

Annual report (2021) on execution of the Deep Geothermal Implementation Plan by companies

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Deep GEOTHERMAL IWG
SUPPORT UNIT



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Introduction

This annual report on the execution of the Implementation Plan (IP) by geothermal companies presents the results of the contribution of geothermal energy industry to the SET Plan activities at the end of 2021.

The objective is to facilitate the execution and monitor the implementation of the IP for the industry part. To keep the IP up to date, EGEC is liaising with the committed companies and with the ETIP deep geothermal members from the private sector.

Information collected in this annual report is then forwarded to activities on overall Monitoring and Synergies and Strategy support (WP6&7) to ensure its treatment and a proper monitoring of the execution of the IP, as well as the improvement to reach the targets. Industry also provides feedbacks on the RD&I public funding programmes available in Europe.

Since 2019, the Support Unit started the assessment by collecting quantitative data on EU and, when available, national cofunded projects. It was completed by a qualitative assessment using publications such as 2019 market reports. Moreover, a first questionnaire (*Annex 1*) was created and started to be disseminated in 2019 in order to collect data from the private sector on their investments in research and innovation (R&I). A second questionnaire was disseminated end 2021/early 2022 to collect specific data on geothermal R&I from oil and gas companies.

This annual 2022, on 2021/2020/2019 activities, is the last reporting.

Methodology of the deliverable

Building from the updated SET Plan Deep Geothermal priorities for ongoing RD&I activities, the deliverable reports on the execution of the Implementation Plan (IP) by the industry. It provides also a general presentation of the activities performed by private actors.

Market actors have been regularly briefed about the 10 RD&I actions as set by the IP. They have also received detailed information with factsheets produced on funding instruments (provided in D4.2).

EGEC is monitoring the IP execution by using several tools:

- The annual EGEC Market reports, which present market developments in Europe with details on deep geothermal plants: size, capacity factor, materials, etc.
- The series of events organised every year and largely attended by industrial stakeholders,
- The ETIP DG and ETIP-RHC (geothermal panel): regular meetings with reporting on R&I results
- EGEC annual innovation award “EGIA” and initiatives

Only activities started after the IP publication (January 2018), or having started before but still ongoing, are considered.

They include co-funded projects, with a public and private financial contribution, supported by European Commission programmes such as Horizon2020, Interreg, COSME; and other ones supported by National public contributions with co-funding from national funds established for transnational cooperation such as ERANET: Geothermica and GeoERA.

Moreover, when available the report covers major national or trans-national research projects with potential input from companies.

This final version of the reporting benefits from data collection operated by the SET Plan and the IWG annual reports. The answers to the questionnaire (*see Annex 1*) from the private sector complete the data collection.

Involvement of private actors in the Implementation Plan

The Implementation Working Group (IWG) on deep geothermal, of the SET plan, adopted in 2021 [update of the Implementation Plan](#).

The updated Implementation Plan includes the following **priorities for RD&I actions in the deep geothermal sector**:

1. Geothermal heat in urban areas
2. Integration of geothermal electricity and heating & cooling in the energy system responding to grid and network demands
3. Improvement of overall geothermal energy conversion performance for electricity and heating&cooling generation
4. Closed loop electric and heating & cooling plants integrated in the circular economy
5. Sustainable and efficient production technologies
6. Development and exploitation of geothermal resources in a wider range of geological settings
7. Advanced drilling/well completion techniques
8. Innovative exploration techniques for resource assessment and drilling target definition
9. Increasing awareness of local communities and involvement of stakeholders in sustainable geothermal solutions
10. Risk mitigation (financial/project)

These updated priorities cover a broad range of topics for the deep geothermal sectors and involve all segments of the deep geothermal value chain. Across the different parts of the geothermal value chain, different types of actors are contributing with their own expertise and resources to advancing the priorities for research, development and innovation in the deep geothermal sectors along the lines identified in the SET Plan Deep geothermal Implementation Plan.

For each priority, the scope is briefly described and the typology of actors implementing the SET Plan Deep geothermal RD&I priorities is described.

The listing presents co-funded projects, with a public and private financial contribution, supported by European programmes such as Horizon2020, Interreg, COSME; and supported by national public contributions co-funded by European funds such as ERANET Geothermica and GeoERA. Moreover, the report covers major national or trans-national research projects with potential input from companies.

The list includes also projects without private financial contribution, but with activities performed by industry.

Monitoring of RD&I activities from geothermal industry in 2020

New European and National co-funded projects in 2020/2021

DeepStor

Title: DeepStor – High-temperature storage in the deep underground

Duration: 2022 - 2027 (Phase I)

Funding Source: Helmholtz

Explanation: HT-ATES demonstration site;

EvA-M2 (2021-2023) and former EvA-M

Application of environmentally friendly inhibitors and CO₂ to prevent carbonate precipitation in deep geothermal energy of the Bavarian Molasse Basin, funded by Federal Ministry for Economic Affairs and Climate Action (€3.2m), SWM subproject leader

VESTA

Title: VESTA Very-High-Temperature Heat Aquifer Storage

Duration: 01.09.2021 – 31.08.2024

Funding Source: BMWK, funded by Federal Ministry for Economic Affairs and Climate Action (€1.5m),

Explanation: The use of high-temperature storage (HTS) is being scientifically investigated on a generic level and based on demonstration projects. For injection and withdrawal temperatures of over 100°C, no test data on a commercial scale are available so far. Many technical, regulatory, legal, environmental and economic challenges need to be solved to enable a broad application of HTS.

Connection: Logging and monitoring program for DeepStor; investigations on oilfluid-rock interactions; further development of modeling tools

Concept study heat storage 120°C, depth 2,500 m, highly permeable calcium carbonate formation incl. planning, feasibility study, concept, simulation, economic modelling

Seismic monitoring

Title: Monitoring equipment: Seismic network

Duration: 2021 – ongoing

Funding Source: Helmholtz

Explanation: Dense seismic network based on short period seismometer/trillium compact, broadband network; DAS; low cost seismometers as citizen science equipment; monitoring data relevant

3D visualization

Title: 3D visualization tools

Duration: 2021 –ongoing

Funding Source: Helmholtz

Explanation: mobil + static equipment; complex scientific process understanding comprehension; dialog with stakeholders, public participation

WarmingUP

Duration: 01.01.2020-31-12-2022

Funding Source: Dutch national subsidies

Explanation: Gain technical and socio-economic knowledge to develop practical instruments for the design and realization of cost-effective, socially acceptable and reliable collective heat networks in the built environment, fed by sustainable heat sources. Foci on 6 themes: 1) network design and system integration, 2) network construction, 3) aquathermal energy, 4) geothermal energy, 5) heat storage, 6) social acceptance

Improving the energy efficiency of geothermal energy utilisation by adjusting the user characteristics

Duration: 01.10.2020 – 30.09.2023

Funding Source: EEA and Norway Grants Fund

Explanation: The project objectives are a long-term improvement in the efficiency of geothermal operations and a decrease in their environmental footprint. Geothermal DH's in Poland, Hungary and Slovakia are case studies

EGMS

Title: End-to-end implementation and operation of the European Ground Motion Service (EGMS)

Duration: 01.01.2021 – 31.12.2024

Funding Source: European Environmental Agency

Explanation: Implementation and operation of a new service element of the Copernicus Land Service. The service makes available ground motion products covering all Copernicus participating states, based on InSAR data from the Sentinel-1 satellite mission.

KA-therm

Title: KA-therm

Duration: 2022 – 2025

Funding Source: Geo:N

Explanation: Scaling of HT-ATES for urban areas in Europe. To this purpose, scenarios for the integration of HT-ATES as a source of district heating supply in urban areas will be developed, considering the necessary scaling of storage to the essential excess heat.

