

# Annual report on execution of the Deep Geothermal Implementation Plan by companies

YEAR 1

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**Deep GEOTHERMAL IWG**  
SUPPORT UNIT



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## Introduction

This annual report on execution of the Implementation Plan (IP) by geothermal companies presents the results at the end of 2019 about how much the geothermal industry contributes to this SET Plan activity.

This annual report prepared by EGEC will be updated in January 2021 and January 2022.

The objective is to facilitate the execution and to monitor the implementation of the IP for the industry part. In order 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 & Strategy support (WP6&7) to ensure its treatment and the proper monitoring of the execution of the IP and the improvement to reach the targets.

Industry also provides feedbacks on the RD&I public funding programmes available in Europe.

In 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 questionnaire (*annex 1*) was created and it started to be disseminated in 2019 in order to collect data from the private sector on their investment in research and innovation. These data will be treated to be reported in the second annual reporting in year 2.

It is already assumed a volume higher than €85 millions (€ 84.674.045 just via co-funding of european projects) invested by the private sector in Research & Innovation for deep geothermal for the period 2018-2020, with an annual basis of about € 30 Mln.

## Methodology of the deliverable

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

Market actors have been regularly briefed about the 10 RD&I actions as set by the IP: events in The Hague, The Netherlands (EGC2019) on 13 June 2019, and 23 September 2019 in Brussels.

They have also received detailed information with factsheets produced on funding instruments (D4.2).

EGEC is monitoring the IP execution with several tools:

- The annual EGEN Market reports which present market developments in Europe with details on deep geothermal plants: size, capacity factor...
- The series of events organised every year and largely attended by industrial stakeholders such as the 2019 workshop on the Innovation Fund and the European geothermal Congress
- The ETIP DG and ETIP-RHC (geothermal panel): regular meetings with reporting on R&I results
- EGEN annual innovation award “EGIA”

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

They refer to co-funded projects, with a public and private financial contribution, supported by European programmes such as Horizon2020, Interreg, COSME; supported by National public contribution to European funds such as ERANET: Geothermica and GeoERA.

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

The next version of this reporting will be more exhaustive benefiting from data collection operated by the SET Plan and the IWG annual reports. The answer to the questionnaire (see *annex*) from the private sector will complete the data collection.

## Involvement of private actors in the IP

The SET Plan Temporary Working Group Deep Geothermal Implementation Plan identified 10 areas of priorities for RD&I actions in the deep geothermal sector. These priorities include:

- Geothermal heat in urban areas;
- Materials, methods and equipment to improve operational availability
- Enhancement of reservoir (conventional and unconventional);
- Improvement of performance;
- Exploration techniques;
- Drilling techniques;
- Flexibility from geothermal CHP plants;
- Zero emissions power plants;
- Community and stakeholder acceptance of geothermal projects;
- Risk mitigation.

These various 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 TWG 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; supported by National public contribution to European funds such as ERANET: Geothermica and eventually GeoERA. Moreover, the report covers major national or trans-national research projects with potential input from companies.

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

## European projects

Project name (min. > € 1 mln)	Website or short description	Start year	End year	Budget / Funding (EUR million)	Relevant activities addresse d/ targets achieved	Results open to SET Plan communi ty (Y/N)
<b>GEOHERMICA</b>						
<b>CAGE</b>	<a href="http://www.geothermica.eu/projects/cage/">http://www.geothermica.eu/projects/cage/</a>	2018	2021	13.5 / 5.8	R&I 6	Y
<b>COSEISMIQ</b>	<a href="http://www.geothermica.eu/projects/coseismiq/">http://www.geothermica.eu/projects/coseismiq/</a>	2018	2021	2.5 / 1.1	R&I 3, NTBE A	Y
<b>GeConnect</b>	<a href="https://www.geothermalresearch.eu/geconnect/">https://www.geothermalresearch.eu/geconnect/</a>	2018	2021	1.2 / 0.9	R&I 3, 6	Y
<b>GEOFOOD</b>	<a href="https://geofoodproject.eu/">https://geofoodproject.eu/</a>	2018	2021	1.7 / 1.2	R&I 7, NTBE A	Y
<b>GEO-URBAN</b>	<a href="http://www.geothermica.eu/projects/geo-urban/">http://www.geothermica.eu/projects/geo-urban/</a>	2018	2021	0.7 / 0.5	R&I 1	Y
<b>HEATSTORE</b>	<a href="https://www.heatstore.eu/project.html">https://www.heatstore.eu/project.html</a>	2018	2021	16.3 / 8.3	R&I 1, 7	Y
<b>PERFORM</b>	<a href="http://www.geothermica.eu/projects/perform/">http://www.geothermica.eu/projects/perform/</a>	2018	2021	3.0 / 2.2	R&I 2, 4	Y
<b>ZoDrEx</b>	<a href="http://www.geothermica.eu/projects/zodrex/">http://www.geothermica.eu/projects/zodrex/</a>	2018	2021	4.9 / 2.9	R&I 6, 3	Y
<b>Horizon 2020</b>						
<b>CARBFIX2</b>	<a href="https://www.carbfix.com/">https://www.carbfix.com/</a>	2017	2021	2.2 / 2.2	R&I, 8	Y
<b>CHPM2030</b>	<a href="https://www.chpm2030.eu/">https://www.chpm2030.eu/</a>	2016	2019	4.2 / 4.2	R&I 3	Y
<b>CoolHeating</b>	<a href="https://www.coolheating.eu/en/">https://www.coolheating.eu/en/</a>	2016	2018	1.6 / 1.6	R&I 1, 7	Y
<b>DEEPEGS</b>	<a href="https://deepegs.eu/">https://deepegs.eu/</a>	2015	2019	42 / 19	R&I 3, 6	Y
<b>DESCRAMBLE</b>	<a href="http://www.descramble-h2020.eu/">http://www.descramble-h2020.eu/</a>	2015	2018	15.7 / 6.8	R&I 6, 3	Y
<b>DESTRESS</b>	<a href="http://www.destress-h2020.eu/en/home/">http://www.destress-h2020.eu/en/home/</a>	2016	2020	24.7 / 10.7	R&I 3, 6	Y
<b>EoCoE-II</b>	<a href="http://www.eocoe.eu">www.eocoe.eu</a>	2019	2021	8.6 / 8.3	R&I 5	Y
<b>GECO</b>	<a href="https://geco-h2020.eu/">https://geco-h2020.eu/</a>	2018	2022	18.2 / 15.6	R&I 8	Y
<b>GeMex</b>	<a href="http://www.gemex-h2020.eu/index.php?lang=en">http://www.gemex-h2020.eu/index.php?lang=en</a>	2016	2020	10 / 10	R&I 3, 5	Y
<b>Geo-Coat</b>	<a href="http://www.geo-coat.eu/">http://www.geo-coat.eu/</a>	2018	2021	4.7 / 4.7	R&I 2	Y
<b>GEOENVI</b>	<a href="https://www.geoenvi.eu/">https://www.geoenvi.eu/</a>	2018	2021	2.5 / 2.5	R&I 8, NTBE A	Y
<b>GEORISK</b>	<a href="https://www.egec.org/georisk-project/">https://www.egec.org/georisk-project/</a>	2018	2021	2.2 / 2.2	NTBE B	Y

