating and cooling systems for buildings, in particular on geothermal based and other renewable energy sources. RED SRL is also active in the energy management of small and medium-sized enterprises and owns an Italian patent on an innovative co-axial borehole heat exchanger. In DeepU, RED SRL leads the exploitation and market planning activities, including the IPR management strategy.

UNIVERSITÀ DEGLI STUDI DI PADOVA

The University of Padova (UNIPD), founded in Italy in 1222, is one of Europe's oldest and most prestigious seats of learning. The geothermal research group belonging to the Department of Geosciences is at the forefront of the research in geothermal energy, especially related to rocks' thermal properties characterisation, the effect of heat transport, underground heat storage, geothermal heat pumps and deep closed loop wells. UNIPD is the DeepU project's coordinator and is directly responsible for the petrophysical characterisation of the rocks.

PREVENT GMBH

Prevent is a German engineering company with affiliated prototyping and manufacturing in the field of plasma drill and laser drill strings, working on optimising lightweight multiple drill pipes and drill heads for plasma and laser deep hole drilling. The company has a long experience in the fields of drilling technology, shaft sinking technology, electrics and electronics, as well as drill rig engineering. For the DeepU project, it develops and manufactures different multiple drill pipes and drill heads for laser drilling with different cryogenic gases.

FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV

Fraunhofer IAPT takes part in the Fraunhofer community of currently 76 institutes in Germany with over 30.000 employees, which is the world's leading organisation, especially for applied research. At its location in Hamburg, Fraunhofer IAPT conducts R&D in the field of laser technologies and additive manufacturing. In the DeepU project, Fraunhofer IAPT is responsible for developing the combined laser and gas process and designing the drilling head using 3D printing technologies.

TERRA GEOSERV LIMITED

GeoServ is a leading Irish and international SME that specialises in providing tailored services to the geothermal, natural resource, energy and environmental sectors. Its specialist services are focussed on delivering turnkey geothermal systems for heating, cooling and energy storage applications and providing project management at the exploration and development stages. Geoserv coordinates the activities related to regulatory and environmental aspects of the DeepU project.

CONSIGLIO NAZIONALE DELLE RICERCHE

The Italian National Research Council (CNR) is a public organisation with Italy's largest network of institutes. It carries out, promotes, spreads, transfers and improves research activities in the main sectors of knowledge growth. Its Institute of Geosciences and Earth Resources (IGG) has provided technologies and solutions for geothermal assessment for many decades and promotes geothermal applications and innovation in the leading international platforms. CNR-IGG is responsible for the DeepU resource modelling and the dissemination and communication activities.

WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

Established in 1945, WUST has evolved into one of Poland's leading technical universities, boasting a legacy built on resilience and academic excellence. WUST has cultivated unparalleled expertise in cryogenic technology, notably being the sole European country where helium is being extracted from natural gas and then liquefied. Their prowess extends to the development, design, production supervision and commissioning of complex cryogenic distribution systems supplying with liquid cryogens superconducting accelerators, free electron lasers, thermonuclear reactors and other Big Science machines.

THE BEGINNING

DeepU

Deep U-tube heat exchanger breakthrough: combining laser and cryogenic gas for geothermal energy exploitation

www.deepu.eu

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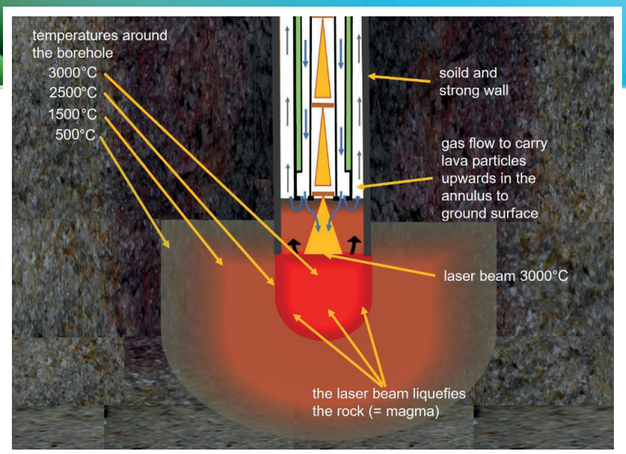
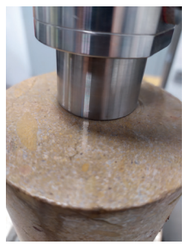
INNOVATIVE DRILLING TECHNOLOGY

What happens to a rock, even the hardest, if a high-temperature laser melts it and then a cryogenic gas suddenly cools it?

Vitrified, waterproof, non-cracked borehole surfaces are expected. The resulting glazed layer on the borehole walls acts as a casing so that a deep heat exchanger is ready immediately after drilling



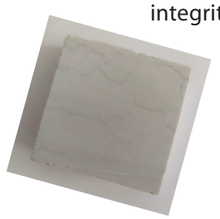
In the DeepU concept, a laser drill-head is combined with special drill strings to sustain the coupled action of laser and cryogenic gas. The fine particles are transported to the surface in the gas stream via the earth tube required for the geothermal heat exchanger. Specific temperature control analysis and innovative laser lenses convey the heat and sustain multilateral drilling. In addition, gases have to be kept cryogenic over a long distance. These innovations guarantee the liquefaction and vitrification of the rocks from the ground surface to significant depths.



INCREASED DRILLING SPEED

The rate of penetration (ROP) should be increased up to 20 to 30 meters per hour, increasing by a great far the drilling speed of traditional drilling methods (i.e. ten times that of rotary methods, reaching max 1-2 m/h in hard rock).

Laboratory tests will prototype the concept. Drilling experiments in a box of about 250 m^3 filled with different rock types will validate and refine the technology. The petro-thermo-mechanical phenomena affecting different rocks will be analysed, and the borehole wall vitrification and integrity will be assessed.



THE DeepU PROJECT CONCEPT

Increasing accessibility of deep geothermal resources for low carbon heating and power generation is a fundamental requirement to accelerate the development of decarbonised and indigenous energy supplies in Europe.
Geothermal technologies provide baseload, indigenous and dispatchable renewable power and heat for space heating and industrial applications throughout the EU. However, besides shallow geothermal heat exchangers used in combination to heat pumps for heating and cooling applications, current geothermal development is limited to accessing water-bearing rocks or creating cracks or fissures to circulate and heat water at depth. The economic viability of existing technologies depends on favourable subsurface conditions to facilitate fluid circulation and on the cost of well drilling and completion. The latter represents over 55% of total project costs.

DeepU can potentially disrupt the geothermal industry by offering a substantial reduction of well drilling costs to deliver deep heat exchange systems.
Since the underground heat is transported by a secondary fluid circulating in deep, closed-loop systems, the high-risk innovation concept of DeepU has the potential to make

geothermal energy systems accessible anywhere

in a targeted and demand-oriented manner, offering a complementary approach and an alternative solution to traditional geothermal energy storage and production.

The DeepU solution will decentralize the power supply also in areas where this is currently deemed uneconomic, to significantly contribute to the energy sector's decarbonisation.

MARKET ANALYSIS FOR A SUSTAINABLE DEPLOYMENT

The project will analyse the exploitation potential and economics of the developed drilling technology utilising numerical simulations calibrated by the laboratory data. In addition, it will assess the legislative aspects and environmental, health and safety (EHS) standards related to the proposed solution. An EHS risks assessment comparing DeepU technology to conventional deep drilling will be performed based on the laboratory results.