HT-OPEN

Dutch research program which aims to investigate the subsurface effects at the HT-ATES pilot of ECW in Middenmeer. Funded by TKI Urban Energy. Extensive subsurface monitoring during the operational phase of the HT-ATES pilot is facilitated by the research project over the course of the following heat storage cycles (2022-2024).

ThermoNet

Title: New concept of the district heat and cooling

Duration: 01. 01.2021 – 29.12.2023

Funding Source: National funding

Explanation: Once multiple buildings have been connected to the thermal network, each building acts as a “prosumer,” both consuming and providing thermal energy to the network. When a building needs heat to the source-side of its ground source heat pumps (GSHPs), it extracts low grade heat from the warmer pipe and returns cooler water into the cooler pipe and vice versa.

GEORUEIL

The commune of Rueil-Malmaison has joined forces with ENGIE Solutions to establish GéoReuil, a company that will use geothermal drilling to provide predominantly local and renewable heating and domestic hot water for the area’s residents in 2022. Geothermal energy will drive decarbonisation.

VELIGEO

Vélizy-Villacoublay and ENGIE Solutions have signed a contract for the SAS ENR company Véligéo, which enabled a geothermal facility to be built for the Vélizy heating network (2021). This innovative project (multidrains well) received the EGEC award 2021. GEOMARNE The Champs-sur-Marne geothermal project, led by the Paris - Marne Valley Urban Agglomeration (CAPVM) is running since 2020. For the first time, residents had been able to take part in this local project through a new crowdfunding solution provided by Lumo

ENGIE CAMPUS

Heated and cooled using 100% renewable energy, the new campus (La Défense, Paris) is a showcase for the energy transition and consistent with ENGIE’s commitment, that aims for net-zero carbon by 2045. The Campus will be powered using a mix of energy including geothermal energy shallow ATES

HEATSTORE DEMOSITE

The demonstration project provides the heating needs for two administrative buildings of Storengy, ENGIE brand. These needs will be addressed with 260 m2 of solar panels combined with a BTES charged and discharged through 12 radial lines of 4 boreholes in series

COOLGEOHEAT

2021-2022. INTERREG research project, 1 mio. euro., VIA lead partner. The Danish and Swedish project consortium researches operational data, design and business models and best practice for shallow geothermal-based 5th generation district heating and cooling (5GDHC). Combined energy-efficient sustainable district...

"Combined energy-efficient sustainable district heating and cooling surface water drainage system (Thermo-road)"

2020-2024. EUDP funded project, 1 mio. euro., VIA lead partner. The project demonstrates in full scale combined 5GDHC and SUDS (sustainable surface water drainage system) in a small residential area in Hedensted, Denmark

mesoTherm

Exploration and exploitation of medium-deep hydrothermal reservoirs – a contribution to the heat transition in North Germany. Funded by Federal Ministry for Economic Affairs and Climate Action, Germany, 2020-2024, € ~3.66 m.

ArtemIS

Upgrade of the geothermal information system GeotIS into an internet portal for the heating transition in Germany: internationalization, knowledge transfer and energy statistics. Funded by Federal Ministry for Economic Affairs and Climate Action, Germany, 2020-2021, € ~0.38 m.

GöMith

An-Projekt MEET – Erweiterung der Demosite Göttingen vom Campus auf das Stadtgebiet Göttingen durch Analyse der geologischen Bedingungen für die Energetische Nutzung der Mitteltiefen Geothermie (Analyses of the geological setting for the energetic utilisation of medium deep geothermal systems). Funded by the municipal utilities "Stadtwerke Göttingen GmbH", 2021-2022, € ~0.02 m.

projet LIFE (Lithium For Europe)

*Li-Capt process developed by GeoLith; from pilot phase to and industrial demonstration project
Partners: Geolith, Tronox, laboratoire Réactions et Génie des procédés de l'Université de Lorraine (LRGP), l'Institut Charles Sadron de l'Université de Strasbourg (ICS), le Laboratoire Lumière, nanomatériaux et nanotechnologies (L2n) de l'Université de Technologie de Troyes (UTT).
Budget: 1,6 M€, cofounded by Région Grand Est.*

RUGGERO BERTANI - EUROPEAN GEOTHERMAL INNOVATION AWARD - 2021 EDITION:

Company	Project	Location:country	Topic
Baker Hughes	Corrosion Resistant Podded Electrical Submersible Pump & Completion System	Netherlands	Geothermal production wells in the Netherlands are susceptible to corrosion along the wellbore due to high salinity contents in the well fluid leading to very expensive workovers on a regular basis. Baker Hughes Artificial Lift Systems has partnered with ECW Geomanagement BV (ECW) to design, develop and successfully execute an industry-first well completion that allows geothermal production to continue, and the casing to be protected against both localized and general corrosion. The completion includes an ESP deployed on production tubing, pressure sealed within a pod, and set in a custom completion system that also allows for deep corrosion inhibitor injection.
BBT SE - BrennerBasis Tunnel - Galleria di Base del Brennero	Smart Flowing - A geoexchangers prototype installed at the Brenner Base Tunnel	Italy	Smart Flowing, tailored for tunnels excavated by TBM (Tunnel Boring Machine), is a geoexchangers prototype consists in a modular horizontal closed-loop system located into the central drain formed by the invert elements of the exploratory tunnel's lining inside the Brenner Base Tunnel. The system consists of seven modules for a total length of 10.5 m and about 90 m of absorber pipes installed in contact with the lower invert segment, submerged by the water drained by the mountain tunnel and enclosed by the upper invert segment. Smart

			Flowing can be categorised into the closed-loop system family of horizontal collectors.
Celsius Energy	Celsius Energy System	France	<p>The Celsius Energy system is an innovative ground source heat pump system consisting of three main elements:</p> <ol style="list-style-type: none"> 1) A closed-loop geothermal energy exchanger, with U-shaped probes arranged in a pyramid-shape pattern to minimize its surface footprint; 2) A heat pump allowing simultaneous supply of heating and cooling; 3) A digital control system, minimizing electricity consumption and guaranteeing system performance by optimizing the use of the subsurface and of heat pumps, coupled to the building in real time. <p>The first Celsius Energy installation is located in Clamart, France. It has achieved reducing CO2 emissions by 90% and operating costs by 40%.</p> <p>Video overviews are available at http://youtu.be/v4ptE-9WExo and http://youtu.be/n6Bzo2-TL2g</p>
Comsof Heat, for their partnership with University of North Dakota	Mandaree, North Dakota: A Case Study on Oil and Gas Well Conversion to Geothermal District Heating Systems for Rural Communities	Belgium	<p>This scoping study sought to repurpose two of the many oil and gas wells found on the Fort Berthold Indian Reservation for geothermal district heating. The plan would provide heating for more than 200 structures and a 4km² greenhouse in a rural Native American community of North Dakota.</p> <p>Providing low-carbon energy alternatives to individual propane heating systems would reduce energy poverty by delivering</p>

and Reykjavik University			geothermal energy at a cost below that of fossil fuels. In addition to the emissions reductions, this project would help the Mandan, Hidatsa, and Arikara (MHA) Nation work towards energy sovereignty on their lands. Such a project would also give the oil and gas workforce of North Dakota another means to participate in the energy transition.
Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG	Energy concept for geothermal cooling and heating	Germany	The project outline describes the innovative integration of an absorption heat pump into a system of heat grids, allowing the heat from geothermally driven high-temperature heat grids to be used year-round to provide low-temperature heating or cooling.
Full-Metal-Power	Full-Metal-Power	Netherlands	Full-Metal-Power brings to reality the "Holy Grail" of PDM Drilling motor power sections. Through a specialized process of removing metal through Electrochemical Machining we are able to produce a stator and rotor with such accuracy that we have eliminated the need for elastomers.
Getech Group plc	Heat Seeker	United Kingdom (UK)	Heat Seeker (R) is an integrated approach to geothermal exploration and development that combines geoscience data, energy demand, and infrastructure information (including competing and complementary energy sources, both conventional and renewable) on a common geospatial platform early in the exploration and development life cycle to