<b>CROWDHERMAL</b>	<a href="https://cordis.europa.eu/project/rcn/224316/factsheet/en">https://cordis.europa.eu/project/rcn/224316/factsheet/en</a>	2019	2022	2.3	NTBE A & B	
<b>GeoWell</b>	<a href="http://geowell-h2020.eu/">http://geowell-h2020.eu/</a>	2016	2019	4.7 / 4.7	R&I 2, 6	Y
<b>MEET</b>	<a href="https://www.meet-h2020.com/">https://www.meet-h2020.com/</a>	2018	2021	11.7 / 10.0	R&I 3,4	Y
<b>S4CE Science for Clean Energy</b>	<a href="http://science4cleanenergy.eu/">http://science4cleanenergy.eu/</a>	2017	2020	9.8 / 9.8	R&I 8	Y
<b>SURE</b>	<a href="http://www.sure-h2020.eu/">http://www.sure-h2020.eu/</a>	2016	2019	6.1 / 5.9	R&I 6, 3	Y
<b>THERMODRILL</b>	<a href="http://www.thermodrill-h2020.org/">http://www.thermodrill-h2020.org/</a>	2015	2019	5.8 / 5.4	R&I 6	Y
<b>Multilateral funding opportunities</b>						
<b>SYSEXPL-REX (D, CH)</b>	SYSEXPL - Systematic Geothermal Exploration via (geo)magnetic Potential Field Methods; REX-Quantitative exploration risk analysis	2019	2023	3.2 / 2.4	R&I 5	Y
<b>IDDP (IS, NO)</b>	<a href="http://iddp.is/">http://iddp.is/</a>					
<b>DGE Rollout (D, NL, B, F)</b>	<a href="https://www.nweurope.eu/projects/project-search/dge-rollout-roll-out-of-deep-geothermal-energy-in-nwe/">https://www.nweurope.eu/projects/project-search/dge-rollout-roll-out-of-deep-geothermal-energy-in-nwe/</a>	2018	2022	18.7 / 11.1	R&I 1, 5	Y

## NATIONAL PROJECTS

list of relevant national projects that address the targets of the Implementation Plan.

Project name (min. > € 1 mln)	Website or short description	Start year	End year	Budget / Funding (EUR million)	Relevant activities addressed/ targets achieved	Results open to SET Plan community (Y/N)
<b>Large national/regional projects</b>						
<b>SCAN</b>	<a href="https://scanaardwarmte.nl/english/">https://scanaardwarmte.nl/english/</a> Seismic campaign, novel data reprocessing and exploration wells to facilitate future geothermal development	2019	2021	15.0 / 15.0	R&I 5	Y
<b>HIPE</b>	<a href="https://www.rvo.nl/subsidies-regelingen/projecten/high-performance-geothermal-well">https://www.rvo.nl/subsidies-regelingen/projecten/high-performance-geothermal-well</a>	2017	2021	6.0 / 3.8	R&I 6	Y (partially)
<b>CRECCIT</b>	<a href="https://www.rvo.nl/subsidies-regelingen/projecten/cost-reducing-enhanced-composite-casing-installation-technology">https://www.rvo.nl/subsidies-regelingen/projecten/cost-reducing-enhanced-composite-casing-installation-technology</a>	2016	2021	10.0 / 5.2	R&I 2, 6	Y (partially)
<b>LEAN</b>	<a href="http://europeangeothermalcongress.eu/wp-content/uploads/2019/07/346.pdf">http://europeangeothermalcongress.eu/wp-content/uploads/2019/07/346.pdf</a>	2018	2021	13.5 / 6.0	R&I 1, 5, 6	Y (partially)
<b>Geothermal Directional Drilling (NL)</b>	<a href="https://www.rvo.nl/subsidies-regelingen/projecten/geothermal-directional-drilling">https://www.rvo.nl/subsidies-regelingen/projecten/geothermal-directional-drilling</a>	2014	2019	8.9 / 4.0	R&I 1, 6	Y (partially)
<b>G2G (NL)</b>	<a href="https://www.rvo.nl/subsidies-regelingen/projecten/g2g-van-gas-naar-geothermie">https://www.rvo.nl/subsidies-regelingen/projecten/g2g-van-gas-naar-geothermie</a>	2014	2020	8.0 / 1.4	R&I 6	Y (partially)
<b>ANIGMA (NO)</b>	<a href="https://www.uib.no/fg/brs/118027/characterising-modeling-geothermal-reservoirs-anigma#project-coordinator-s-">https://www.uib.no/fg/brs/118027/characterising-modeling-geothermal-reservoirs-anigma#project-coordinator-s-</a>	2015	2019	1.2	R&I 5	?
<b>EGS Alsace (FR)</b>	<a href="http://geothermie.es.fr">geothermie.es.fr</a>	2015	2019	4.7	R&I 3	
<b>GEFISS (FR)</b>	<a href="http://www.geodenergies.com/sites/default/files/upload/documents/fichesprojet/fiche_synthetique_gefiss_en.pdf">http://www.geodenergies.com/sites/default/files/upload/documents/fichesprojet/fiche_synthetique_gefiss_en.pdf</a>	2018	2022	3.5 / 1	NTBE A	