			focus on opportunities with the lowest technical risk and highest potential social and financial return to maximize investment efficiency, decarbonization, and deployment speed.
GRE GEO Consortium / Geothermica	GRE GEO - Glass Fiber Reinforced Epoxy Casing System for Geothermal Application	Germany	The GRE-GEO (glass fiber reinforced epoxy casing for geothermal application) project is developing a new well completion strategy that aims to establish a corrosion-resistant alternative to the conventional steel casings, increasing the reliability and lifespan of the casing system, while avoiding extra investments for workover operations. Corrosion and scaling significantly reduce the lifespan of traditionally used steel casing systems, the primary function of which is to guarantee the wellbore integrity. Consequently, workover procedures are forced earlier than expected, and becoming a substantial financial burden. In contrast, Glass fiber casings (GRE) do provide a much-desired alternative as this material is corrosion resistant.
Helmholtz Centre Potsdam	Fluxtec	Germany	Gas emissions at the Earth's surface are fingerprints of deep geothermal resources. Area-wide information on emission rates and chemical composition provide reliable data on the fluid circulation in reservoirs and help to reduce the high exploration risks in geothermal projects. We have developed innovative workflows (TRL 8-9) for the systematic analysis of gases (e.g. CO ₂ , CH ₄) rising along permeable zones to the surface. In addition, we demonstrated that long-term

			<p>monitoring of gas emissions is a useful approach to understand changes in reservoirs due to exploitation (TRL 7-8). In 2021, the start-up project fluxtec was launched by Anna Jentsch and Egbert Jolie with the goal to become an international service provider for gas analytics.</p>
Izmir Institute of Technology	Capture and using CO2 as an inhibitor in geothermal power plant	Turkey	<p>Scaling is a serious issue for geothermal power plants since it remarkably decreases the harvesting of energy. For the cleaning of metal silicate scaling, the reduction of pH by CO2 has been an effective solution. In this project, CO2 gas is injected to the geothermal system to prevent the formation of metal silicate scaling which have employed in the Tuzla Geothermal Power Plant (TGPP) in Turkey for pH modification. With this study, the application of other inhibitors in TGPP system has ended. The use of CO2 provides serious contributions both environmentally and economically. It will be implemented in many power plants.</p>
MS Energy Solutions Ltd	WeHEAT Systems - Wells for Heat Exchanger Advanced Technologies	Hungary	<p>The WeHEAT technology developed by MS Energy Solutions Ltd. is a deep borehole heat producing system that can also be implemented in already drilled wells, therefore to reduce the CAPEX significantly, and to get rid of P&A costs for the o&g industry. Its greatest advantage is that it produces geothermal energy without extraction of formation water. It is a fully closed system that allows direct heat use for users living in the vicinity of the well through geothermal heat recovery. No emission, no OPEX, cheap sustainable green</p>

			energy. Installed in an already drilled well the capacity can be as high as 900kW of heat energy, drilling a specific well for a WeHEAT System can produce electricity too.
OGLombardia	TO PROTECT AND HEAT	Italy	The Project is a new method for heating and cooling buildings, with a low enthalpy geothermal system, which is implemented simultaneously with the attenuation of vibrations induced in the structures by seismic phenomena. It aims to provide low enthalpy geothermal energy and simultaneously protect buildings and structures from earthquakes.
Perryman Technologies Research	Geothermal Lithium Extraction	France	Full Spectrum Solar© Thermal Utilizing IXED & ultrasonics solar thermal powered separation chlorides & precipitation of Li ₂ CO ₃ from geothermal brine with H ₂ O recovery. The aim of the main processes are as follows: (1) the EID method is used to maximize the separation of magnesium and lithium from the brine to obtain a low Mg/Li anolyte; (2) removing the multivalent ions (e.g., Mg ²⁺ , Ca ²⁺ , and SO ₄ ²⁻) from the obtained anolyte via the NF method; (3) concentrating the permeate flow produced by NF with the RO method (we could use forced rapid evaporation here); (4) further increasing the lithium concentration by evaporation(we could use forced rapid evaporation here);

			(5) precipitating Li_2CO_3 by adding Na_2CO_3 (Sodium Carbonate).
Private	Heat extraction from dry hot wells	Italy	The project is aimed to extract energy from the dry, hot wells, that normally are dug, by mistake, when a geothermal field is developed. The idea is to increase the internal surface of the well, making it deeper and digging several sloping branch from its bottom, fill it with an high boiling temperature not polluting liquid, like molten salts, to fill every cracks in the well wall and to allow heat movement by convection, and finally insert into the liquid filled well an heat exchanger, to produce underground super heated water, that will be then sent to a flash steam turbine.
Storengy Deutschland GmbH	targeo - green heat for municipalities	Germany	According to a study conducted www.ifeu.de in 2017, around 40 % of the building stock is economically viable for heat pumps today, the double by 2050. With targeo, we offer municipal utilities and other regional heat transition players a software-supported consulting approach in which we identify technically feasible and economically suitable potential for ground-source heat pumps in a region. For this purpose, we superimpose different building and geothermal data and create an interactive map in which the technical suitability, the

			business case and the possible CO2 savings are shown for each building. Results are presented in digital twins which are basis of energy strategy definition of many market participants.
TERMOLINE Romania	Energy recovery system from thermally used geothermal	Romania	The project "Energy recovery system from thermally used geothermal water" consisting of a container equipped with geothermal probes where geothermal wastewater (used to heat buildings, pools, aquapark) is collected. It is primary energy source for GSHP working in tandem with hybrid HyHP (brine/air-to-water). HyHP are one of the novelties of the system: thermally used water does not have a constant regime as GSHP uses it as primary energy source. The air-to-water circuit of HyHP uses air a constantly available heat/cold source. When the wastewater in the container cools below 5°C, GSHP stop but the HyHP switches to air-to-water mode and continues to supply heat until of the water collected in the container will reach a designed temperature.

EGEC MARKET REPORT 2020/2021

The most relevant technological developments within the geothermal industry in 2021:

Innovation in geothermal power plant development

The geothermal project in Geretsried is now seeing an update by Canadian technology company Eavor Technologies. The project saw two drilling campaigns in the past that did not produce the necessary results for further successful development in 2013 and 2017. Now, with its technology of a closed-loop system, Eavor is targeting to extract the good heat resource discovered in the earlier drilling campaigns. The approval process via the Mining Office South with the government of Upper Bavaria is in the decisive phase. If everything goes as the investors and operators hope, construction of the first well is to begin in spring 2022. A total of four so-called loops, each with two boreholes, are planned.

In the Kirchstockach geothermal plant, city utility SWM decide to convert from an initial only power plant, to the co-production of geothermal heat from the plant for local district heating.

A special feature of Garching an der Alz geothermal plant in Bavaria, is the type of cooling, which, on the basis of continuous water cooling, enables significantly more efficient production processes and can thus convert more energy from the thermal water into electricity while at the same time using less electricity. So far, all existing German systems have run with air condensers.

Heating and Colling systems

The year 2021 marks the commissioning of new geothermal district heating and cooling in 9 different European countries, among which 3 are far from traditional geothermal district heating and cooling markets (Finland, Cyprus and Norway), materialising the geographical diversification of geothermal heating and cooling uses. Moreover, two systems are district cooling geothermal systems – or at least include some cooling capacity – which is another signal towards the role geothermal projects are going to play in an energy system where renewable cooling is an increasingly valuable resource.

R&I PUBLIC FUNDING INSTRUMENTS FOR INDUSTRY

EU State Aid Guidelines

The Commission adopted the current guidelines on State aid for environmental protection and energy measures in 2014. As part of its modernisation agenda, a 2021 initiative revises the guidelines against the backdrop of the industrial strategy, the digital transition and the European Green Deal. It aims at helping to transform the EU into the world's first carbon-neutral, circular and zero-pollution economy by 2050.

Pre-market technologies have a higher risk factor, which, when combined with their capital-intensive nature, requires additional State Aid support. Technology and project developers are often SMEs, research institutes and universities with limited resources. Furthermore, demonstration projects are usually small in scale, so these do not distort competition. Timely access to State Aid to advance EU expertise in renewable innovative technologies and bridge the gap between R&I stage and commercialisation is a vital component in delivering successful innovative renewable energy projects.

The revised Guidelines include important adjustments to align the rules with the Commission's strategic priorities, in particular those set out in the European Green Deal, and with other recent regulatory changes and Commission proposals in the energy and environmental areas, including the Fit for 55 package.

In particular, the CEEAG:

Broaden the categories of investments and technologies that Member States can support to cover all technologies that can deliver the European Green Deal. A new single section covers the reduction or avoidance of greenhouse gas emissions, facilitating the assessment of measures supporting the decarbonisation of different sectors of the economy, including through investments in renewable energy, energy efficiency in production processes and industrial decarbonisation, in line with the European Climate Law. The revised rules generally allow for aid amounts up to 100% of the funding gap, especially where aid is granted following a competitive bidding process, and introduce new aid instruments, such as Carbon Contracts for Difference to help Member States respond to the greening needs of industry.

Cover aid for numerous areas relevant for the Green Deal. This includes new or updated sections on aid for the prevention or reduction of pollution other than due to greenhouse gases, including noise pollution, aid for resource efficiency and circular economy, aid for biodiversity and for the remediation of environmental damage. Moreover, the CEEAG feature dedicated sections for aid incentivising investments in flagship areas such as energy performance of buildings, and clean mobility, covering all transport modes.

Introduce changes to the current rules on reductions on certain electricity levies for energy intensive users. The rules aim at limiting the risk that, due to these levies, activities in certain sectors move to locations where environmental disciplines are absent or less ambitious than in the EU. In order to cater for the enhanced decarbonisation efforts required to meet the EU climate targets, the CEEAG cover the reductions in all levies financing decarbonisation and social policies. Furthermore, with a view to enable Member States to maintain a level playing field, and based on objective indicators at sector level, the CEEAG have streamlined the number of eligible sectors. The rules have also been reviewed to better sustain the progressive decarbonisation of these companies by, among others, linking levy reductions to commitments by the beneficiaries to reduce their carbon footprint.

Introduce safeguards to ensure that the aid is effectively directed where it is necessary to improve climate and environmental protection, is limited to what is needed to achieve the environmental goals and does not distort competition or the integrity of the Single Market. In this respect, the CEEAG will for example enhance stakeholder participation in the design of large aid measures requiring Member States to consult stakeholders on their main features.

Ensure coherence with the relevant EU legislation and policies in the environmental and energy fields, by, among others, ending subsidies for the most polluting fossil fuels, for which a positive assessment by the Commission under State aid rules is unlikely in light of their important negative environmental effects. Measures involving new investments in natural gas are unlikely to be approved unless it is demonstrated that the investments are compatible with the Union's 2030 and 2050 climate targets, facilitating the transition from more polluting fuels without locking-in technologies that may hamper the wider development of cleaner solutions. The CEEAG also include a new section on aid for the closure of coal, peat and oil shale plants to facilitate decarbonisation in the power sector.

Increase flexibility and streamline the previous rules, also by eliminating the requirement for individual notifications of large green projects within aid schemes previously approved by the Commission.

Sustainable Finance regulations

Overview of the Sustainable Finance Framework

The sustainable finance framework aims to direct private and public financial flows towards companies, technologies and projects that are consistent with the long-term objective of a decarbonised economy. The framework is structured around a major concern of standardisation and preventing greenwashing, notably in light of the rapidly increasing number of “green” financial products. Overall, the Sustainable Finance framework seeks to identify a list of sustainable investments, increase the amount of money being channelled to such investments, and ensuring that these financial flows are robust both from an environmental and financial perspective. At the heart of the Sustainable Finance framework

is the European Taxonomy for Sustainable Investments which discriminates between investments that are sustainable and those that are not.

The Taxonomy, and the Sustainable Finance Regulation from which it derives, are only parts of the sustainable framework however. They are central components, but the robustness of the Taxonomy is for instance legitimised in principle by the Platform on sustainable finance, a group of experts who work to ensure the alignment of the sustainable finance criteria and their implementation are consistent with the environmental objectives at the core of the sustainable finance framework. Moreover, the success of the Sustainable Finance is very much reliant on the extent to which it is taken up by financial stakeholders as a relevant indicators of the “sustainability” of an investment portfolio or a financial product.

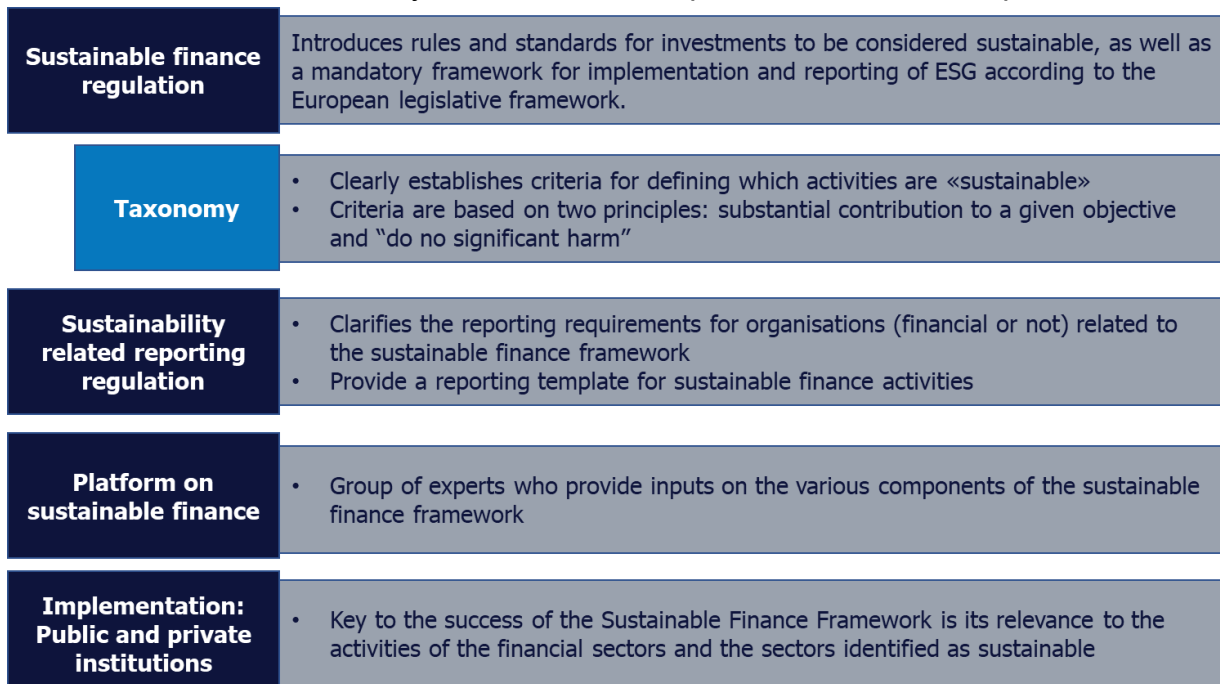


Figure 1. Main components of the Sustainable Finance Framework

A core matter of the sustainable finance framework is to answer the question “why should an investor or a project developer seek compliance with this scheme”. From the perspective of the European Commission developing the framework and based on the demands of the financial industry and industries potentially eligible as sustainable investments, the reasons would include:

- Increased transparency and reliability of “green finance” increases capital flows towards such products thanks to greater trust of consumers and investors;
- Greater “green finance” availability means lower cost of financing for project developers;
- Sustainable Finance Framework to prevent greenwashing and set thresholds for the consistency and robustness of ESG strategies of companies.