<b>FaMeK (DE)</b>	Fiber-optic acoustic measuring system for more accurate and cost-effective exploration of deep geothermal wells	2018	2020	2.6 / 1.3	R&I 6	Y
<b>Drill:BOGS (DE)</b>	Acquisition, implementation and first operation of a fully automatic, large-scale drill rig for the development of next generation drilling technologies for the exploration of deep geothermal systems	2018	2020	0.52	R&I 6	Y
<b>EffGeo (DE)</b>	Specific and general improvements in efficiency of geothermal power plants	2018	2021	0.83 / 0.4	R&I 4	Y
<b>ReSalt (DE)</b>	Reactive Reservoir systems - Scaling and Erosion and its Impact on Hydraulic and Mechanic Reservoir properties	2018	2020	2.0 / 1.9	R&I 2 & 3	Y
<b>GeoMo (DE)</b>	Geothermal monitoring for the installation and operation of probes with integrated monitoring of the consumption for individual optimization of the heat pump	2019	2021	1.9 / 1.5	R&I 1	Y
<b>INSIDE (DE)</b>	Handling induced seismicity and ground displacements as interference aspects during the operation of geothermal projects in the South German Molasse basin.	2019	2022	4.7 / 3.1	R&I 1 & CC A	Y
<b>GeoFern (DE)</b>	Geothermal District Heat Supply in Berlin	2019	2022	1.8	R&I 1	Y
<b>GeoMare (DE)</b>	Optimized control and operation technology with sustainable reservoir management for the deep geothermal heat projects in the Munich area	2018	2021	5.3 / 3.1	R&I 1	Y
<b>Roll-out of Deep Geothermal Energy in NWE – Germany (DE)</b>	Roll-out of Deep Geothermal Energy in NWE – Germany; a project portfolio that aims to substitute coal-fired energy supply into district heating schemes with geothermal energy supply	2019	2022	6.2 (2.35 German Funding, 3.85 NER 300 for German Part)	R&I 1	Y
<b>OBE (DE)</b>	Optimization of drilling operations for geothermal projects through realistic real-time simulation	2019	2022	1.3	R&I 6	Y
<b>SEIGER (DE)</b>	Seismic monitoring of deep geothermal power plants and possible seismic impact	2019	2022	3.3 / 2.8	NBTE-A	Y
<b>VALTRE (CH)</b>	Validating technologies for EGS development	2017	2020	12.4 / 2.3	R&I 3	Y

## R&I ACTIVITIES

Description of Research and Innovation Activity	DG TWG
Title: <b>GEO THERMAL HEAT IN URBAN AREAS</b>	R&I Activity.1
<p><b>Scope:</b> To enhance the European heat transition to renewable energy by providing geothermal based solutions for urban areas. To contribute to decarbonising energy use for heating and cooling in cities and to improve air quality.</p>	
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project CoolHeating:</u> Market uptake of small modular renewable district heating and cooling grids for communities, from 01-01-16 to 31-12-18 Total budget= € 1.644.340,00 EU contribution – h2020= € 1.644.340,00 <b>Private contribution= € 0</b></p> <p><u>project GEOFOOD:</u> Food production in Europe requires further steps in reducing the carbon footprint. This project showcases the opportunities of direct use of geothermal energy to increase food production in highly productive circular systems. Total budget= € 1.749.656,00 Geothermica contribution = € 1.249.204,00 <b>Private contribution= € 500.452</b></p> <p><u>project GEO-URBAN:</u> The GEO-URBAN project aims to explore the potential for low enthalpy geothermal in urban environments.. Total budget= € 737.233 Geothermica contribution = € 539.275 <b>Private contribution= € 197.958</b></p> <p><u>project DGE-ROLLOUT:</u> Roll-out of Deep Geothermal Energy in North-West Europe, from 25/10/2018 to 24/10/2022 Total budget= € 18.697.123,46 EU contribution Interreg= € 11.158.964,07 <b>Private contribution= € 7.538.159,39</b></p>	
<b>TRL at start: 7</b>	<b>TRL at end: 9</b>
<b>Total budget required: €73.3m</b>	<b>Flagship: Yes</b>