THE SUSTAINABLE FINANCE TAXONOMY AND GEOTHERMAL ENERGY

The environmental priorities of the sustainable finance taxonomy reflect the main areas of environmental regulation developed at the European level. Two fundamental principles allow to identify a sustainable investment: it must make a **substantial contribution** to a given environmental objective, and **it must do no significant harm to all the others**. This means that in principle a project which provides great climate change mitigation benefits but is not complying with requirements for water protection cannot be considered a sustainable investment. In practical terms, various “taxonomies” are being drafted to clearly define the eligibility of investments. The taxonomies for climate change mitigation and adaptation are already available. An additional taxonomy on local environmental impacts and a Social taxonomy are currently respectively on the drafting board and being discussed. The full list of environmental impacts that the taxonomy focuses on include:

- (a) climate change mitigation;
- (b) climate change adaptation;
- (c) the sustainable use and protection of water and marine resources;
- (d) the transition to a circular economy;
- (e) pollution prevention and control;
- (f) the protection and restoration of biodiversity and ecosystems.

For the purpose of this document, whenever we refer to the ‘taxonomy’ without any further precision, we will be referring to the Sustainable Finance Taxonomy on Climate Change Mitigation. This is indeed the category under which geothermal projects are most usually the target of investment as a renewable energy production technology.

Geothermal energy technologies are clearly identified as sustainable investments in the sustainable finance taxonomy. Geothermal power plants, geothermal district heating and cooling, geothermal cogeneration, geothermal heat pumps, ATES, UTES and other forms of thermal energy storage can all be eligible as a “sustainable investment”. They are however – like all investment categories identified in the taxonomy delegated act – required to comply with a set of criteria listed in the table below.

	Geothermal electricity	Geothermal CHP	Geothermal DHC	Geothermal heat pumps	Energy Storage
Emissions	LCE > 100gCO2e/kWh Verified by independent 3rd party	LCE > 100gCO2e/kWh Verified by independent 3rd party	LCE > 100gCO2e/kWh Verified by independent 3rd party	Refrigerant GWP <675 Compliance with Ecodesign	The activity stores thermal energy, including UTES or ATES
Adaptation	No specific criteria	No specific criteria	No specific criteria	No specific criteria	No specific criteria
Water protection	No specific criteria	No specific criteria	No specific criteria	No specific criteria	No specific criteria
Circular economy	n/a	n/a	n/a	Emphasis on circularity in supply chain	Waste management required
Pollution prevention	Compliance with EU air quality legal framework	Compliance with EU air quality legal framework	Compliance with EU air quality legal framework	n.a.	n.a.
Biodiversity	No specific criteria	No specific criteria	No specific criteria	n.a.	No specific criteria

Table 1. Criteria for geothermal technologies in the sustainable finance taxonomy on climate change mitigation¹.

Geothermal technologies fall within 5 different categories of sustainable investments. This raises some questions for implementation: what happens when a project ticks several boxes. Cases of geothermal heating and cooling projects that include both a heat pump and a thermal storage component are not uncommon for instance. This should however only be a minor issue which would not impact greatly financial flows: geothermal project would either be assimilated to their dominating category, or broken down according to investment expenditure per category (the later option requiring further reporting from the part of financing actors).

A more salient topic in the case of geothermal projects' compliance with the sustainable finance taxonomy regards the issue of the threshold on life-cycle emissions that geothermal power, cogeneration and heating and cooling plants are required to demonstrate compliance with. Doing a full LCE (Life Cycle Emissions) assessment before an investment is not practical (or even always possible) endeavour, nor indeed is it a cheap one. Moreover, stakeholders in the geothermal sector will be quite aware that the natural emissions of the geothermal resource must be deducted from the footprint of the power plant. The GEOENVI project has anticipated these challenging questions and developed a simplified methodology for geothermal project developers to be able to assess the LCE emissions their projects are likely to have. Such simplified tools and services are likely to be the core drivers of implementation and verification of this LCE thresholds for reasons of practicality: if not the cost of the certification as a sustainable investment is likely to significantly exceed the benefits.

The sustainable finance taxonomy is supposed to be an evolving document to reflect the reality of the industries, but also to progressively align requirements more closely with the requirements of an increasingly decarbonised economy. In the case of geothermal projects for instance, this can include a progressive lowering of reporting requirements (especially regarding LCE compliance) since a greater amount of LCA (Life Cycle Analysis) availability will contribute to demonstrate the systematic compliance of geothermal project with the criteria (especially in the case of binary plants, CHP or heating and cooling projects).

¹ All Life Cycle Emission thresholds listed must "calculated using Commission Recommendation 2013/179/EU or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018." For more information on the question of geothermal life-cycle emissions, you may refer to www.geoenvi.eu

The GEOENVI Simplified Life Cycle Assessment Tool

It is unpracticable for a project developer to undertake a full LCA of its project before any investment has taken place. Indeed, the actual parameters of the projects can usually only be know after the first well has been drilled – i.e. after spending an important part of the CAPEX. The GEOENVI project, funded by the European Union Horizon 2020 programme, has brought together academia and industry to design a simplified tool that can help project developers evaluate the impact of their investments prior to construction based on best available scientific knowledge. The LCA tool allows developers to estimate the life cycle impact for various geothermal technologies (from power plants to district heating and cooling projects) across a wide range of environmental impacts.

This tool is a crucial tool to provide reliable and transparent indicators to investors looking to invest in a geothermal project for compliance with the Sustainable Finance Framework. It has been developed according to the same ISO standards required by the Taxonomy Delegated Act to ensure consistency with the sustainable finance framework.

Implementation of the sustainable finance framework: what outlooks for the geothermal industry?

The sustainable finance framework may be an opportunity for geothermal project developers, allowing them to access financing more easily at a cheaper cost. On the short term however, this new framework is unlikely to significantly change the financing conditions for geothermal projects since gas, the most significant competitor of geothermal projects in attracting financing (whether for the provision of baseload and flexible electricity or for the production of heating and cogeneration) is set to be considered a sustainable investment like geothermal energy² is.

The sustainable finance framework will first impact companies and stakeholders in the financial sector which will be required to report the consistency of their books with the sustainable finance taxonomy. This may lead to some reporting requirements for project managers and developers. Indeed, the sustainable finance framework will apply as much to existing loans provided to a geothermal power plant for instance, and for upcoming projects. For geothermal project developers the sustainable finance framework is susceptible to impact:

- Public finance: financing from public financial institutions to renewable energy projects is going to be rapidly aligned with the sustainable finance framework. The European Investment Bank, which has for instance provided a loan for several tens

² Actually, gas projects can be deemed eligible even if they generate operational emissions up to 270 gCO₂eq/kWh for heating, cogeneration and up to 550 kgCO₂e/kW for electricity projects, a much more permissive threshold that that required for other technologies – including geothermal – across the taxonomy.

of million euros to geothermal developers in the Netherlands has stated that it will be looking to align its energy lending criteria with the Taxonomy. Other public investment banks are likely to follow as the legislative package underlying the sustainable finance comes into force.