Description of Research and Innovation Activity	DG TWG
<p><b>Title:</b> MATERIALS, METHODS AND EQUIPMENT TO IMPROVE OPERATIONAL AVAILABILITY (HIGH TEMPERATURES, CORROSION, SCALING)</p>	<p>R&amp;I Activity.2</p>
<p><b>Scope:</b> Developing new materials, methods and equipment suitable to solve problems commonly encountered in geothermal applications (resistance to corrosion and scaling) for low and high temperatures; decreasing the overall cost of a geothermal project.</p>	
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project Geo-Coat:</u> Development of novel and cost effective corrosion resistant coatings for high temperature geothermal applications, from 01-02-18 to 31-01-21 Total budget= € 4.722.722,50 EU contribution H2020= € 4.722.722,50 <b>Private contribution= € 0</b></p> <p><u>project REFLECT:</u> Redefining geothermal fluid properties at extreme conditions to optimize future geothermal energy extraction, from 1 January 2020 to 31 December 2022 Total budget= € 4 992 761,25 EU contribution H2020= € 4 992 761,25 <b>Private contribution= € 0</b></p> <p><u>project GEOPRO:</u> Accurate Geofluid Properties as key to Geothermal Process Optimisation, from 1 November 2019 to 31 October 2022 Total budget= € 4 898 982,50 EU contribution H2020= € 4 898 982,50 <b>Private contribution= € 0</b></p> <p><u>project GeoHex:</u> Advanced material for cost-efficient and enhanced heat exchange performance for geothermal application, from 1 November 2019 to 31 October 2022 Total budget= € 4 989 401,25 EU contribution H2020= € 4 989 401,25 <b>Private contribution= € 0</b></p> <p><u>project MATCHING:</u> Materials Technologies for performance improvement of Cooling Systems in Power Plants, from 01-03-16 to 31-08-19 Total budget= € 11.847.291,75 EU contribution H2020= € 9.706.413,77 <b>Private contribution= € 1.780.877,98</b></p> <p><u>project PERFORM:</u></p>	

<p>Demonstration of cost-efficient, next-generation technologies and methods (cation-, particle filters, CO2-injection, thermal stimulation) will enable the reduction of obstructive elements and resistance to fluid injection. Predictive modelling of physical and chemical processes will permit long-term doublet performance projection.</p> <p>Total budget= € 3.011.717,00 Geothermica contribution = € 2.236.825,00 <b>Private contribution= € 774.892</b></p>			
<p><b>TRL at start:</b> 5 (Equipment); 4 (Materials)      <b>TRL at end:</b> 9 (Equipment); 6 (Materials)</p>			
<p><b>Total budget required:</b> €25.6m</p>		<p><b>Flagship:</b></p>	<p>No</p>

Description of Research and Innovation Activity	DG TWG
<p><b>Title:</b> ENHANCEMENT OF RESERVOIR (CONVENTIONAL AND UNCONVENTIONAL);</p>	<p>R&amp;I Activity.3</p>
<p><b>Scope:</b> Demonstration of techniques for reservoir improvement in different geological settings and up-scaling of power plants, and/or (industrial) heat production. Development of reservoirs (including EGS, ultra-deep hydrothermal and petro-thermal) in untested geological conditions with innovative methods for reservoir exploitation.</p>	
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project SURE:</u> Novel Productivity Enhancement Concept for a Sustainable Utilization of a Geothermal Resource, from 01-03-16 to 31-08-19 Total budget= € 6.143.415,00 EU contribution H2020= € 5.892.165,00 <b>Private contribution= € 251.250</b></p> <p><u>project DEEPEGS:</u> Deployment of deep enhanced geothermal systems for sustainable energy business, from 01-12-15 to 30-11-19 Total budget= € 44.057.258,66 EU contribution H2020= € 19.999.740,88 <b>Private contribution= € 24.057.517,78</b></p> <p><u>project DESTRESS:</u> Demonstration of soft stimulation treatments of geothermal reservoirs, from 01-03-16 to 29-02-20 Total budget= € 25.132.511,25 EU contribution H2020= € 10.713.408,63 <b>Private contribution= € 14.419.102,62</b></p> <p><u>project MEET:</u></p>	

<p>Multidisciplinary and multi-context demonstration of EGS exploration and Exploitation Techniques and potentials, from 01-05-18 to 31-10-21                  Total budget= € 11.736.955,53                  EU contribution H2020= € 9.972.818,88  <b>Private contribution= € 1.764.136,65</b></p> <p><u>project GEMex:</u>                  Cooperation in Geothermal energy research Europe-Mexico for development of Enhanced Geothermal Systems and Superhot Geothermal Systems, from 01-10-16 to 31-05-20                  Total budget= € 9.999.792,50                  EU contribution H2020= € 9.999.792,50  <b>Private contribution= € 0</b></p> <p><u>project COSEISMIQ:</u>                  improve and validate the advanced technologies for monitoring and controlling induced seismicity                  Total budget= € 2.479.458,00                  Geothermica contribution = € 1.148.958,00  <b>Private contribution= € 1.330.500,00</b></p>			
<b>TRL at start:</b> 4		<b>TRL at end:</b> 8	
<b>Total budget required:</b> € 382.5m		<b>Flagship:</b>	No

Description of Research and Innovation Activity		DG TWG	
<p><b>Title:</b> IMPROVEMENT OF PERFORMANCE (CONVERSION TO ELECTRICITY AND DIRECT USE OF HEAT)</p>		<p>R&amp;I Activity.4</p>	
<p><b>Scope:</b> To improve the overall conversion efficiency and reduce the cost of geothermal energy utilization. To develop an EU technology solution with a perspective to become a worldwide standard. To improve the efficiency of binary cycle power plants, including application to high temperatures, use as bottoming cycle and the capability of dealing efficiently with variable heat and electricity supply.</p>			
<p><b>Ongoing R&amp;I Activities:</b></p>			
<b>TRL at start:</b> 5-6		<b>TRL at end:</b> 7-8	
<b>Total budget required:</b> €21m		<b>Flagship:</b>	No

Description of Research and Innovation Activity		DG TWG
<b>Title:</b> EXPLORATION TECHNIQUES (INCLUDING RESOURCE PREDICTION AND EXPLORATORY DRILLING)		R&I Activity.5
<b>Scope:</b> Improving the precision of pre-drilling exploration and performance prediction by regularly updating methodological approaches. Moving beyond the state of the art by testing new tools, developing new approaches and taking advantage of improved software and computing power, thereby reducing uncertainty and bringing down exploration costs.		
<b>Ongoing R&amp;I Activities:</b>  <u>project DARLINGe :</u> Danube Region Leading Geothermal Energy, from 01-01-17 to 30/06/2019 Total budget= € 2.525.760,70 EU contribution Interreg= € 2.146.896,60 <b>Private contribution= € 378.864,10</b>		
<b>TRL at start:</b> 5-6		<b>TRL at end:</b> 7-8
<b>Total budget required:</b> €49m		<b>Flagship:</b> No