- Geothermal derisking: geothermal risk mitigation schemes are largely financed and managed via public financial institutions or direct public support which means they will likely be increasingly considered as a sustainable finance scheme. This can be quite interesting for increasing the visibility of such schemes and attracting private finance towards them – although this will only be a possibility in markets where maturity is high enough for the funds to have a sufficient degree of profitability to interest private stakeholders. In an early phase, such derisking funds could however be relevant for actors of the insurance sector looking to increase their exposure to sustainable finance schemes.
- Availability of green finance: In the medium term, the sustainable finance scheme could allow geothermal project developers to access financing at a lower price. This will however be a secondary factor in the cost of financing which will continue to be primarily defined by the specific level of risk of an investment, which in many cases requires dedicated derisking schemes in the geothermal sector. For the geothermal heat pump sector however, we may see the emergence of funding schemes to finance large scale deployment of heat pumps on models already observed for instance in the US in the solar panel industry. This however requires a high degree of standardisation of geothermal heat pump projects.

Takeways:

- **Ambivalent policy:** The sustainable finance framework is not going to restructure the energy system by itself, and is mostly a nudge for the financial sector. For this reason the prospects for the geothermal industry lack clarity and certainty in the early phase of implementation. Moreover, the lack of internal consistency of the taxonomy in terms of reporting requirements or even thresholds is an issue for the credibility of the framework.
- **Evolving text, subject to political forces**
- **Geothermal is a sustainable investments** – criteria must be refined to aligned with reality of the sector
- **Requirements of reporting are yet to be clarified**, especially for new projects

EU Funding Instruments

To facilitate the access of geothermal industry to EU public funding opportunities, the Support Unit prepared and published a series of factsheets on EU funding instruments. These factsheets are accessible on the DG-IWG website.

Innovation Fund

The **Innovation Fund** just like its predecessor, NER300, is one of the world's largest funding programmes for demonstration of innovative low-carbon technologies and a key funding instrument for delivering the EU's economy-wide commitments under the Paris Agreement. It also supports the European Commission's strategic vision of a climate neutral Europe by 2050. The Innovation Fund will focus on:

- Innovative low-carbon technologies and processes in energy intensive industries, including products substituting carbon intensive ones;
- Carbon capture and utilisation (CCU);
- Construction and operation of carbon capture and storage (CCS);
- Innovative renewable energy generation;
- Energy storage.

The budget of the Fund will be combined with the revenues from the EU Emissions Trading System (EU ETS) – from the auctioning of 450 million allowances from 2020 to 2030, and any unused funds from the NER300 programme. The total budget may amount to about €12 billion, depending on the carbon price.

The Innovation Fund will address several objectives:

- help create the right financial incentives for projects to invest now in the next generation of technologies needed for the EU's low-carbon transition;
- boost growth and competitiveness by empowering EU companies with a first-mover advantage to become global technology leaders;
- support innovative low-carbon technologies in all Member States in taking off and reaching the market.

The Innovation Fund has taken into account the main lessons learned from its predecessor, the NER300 programme. As a result, the following aspects have been improved:

- It is open to projects from energy intensive industries;
- It improves the risk-sharing for projects, which means that its grants cover up to 60% of the additional capital and operational costs of innovation;
- It provides support in more flexible way, following the cash-flow needs of the project through pre-defined milestones;
- It has a simpler selection process and stronger synergies with other EU funding programmes.

It will focus on highly innovative technologies and big flagship projects with European value added that can bring an significant emission reductions. It is about sharing the risk with project promoters to help with the demonstration of first-of-a-kind highly innovative projects. It aims to finance a varied project pipeline achieving an optimal balance of a wide range of innovative technologies in all eligible sectors (energy intensive industries, renewable energy, energy storage, CCS and CCU) and Member States. At the same time, the projects need to be sufficiently mature in terms of planning, business model and financial and legal structure. The Fund will also support existing projects on innovative low-carbon solutions that lead to emission reductions in multiple sectors, for example through industrial symbiosis or business model innovation. It is also open to small-scale projects with total additional costs under €7.5 million which can benefit from simplified application and selection procedures.

Recovery and Resilience Facility

The **Resilience and Recovery Facility (RRF)** launched in July 2020, is designed to inject additional funding into Member States to aid their economic recovery after the COVID-19 pandemic. It supports projects and programmes (sometimes referred to as reforms) which deliver 'green and digital transitions' and contribute to 'strengthening the growth potential, resilience and cohesion of the Member State concerned'.

€10 billion grants and €26 billion loans will be made available, in conjunction with other 'Next Generation EU' funds, to Member States.

The aim is for governments to outline how they will stimulate and reform their economies to deliver 'smoother' longer outcomes by 2024. The funds are dispersed depending on the applications made from Member States in their national RRF Facility bids.

THE PROCESS

1. Member States will submit Recovery and Resilience plans to the Commission from 2020 to 2022. They have to be submitted by 30 April, each year. To obtain funding in that year.
2. Given the urgency of the need for economic stimulation, governments have been asked to prepare draft RRFs by September 2020 already.
3. This allows for feedback/consultation with Member States before finalising funding. Should there be problematic projects submitted, this gives time for them to be raised to the European Council meeting in October. Otherwise, the Commission will then adopt a decision (Commission decisions cannot be amended by the Council of Parliament) endorsing that they are to be fast-tracked for financing.
4. The Commission will publish each Member State's RRF plan to allow for oversight from the European Council, Council and European Parliament. These plans will have to fit into European Semester as well as National Climate & Energy Plans (NCEPs), Just Transition plans and Partnership Agreement plans (linked to Cohesion funding).
5. The Commission will report annually on the progress of investments against the RRF plans.

PROJECTS AND PROGRAMMES/REFORMS

• **Projects:** These can be central of different TRL levels or specific investments that were held updated/developed by the pandemic.

• **Programmes/reforms:** This applies to national legislation and enabling frameworks such as subsidies. They need to be eligible for EU funding as grants or loans. New investment programmes or reforms to existing programmes can also be suggested to the government.

Note: There is scope for funding source reform. So projects that could be innovative (and applicable to the EIS) but have financial gaps are eligible, as are digital, as well as green, industries. But are not unduly constrained due to financial constraints which could be attributed to the pandemic.

Just Transition

Just Transition Mechanism

The **Just Transition Mechanism** is a new funding instrument of the EU that has been announced by the Commission President Ursula von der Leyen as part of the European Green Deal. To ensure no one is left behind, the Just Transition Mechanism will mobilise at least €100 billion of investments over 2021-2027 with financing coming from the EU budget, co-financing from Member States as well as contributions from InvestEU and the European Investment Bank (EIB). Extrapolated over ten years, the Just Transition Mechanism will mobilise around €140 billion.



The Just Transition Mechanism will focus on the social and economic costs of the transition in the most impacted regions and finance projects ranging from creation of new workplaces through support to companies, job search and re-training assistance for jobseekers who lost employment due to the transition, but also renovation of buildings and investments in renewable energy, district heating networks and sustainable transport.

Just Transition Fund

The **Just Transition Fund** is the first pillar of the Just Transition Mechanism. The fund will be equipped with €40 billion (as of July 2020 this is the final number proposed by the European Commission, subject to IMF regulations). This amount corresponds to fresh money made available to support EU countries in their transition, out of which €10 billion should come from budget appropriations, while the remaining additional resources of €30 billion, covering the period from 2021 to 2024, will constitute external assigned revenue stemming from the European Recovery Instrument.

LIFE Programme 2021 – 2027

Programme design

LIFE is a funding programme dedicated to environmental and climate objectives. It is divided in two main portfolios - Environment and Climate Action. Each portfolio covers two main sub-programmes.