Description of Research and Innovation Activity	DG TWG
<p>Title: <b>ADVANCED DRILLING/WELL COMPLETION TECHNIQUES</b></p>	<p>R&amp;I Activity.6</p>
<p><b>Scope:</b> Reduction in drilling/well completion costs. Demonstrate concepts that can significantly reduce drilling/well completion costs (reduce drilling time and non-productive time, reduce costs, mitigate risks) or enhance reservoir performance (including directional and horizontal multilateral drilling). The target is to reduce cost for drilling and underground installations by at least 25% compared to the situation today.</p>	
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project Descramble:</u>            Drilling in supercritical geothermal condition, from 01-05-15 to 30-04-18            Total budget= € 15.687.222,50            EU contribution H2020= € 6.753.635,00  <b>Private contribution= € 8.933.587,50</b></p> <p><u>project ThermoDrill:</u>            Fast track innovative drilling system for deep geothermal challenges in Europe, from 01-09-15 to 31-08-18            Total budget= € 5.824.745,00            EU contribution H2020= € 5.380.995,00  <b>Private contribution= € 443.750</b></p> <p><u>project GeoWell:</u>            Innovative materials and designs for long-life high-temperature geothermal wells, from 01-02-16 to 31-01-19            Total budget= € 4.704.913,75            EU contribution H2020= € 4.704.913,75  <b>Private contribution= € 0</b></p> <p><u>project Geo-Drill:</u>            Development of novel and cost-effective drilling technology for Geothermal Systems, from 1 April 2019 to 30 September 2022            Total budget= € 4 996 400            EU contribution H2020= € 4 996 400  <b>Private contribution= € 0</b></p> <p><u>project CAGE:</u>            CAGE is a development and demonstration project of several cost-saving and output-improving installation technologies. The objective is to demonstrate a new concept, suitable for limestone areas and target depths of 1 to 2.5 km. The demonstration contains the following innovations: Crane-based drilling, Enhanced Casing Installation (ECI / ECCL) technology (Casing While Drilling), Lightweight and corrosion-resistant High Strength Composite Casing (HSCC), Acoustic Multi-Sensor Parameter Analysis (MSPA) supported Radial Drilling, Airlift technology to replace the costly Electrical Submersible Pump            Total budget= € 13.457.698,00            Geothermica contribution= € 5.834.888,00  <b>Private contribution= € 7.622.810,00</b></p> <p><u>project GECONNECT:</u></p>	

<p>GeConnect aims at increasing the reliability of the downhole construction of geothermal wells beyond the state of the art using flexible couplings                  Total budget= € 1.196.126,00                  Geothermica contribution= € 868,891  <b>Private contribution= € 327.235</b></p> <p><u>project ZoDrEx:</u>                  ZoDrEx aims at demonstrating drilling, completion and production technologies increasing technical and economic successes of geothermal projects.                  Total budget= € 4.890.706,00                  Geothermica contribution= € 2.860.282,00  <b>Private contribution= € 2.030.424</b></p>		
<b>TRL at start:</b> 5 (improvement), 3 (novel)	<b>TRL at end:</b> 7 (improvement), 5 (novel)	
<b>Total budget required:</b> €52.1m	<b>Flagship:</b>	No

Description of Research and Innovation Activity	DG TWG
<p><b>Title:</b> INTEGRATION OF GEOTHERMAL HEAT AND POWER IN THE ENERGY SYSTEM AND GRID FLEXIBILITY</p>	R&I Activity.7
<p><b>Scope:</b> Integration of flexible generation from geothermal power in the energy sector</p>	
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project GeoSmart:</u>                  Technologies for geothermal to enhance competitiveness in smart and flexible operation, from 01-06-19 to 31-05-23                  Total budget= € 19.105.236,25                  EU contribution H2020= € 17.363.898,25  <b>Private contribution= € 1.741.338</b></p> <p><u>project HEATSTORE:</u>                  The main objectives of this project are to lower the cost, reducing the risks and to optimize performance of high temperature (~25 to ~90°C) underground thermal energy storage technologies by demonstrating 6 distinct configurations of heat sources, heat storage, and heat utilization                  Total budget= € 16.265.971,00                  Geothermica contribution= € 8.305.268,00  <b>Private contribution= € 7.960.703</b></p>	
<b>TRL at start:</b> 4-5	<b>TRL at end:</b> 7-9
<b>Total budget required:</b> €11.5	<b>Flagship:</b> Yes



Description of Research and Innovation Activity		DG TWG	
Title: <b>ZERO EMISSIONS POWER PLANTS</b>		R&I Activity.8	
<p><b>Scope:</b> Increasing the feasibility of closed-loop reinjection and demonstrating the capture of non-condensable gases (Zero emission power plants).</p> <p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project GECO:</u> Geothermal Emission Gas Control, from 10-01-18 to 30/09/2022 Total budget= € 18.220.330,50 EU contribution H2020= € 15.599.842,88 <b>Private contribution= € 2.620.487,62</b></p>			
TRL at start: 5-6		TRL at end: 6-7	
Total budget required: €123.4m		Flagship:	Yes

Description of Research and Innovation Activity		DG TWG	
Title: <b>INCREASING AWARENESS OF LOCAL COMMUNITIES AND INVOLVEMENT OF STAKEHOLDERS IN SUSTAINABLE GEOTHERMAL SOLUTIONS</b>		NTBE-A	
<p><b>Scope:</b></p> <p><b>A:</b> Public acceptance: improve community perceptions about non-condensable gas emissions, micro-seismicity, stimulation, and other environmental effects. Coordination of national and regional regulatory oversight practices for health, safety and environmental aspects of geothermal projects.</p> <p><b>B:</b> Best practices for managing health, safety and environmental aspects of geothermal projects. Seismic monitoring and mapping of seismic events, guidelines for stimulation indicators in order to prevent surface impacts.</p>			
<p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project GEOENVI:</u> Tackling the environmental concerns for deploying geothermal energy in Europe, from 11-01-18 to 30/04/2021 Total budget= € 2.495.871,50 EU contribution= € 2.495.871,50 <b>Private contribution= € 0</b></p> <p><u>project CROWDHERMAL:</u></p>			

Community-based development schemes for geothermal energy, from 01-09-19 to 31/08/2022		
Total budget= € 2.305.801,25		
EU contribution= € 2. 2.305.801,25		
<b>Private contribution= € 0</b>		
<b>TRL at start:</b> not applicable	<b>TRL at end:</b> not applicable	
<b>Total budget required:</b> €21m	<b>Flagship:</b>	No

Description of Research and Innovation Activity		DG TWG
Title: <b>RISK MITIGATION (FINANCIAL/PROJECT)</b>		NTBE.B
<p><b>Scope:</b> Coordination of national geological risk mitigation methods and financial schemes (e.g. exploration grants, geothermal guarantee schemes).</p> <p><b>Ongoing R&amp;I Activities:</b></p> <p><u>project GEORISK:</u>          Developing geothermal and renewable energy projects by mitigating their risks, from 10-01-18 to 31/03/2021          Total budget= € 2.184.118,38          EU contribution H2020= € 2.184.118,38  <b>Private contribution= € 0</b></p>		
<b>TRL at start:</b> NA		<b>TRL at end:</b> NA
<b>Total budget required:</b> €177m	<b>Flagship:</b>	No

## SUMMARY

Description of Research and Innovation Activity	DG TWG	Private financial contribution in co-funded projects
Title: Geothermal heat in urban areas	R&I Activity.1	8.236.569
Title: Materials, methods and equipment to improve operational availability (high temperatures, corrosion, scaling)	R&I Activity.2	2.555.769
Title: Enhancement of reservoir (conventional and unconventional);	R&I Activity.3	41.822.507
Title: Improvement of performance (conversion to electricity and direct use of heat)	R&I Activity.4	0
Title: Exploration techniques (including resource prediction and exploratory drilling)	R&I Activity.5	378.864
Title: Advanced drilling/well completion techniques	R&I Activity.6	19.357.806
Title: Integration of geothermal heat and power in the energy system and grid flexibility	R&I Activity.7	9.702.041
Title: Zero emissions power plants	R&I Activity.8	2.620.487
Title: Increasing awareness of local communities and involvement of stakeholders in sustainable geothermal solutions	NTBE-A	0
Title: Risk mitigation (financial/project)	NTBE.B	0
<b>TOTAL</b>		<b>84.674.045</b>

## Monitoring of RD&I activities from geothermal industry in 2019

Significant levels of funding for R&I are coming from industry. A large part of the RD&I from industry is dedicated to innovation and high TRL. The total number of private projects is hard to estimate, but it can be assumed that it represents a third of all RD&I investment for geothermal in Europe.

The variation in R&D efforts among EU Member States also holds true for the R&D expenditure of industries in the geothermal sector. The scale of technologies involved is so vast and the related value chain so complex that it is impossible to identify all private investments at the different stages of geothermal innovation processes.

The approach adopted is therefore to estimate the R&D commitments from industry in 2019, basing this calculation upon the resources dedicated to R&D on an annual basis.

According to our estimation, the total turnover of geothermal industries in the EU was € 2.7 billion in 2019. Nearly all private R&D investments are currently carried out by material and equipment manufacturers: the turnover generated by the sale of services (e.g. installation, planning, maintenance) has therefore been excluded from the following calculations. The ratio of R&D expenditure to net sales varies significantly, however for most companies this is in the range of 1% to 3%.

The best innovation in the geothermal sector are rewarded every year. It gives an idea of the trends in R&I:

### RUGGERO BERTANI - EUROPEAN GEOTHERMAL INNOVATION AWARD - 2019 EDITION:

- CLIMEON (Sweden), for the geothermal plant Fludaorka, Iceland, where a HeatPower module of 2x2x2 m and 150 kW can produce electricity from low temperature geothermal resources (80–130°C).
- GEOFLUID (France), for their anti-corrosion well concept implemented at the district heating grid of Bonneuil-sur-Marne, France.
- GPC IP (France), for the validation of the sub-horizontal doublet and reservoir evaluation concept at the district heating system in Cachan, Paris.
- JANSEN AG (Switzerland), for the Jansen HIPRESS borehole heat exchanger for applications in depths of 300+ meters.

- TURBODEN (Italy), for the first 5 stages large axial ORC turbine, as installed on the Velika Ciglena geothermal power plant, Croatia

## RUGGERO BERTANI - EUROPEAN GEOTHERMAL INNOVATION AWARD - 2020 EDITION:

- **Bakker Oilfield Supply:** Their endorsed project is “Degasser 2.0 rental”.  
This rental product is designed for geothermal projects with temperatures up to 150°C. It is used in almost every Geothermal Project in the Netherlands for separation of fluids like water, gas and oils from each other.  
With this product, developers are able to separate harmful gases and oils from water and steam. After separation they can safely release steam and water to turbines and/or open air. This type of equipment is not available in the rental market for this range of temperature. The product has been used in a few projects already and has proven its reliability.
- **CarbFix:** The EU-funded CarbFix project has been selected as one of the five outstanding finalists of the Ruggero Bertani European Geothermal Innovation Awards 2020. The CarbFix process captures CO<sub>2</sub> and other sour gases from emission sources. In less than two years, 95% of these gases are transformed into rocks underground. The process was designed to help nature rebalance the carbon cycle by mimicking natural mineralisation of CO<sub>2</sub> in favorable rock formations.  
A devoted research and innovation team transformed CarbFix from an idea on paper to a proven, reliable process on an industrial scale in less than eight years; an effort led by scientists at the University of Iceland, Columbia University, CNRS and Reykjavik Energy.  
CarbFix has large global scaling potential in and beyond the geothermal industry. The plans to apply this technology to sites in Italy, Turkey and Germany are well underway. The ambition is to become a key instrument in tackling the climate crisis and slashing global CO<sub>2</sub> emissions.
- **EAVOR-Loop:** Up to now deep geothermal closed systems only produced a small amount of energy from mostly vertical single deep wells. The Eavor Loop project overcomes this disadvantage with a concept of vertical wells being connected by several horizontal wells.  
The systems are designed for 40 MW and above, thus converting individual geothermal projects into industrial projects. New technologies are combined and