ENVIRONMENT	CLIMATE ACTION
Nature and Biodiversity	Climate Change Mitigation and Adaptation
Circular Economy and Quality of Life	Clean Energy Transition

The **Clean Energy Transition** sub-programme is a new feature of LIFE 2021-2027. It is the first time that the clean energy transition is specifically covered within LIFE programme. It will be a continuation of the marketable activities that were funded under Horizon 2020. The aim is to support the shift towards a clean energy, especially in regions that lag behind and have difficulty to attract funding from the European Structural and Investment Funds. It will encourage investments in projects focusing in particular on energy efficiency and small-scale renewables.

Budget

The European Commission proposed in June 2018 a regulation¹ establishing the LIFE programme for the period 2021-2027. Funding for this Programme comes from the EU's Multiannual Financial Framework (MFF). The current proposal is for €5.45 billion or 2.43% to be used for the Fund 1. The final budget for the LIFE Programme depends on the outcome of the MFF negotiations. Comparing to the current LIFE 2014-2020 programme, the proposed budget will increase.

FIG 1. ALLOCATION OF LIFE BUDGET FOR SUB-PROGRAMMES

Connecting Europe Facility

The **Connecting Europe Facility (CEF)** is one of the key EU funding instruments to promote growth, jobs and competitiveness through targeted infrastructure investment at European level. It fills the missing links in Europe's energy, transport and digital backbone and supports the development of high performing, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services.

The CEF benefits people across all Member States, as it makes travel easier and more sustainable, it enhances Europe's energy security while enabling wider use of renewables, and it facilitates cross-border interaction between public administrations, businesses and citizens.

In addition to financial grants, the CEF offers financial support to projects through innovative financial instruments such as guarantees and project bonds. These instruments create significant leverage in the use of EU and state aid as a catalyst to attract further funding from the private sector and other public sector actors.

The Innovation and Networks Executive Agency (INEA) implements most of the CEF programme budget. In the next long-term EU budget 2021-2027, the European Commission has proposed to renew the Connecting Europe Facility, allocating €4.2 billion to support investments in European infrastructure networks, including €3.7 billion for energy.

The CEF is divided into three sectors:
CEF Energy
CEF Transport
CEF Telecom

CEF ENERGY

The EU's energy infrastructure is aging and, in its current state, not suited to match future demand for energy, to ensure security of supply or to support large-scale deployment of energy from renewable sources. Despite the regulatory, financial and policy framework that exists to stimulate such investments, under current market and regulatory conditions some energy projects are not commercially viable and would normally not make it into investment programmes of infrastructure developers.

CEF is envisaged to address both groups of factors behind the investment gap in the energy sector. Financial instruments, by bringing in new classes of investors and mitigating certain risks, will help project promoters to access the necessary financing for their projects. Grants to contribute to the construction costs will be applied to fill the gaps in commercial viability of the projects that are particularly relevant for Europe.

A total budget of €5.25 billion is made available for energy projects for the 2014-2020 period, of which €4.6 in the form of grants managed by INEA.

Sustainable Europe Investment Plan

What is the Sustainable Europe Investment Plan?

The **Sustainable Europe Investment Plan**, often referred to as the European Green Deal Investment Plan (EGDIP), represents the main investment pillar of the EU Green Deal. It will have to mobilise at least €1 trillion in sustainable investments over the next decade in order to achieve a climate-neconomy by 2050.

The Sustainable Europe Investment Plan sets out three main goals:

- It has to increase funding for the transition and mobilise at least €1 trillion to support sustainable investments over the next decade through the EU budget and associated instruments in particular InvestEU;
- It has to create an enabling framework for private investors and the public sector to facilitate sustainable investments;
- It has to provide support to public administrations and project promoters in identifying, structuring and executing sustainable projects.

HOW WILL IT BE FINANCED?

The European Commission published a graph explaining the financing for this instrument. Currently, the main contributors to the EGDIP will be the EU's budget, EIB, contributions from the



Member States and private investors. It is clear that the EU budget alone cannot be enough to meet

¹EU Commission, COM, The European Green Deal Investment Plan and Just Transition Mechanism explained, https://ec.europa.eu/economy_finance/infographic_en

The Modernisation Fund

The **Innovation Fund** just like its predecessor, NER300, is one of the world's largest funding programmes for demonstration of innovative low-carbon technologies and a key funding instrument for delivering the EU's economy-wide commitments under the Paris Agreement. It also supports the European Commission's strategic vision of a climate neutral Europe by 2050. The Innovation Fund will focus on:

- Innovative low-carbon technologies and processes in energy intensive industries, including products substituting carbon intensive ones;
- Carbon capture and utilisation (CCU);
- Construction and operation of carbon capture and storage (CCS);
- Innovative renewable energy generation;
- Energy storage.

The Modernisation Fund

The initiative for the fourth phase of the EU ETS Directive (2018/1534), covering the period 2021 - 2030, introduced a number of important changes concerning the funding mechanisms in the EU system. Among these changes, a new funding instrument was put in place: the Modernisation Fund.

The Modernisation Fund is a totally new funding instrument that is meant to support investments proposed by the eligible EU Member States, including the financing of small-scale investment projects, to modernise energy systems and improve energy efficiency. It will operate under the responsibility of the beneficiary Member State. As for now, the ten beneficiary member states are the following: Bulgaria, Czech Republic, Estonia, Croatia, Latvia, Lithuania, Hungary, Poland, Romania and Slovakia.¹

The Modernisation Fund will be made up of two percent of the total quantity of allowances available during Phase 4, which shall be moved between 2021 and 2030.

The European Investment Bank (EIB) will supervise the funding allocation mechanism and selection process.

In order to use the Modernisation Fund for financing investments, the Member State has to propose investments to the EIB first and to the investment operator. This investment operator consists of 15 members: the ten beneficiary Member States, the European Commission, the EIB and three

¹ European Commission, COM, Climate, Innovation and Modernisation Fund presentation, 12 September 2018, https://ec.europa.eu/economy_finance/infographic_en

Horizon Europe Programme

Horizon Europe will be the EU's next Framework Programme for Research and Innovation that will replace Horizon 2020. It will run from 2021 to 2027 with a proposed budget of €100 billion. Set to launch in 2021, Horizon Europe will build on the achievements and success of Horizon 2020, bridging the past and the future of research and innovation in Europe.

It has a slightly different structure than its predecessor and a larger budget (the European Commission is proposing a total budget of €100 billion for 2021-2027), with keeping with the design of its predecessor, Horizon Europe is divided into three main pillars:

- Excellent Science;
- Global Challenges;
- European Industrial Competitiveness.

While Horizon 2020 was structured around seven main Societal Challenges, Horizon Europe identifies five overarching Global Challenges for Action: Health, Industry and Secure Society, Digital and Industry, Climate, Energy, and Mobility and last but not least Food and Natural Resources. At the same time, Horizon Europe will continue to drive Europe's scientific excellence through the European Research Council (ERC) and the Marie Skłodowska-Curie fellowships and exchanges and draw on the scientific advice, technical support and dedicated resources of the Joint Research Centre (JRC). It will also add a new level of ambition and boost the scientific, economic and societal impact of EU funding.

Horizon Europe will also introduce several new main features:

- A European Innovation Council (EIC) to help the EU become a frontrunner in market-creating innovation;
- New EU-wide research and innovation missions focusing on societal challenges and industrial competitiveness;
- Maximising the innovation potential across the EU;
- The principle of open science that will require open access to publications and data;
- A new generation of European Partnerships and increased collaboration with other EU programmes.

The 2021-2027 programme will also five mission areas: adaptation to climate change including social transformation, carbon, climate-neutral and smart cities, healthy oceans, seas, coastal and inland waters, soil health and food. Each mission will have a dedicated mission board and assembly.

Horizon Europe also aims at creating a new generation of European Partnerships and increasing their effectiveness and impact, by regrouping the current landscape into three new types of partnerships (co-funded, co-programmed, institutionalised) and rationalising the overall number of initiatives.

Assessment of private sector investment in R&I (2021)

As highlighted in D4.2, **private financing is leading the investments race in R&I on the European level**. According to the European Commission's *Report on the progress of clean energy competitiveness*, the EU has invested in recent years an average of **nearly EUR 20 billion a year on clean energy R&I** prioritised by the Energy Union³:

- EU funds contribution - 6%
- Public funding from national governments accounts - 17%
- **Business contribution estimated - 77%**

To support the statement above, the case studies below and the answers to the 2021 questionnaire provide a few examples of successful private sector investment in R&I within geothermal energy industry.

ANSWERS TO THE QUESTIONNAIRE 2021 ON SURVEY ON THE R&I SWITCH FROM OIL AND GAS TO GEOTHERMAL

I. Company's Research and Innovation background

As expected, it is hard to estimate the total number of employees in geothermal research and innovation department of oil&gas companies as most people who work in geothermal also support oil&gas as well either in sales or technological development.

One can assume that more than 10,000 persons active in oil&gas are also doing innovation for geothermal.

We assume that developing technology that works for geothermal is also supporting O&G and vice versa.

It is interesting to highlight that the geographical coverage of these research activities are global or national, nearly none of them are at European scale.

II. R&I investment level and switch to geothermal

The amount of R&I investment and the switch to geothermal was not answered by many companies as it was considered as a Confidential information

But R&I activities performed by subsurface services companies in exploring, evaluating, drilling and operating geothermal resources are significant. They have also developed

³ Report from the Commission to the European Parliament and the Council on progress of clean energy competitiveness,

https://ec.europa.eu/energy/sites/ener/files/report_on_clean_energy_competitiveness_com_2020_953.pdf

numerical models for 80% of the operating geothermal power projects around the world. This work has led to the successful installation and operation of ca 2,000 MW of geothermal power in Europe and 8,000 Mwe globally. It enabled more than USD 20 billion in geothermal project financing.

In conclusion, it was highlighted that the main barrier that are stopping oil&gas companies and organisations from investing in geothermal projects/technologies is the lack of potential and replicability of their products

Conclusion

The report concludes that the global and European landscape of private investments in geothermal and other renewables is showing a rather decreasing trend for 2 years. The COVID pandemic has also an impact on the overall investment rate in geothermal energy and had also affected the R&I aspects of technology development.

Despite this trend, the EU should act to avoid the scaling back of private investment in the clean energy industry. It needs to better evaluate the impact of EU energy R&I funding, notably in the context of the REPowerEU plan, the EU economic recovery, ensure the alignment of EU and national priorities (under the Strategic Energy Technology Plan) in the NECPs, and boost private capital and innovation.

An effort to reverse this trend will have to be made by both: public and private sectors. This report also includes an overview of EU funding instruments that are available across the entire innovation value chain, with programmes for energy research, development and innovation (RD&I). This information is crucial for private actors that want to co-finance European or national R&I projects.

To sum up, aligning the SET Plan priorities with the economic recovery and involving private companies in delivering new geothermal technologies is key.

Annex 1: Questionnaire 2020 on 2019 activities

Questionnaire

Objective

This questionnaire is addressed to private companies that are working in geothermal Research & Innovation (R&I). The goal is to collect data on the annual expenditure of geothermal private actors on R&I activities and projects. This information is crucial for understanding the funding needs of the European geothermal industry and its contributions to the 10 RD&I actions set by the revised SET-Plan - Deep Geothermal Implementation Working Group's [Implementation Plan](#).

Company's background

1. Total number of employees in your (geothermal) research department in 2019?
2. On how many R&I projects are you currently working on? How many of them are focused on geothermal?
3. What is the geographical coverage of these research activities: only in your country, in several countries in Europe, globally?

R&I investment level

1. What triggers innovation projects in your company today? (possibly of multiple choices)
 - Emergence of new technologies
 - Emergence of new business models
 - Market changes (e.g. demographics, macroeconomics)
 - Need to expand to new markets
 - Need to improve cost efficiency
 - Change in regulations
 - Government incentives
 - Other (please specify)
2. What was your R&I investment in the year 2019? (if available, also for previous years)
 - Amount in €
 - % of the turnover
3. How much of this R&I investment would fall into the following categories?

Basic research (including exploratory activities) _____ %

Applied research/technology development _____ %

Development for market launch/uptake _____ %
other (please specify): _____ %
Total %

4. At what average rate do you expect the company to change (increase or decrease) its overall R&I investment over the next 5 years (2020-2025) (if relevant)?
About _____ % per year
5. At which technology readiness level (TRL) level do you focus?
6. What is for your company the most important element when designing new technologies?
7. Did your company already co-financed any national or European geothermal R&I project?
- Yes
- No

If yes, what was the share of your contribution (in EUR or %) for such projects? Can you provide any examples?

8. Did you apply for any national private financing schemes/funds to support your geothermal R&I projects?
- Yes
- No

If yes, can you provide information on the share (in EUR or %) of these national private financing schemes/funds for your geothermal R&I projects

Market uptake

1. Did you already commercialise some of your innovation project results/technologies?
2. If yes: on which markets did you commercialise these?

Barriers

1. What are the main obstacles to foster innovation within your company today?
2. Have your R&I projects been impacted by the COVID-19 lockdown in your country?

Your contribution to the 10 RD&I actions as set by the revised Implementation Plan of the SET Plan IWG on deep geothermal.

Please indicate below (in % or in € million) to which extent your R&I activities and projects are contributing to the 10 RD&I actions of the revised Implementation Plan of the Deep Geothermal IWG:

- Geothermal heat in urban areas
- Integration of geothermal heat and power in the energy system and grid flexibility
- Improvement of overall geothermal energy conversion performance for electricity, heating and cooling generation
- Closed loop electric, heating and cooling plants integrated in the circular economy
- Methods, processes, equipment, and materials to ensure the steady availability of the geothermal resources and improve the performance of the operating facilities
- Development and exploitation of geothermal resources in a wider range of geological settings
- Advanced drilling/well completion techniques
- Innovative exploration techniques for resource assessment and drilling target definition
- Increasing awareness of local communities and involvement of stakeholders in sustainable geothermal solutions
- Risk mitigation (financial/project)

➤ Other comments/input

Annex 2: Questionnaire 2021 on Survey on the R&I switch from oil and gas to geothermal

Survey on execution of the Deep Geothermal Implementation Plan by companies

- III. Company's Research and Innovation background
 - 1. Total number of employees in your (geothermal) research and innovation department in 2020
 - 2. How many geothermal research and innovation projects do you currently have in the pipeline?
 - 3. Geographical coverage of the research activities
What is the geographical coverage of these research activities
 - a) Only in your country
 - b) in several European countries
 - c) On the global level

- IV. II. R&I investment level and switch to geothermal
 - 1. In the last 3 years, has your company invested / considered to invest in geothermal technologies or geothermal R&I projects?
 - 2. If yes, what triggered the switch to geothermal energy? (possibility to choose multiple answers):
 - a) Governmental push or new policy initiatives (i.e. European Green Deal, Climate Neutrality for 2050, national climate and energy targets etc.)
 - b) Emergence of new business models (based on corporate sustainability, combining the financial and environmental goals etc.)
 - c) Expand into a new market, transfer technologies and skills
 - 3. If no, what are the main barriers that are stopping your company/organisation from investing in geothermal projects/technologies?
 - a) High upfront costs
 - b) Insufficient funds to develop geothermal projects
 - c) Lack of technical expertise
 - d) Lack of potential/replicability

- V. III. Additional questions
 - 1. what is your average annual R&I investment in geothermal operations? (average amount in € or % of the company's turnover)
 - 2. On which areas are your focusing
 - 3. Other comments and final inputs (links to publications, websites etc.)