optimised for geothermal energy exploitation in areas and rocks where it has not been possible before.

- **Vulcan Energie Ressource:** Lithium is currently produced in open pit and underground mines or from salt flats in South America. The environmental impact is huge in terms of carbon footprint, land use and water consumption.

Vulcan's concept is different, as the environmental impact should be minimal. Deep geothermal reservoirs are widespread in the Upper Rhine Graben area. The geothermal brines in these reservoirs contain a large amount of lithium.

Vulcan's idea is to extract the lithium from the brine using direct lithium extraction. The lithium will be extracted after the energy of the brine has been used for power and heating production. The energy needed for the extraction is generated directly in the geothermal plant. So the lithium can be produced with zero carbon emissions.

The Direct Lithium Extraction will be implemented in the pilot project based on the requirements of the geothermal brine and to avoid environmental hazards and damages to the brine cycle by scaling or corrosion. But further research must be done to understand the mechanisms in the geothermal reservoirs when the lithium is extracted.

- **ZAE Bayern:** In shallow geothermal systems, the thermal response test is the procedure commonly used to measure thermal underground properties. The research project "QEWS II" developed and tested a test rig to ensure the quality of thermal response test devices.

The test rig emulates the thermal behaviour of a real borehole heat exchanger of different lengths and underground properties.

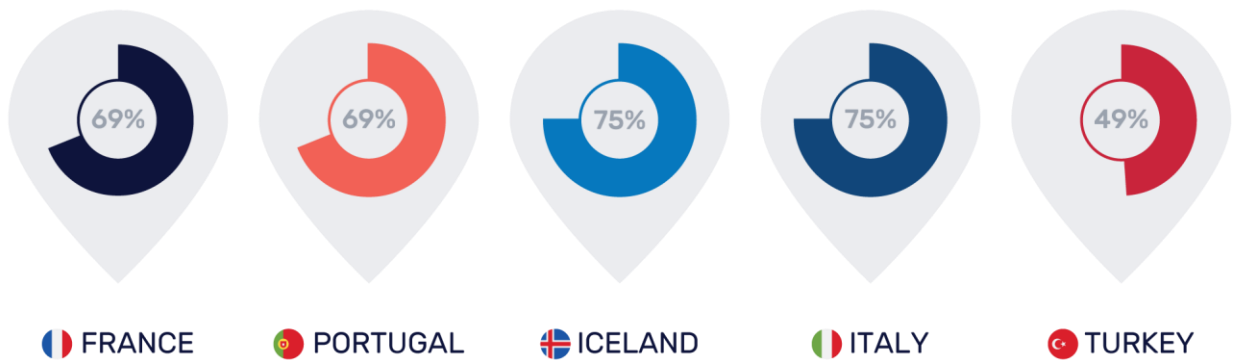
The thermal response test unit is connected to the emulated borehole in the same way as it would be to the real borehole. This way, it reproduces the emulated underground properties with accuracy and can determine whether the unit works correctly.

This project is one of a kind. There is not such a test rig available on the market today. Before this device was developed, the only way to compare different thermal response test units was to test them at the same real borehole where the boundary conditions vary, and the underground properties are not perfectly known.

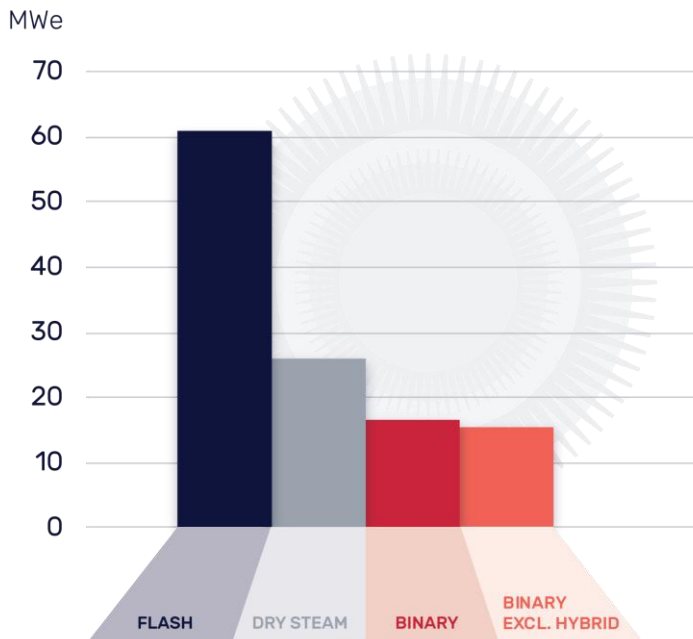
## EGEC MARKET REPORT 2019

The Annual EGEN Market Report depicts also some technological trends. These new projects allow to assess on a qualitative basis the orientations of the geothermal industry. For example:

Comparison geothermal electricity average capacity factors in Europe:

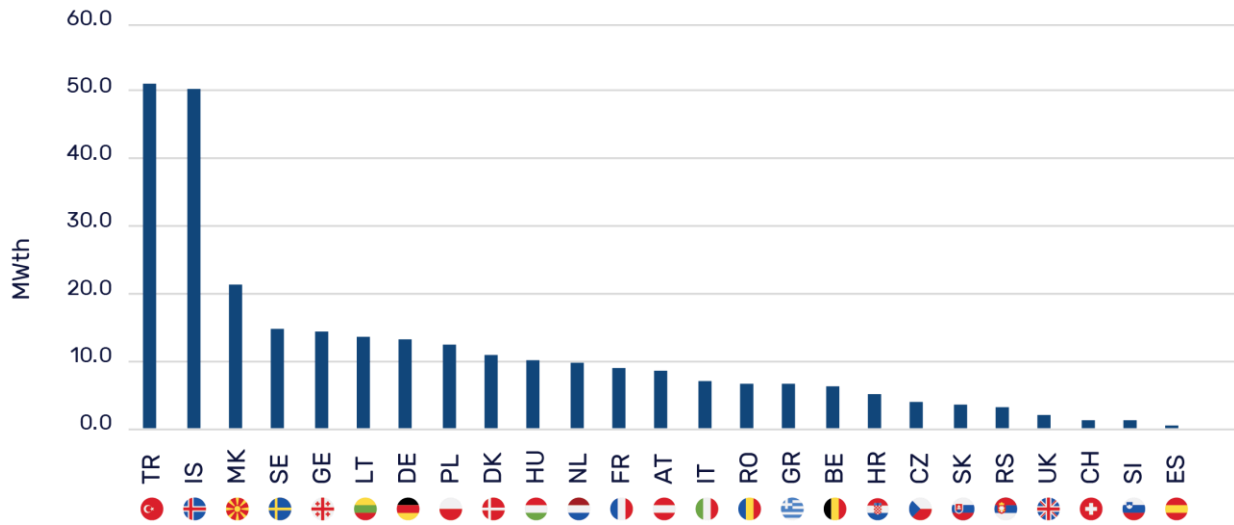


Average size of geothermal electricity turbines by types of plants:



Average size of deep geothermal heating and cooling plant per country:





## NEW R&I PUBLIC FUNDING INSTRUMENTS FOR INDUSTRY

The IWG organised in September 2019 a workshop on the Innovation Fund. The geothermal stakeholders were asked to present project ideas. On 23/09/19, the geothermal workshop on the Innovation Fund saw the presentation of innovative geothermal projects in view of presenting the dynamics of the sector to the EU institutions in charge of managing the Innovation Fund and the Modernisation Fund.

Details can be found on the [Event website \(with presentations\)](#)

### Key priorities for financing geothermal innovation:

The delivery of support must be adapted to the project and actively contribute to bridge the valley of death: i.e. to reduce the financial risk of the project (e.g. milestone based grants can be a solution in some cases)

### Key priorities of geothermal innovative projects:

Reducing costs (through innovative technologies, standardisation of processes);  
Identifying new business models: providing flexibility, production of raw materials,...

### Key innovation presented: New generation of power plants

- Zero emission power plant
- Modular geothermal CHP systems
- Geothermal CHP and seasonal storage
- Modular power production units
- Deep closed loop systems

### Key innovation presented: New generation of heat plants

Large scale geothermal DH integration  
Geothermal use for industry  
ATES Integration in district heating

Key innovation presented: the world race on lithium extraction

A global competition where European geothermal industry needs public support for Geothermal lithium production

SUMMARY

Description of Research and Innovation Activity	DG TWG	Private projects
Title: Geothermal heat in urban areas	R&I Activity.1	
Title: Materials, methods and equipment to improve operational availability (high temperatures, corrosion, scaling)	R&I Activity.2	anti-corrosion well concept implemented at the district heating grid  “Degasser 2.0 rental” for separation of fluids like water, gas and oils from each other
Title: Enhancement of reservoir (conventional and unconventional);	R&I Activity.3	The Eavor Loop project with a concept of vertical wells being connected by several horizontal wells
Title: Improvement of performance (conversion to electricity and direct use of heat)	R&I Activity.4	HeatPower module of 2x2x2 m and 150 kW can produce electricity from low temperature geothermal resources (80–130°C).  first 5 stages large axial ORC turbine
Title: Exploration techniques (including resource prediction and exploratory drilling)	R&I Activity.5	

Title: Advanced drilling/well completion techniques	R&I Activity.6	sub-horizontal doublet and reservoir evaluation concept at the district heating system
Title: Integration of geothermal heat and power in the energy system and grid flexibility	R&I Activity.7	Direct Lithium Extraction
Title: Zero emissions power plants	R&I Activity.8	CarbFix process captures CO <sub>2</sub> and other sour gases from emission sources

## Assessment of private sector investment in R&I

### STATE OF THE ART

RD&I in geothermal is dynamic in Europe with many ongoing research and innovation projects and new funding structures. The European geothermal industry is already leading in terms of innovation, and aims to keep this global leadership.

A large part of the RD&I from Industry is dedicated to innovation and high TRL. It can be assumed that it represents one third of the total investment for RD&I in geothermal in Europe. Total number of private projects is hard to estimate as it has to combine private co-funding in European and National projects, direct investment in R&I by the geothermal industry and last but not least the investment done in other sectors and indirectly benefiting to the geothermal sector. A particularity of the geothermal sector is that it is benefiting from RD&I performed by other sectors like in geosciences (oil&gas), deep drilling, and equipments such as turbines and heat pumps.

It is difficult to estimate precise expenditures in R&D for this sector, as it is strongly dominated by SMEs, and large companies are normally involved in more sectors than just the geothermal. The geothermal sector benefits from R&D, especially regarding drilling, performed in other sectors such as the oil and gas. A typical example is the technique of horizontal shale gas drilling that has been demonstrated for the first time at the geothermal system in the Paris Basin in 2018.

Taking the example of geothermal district heating systems:

- Suppliers of systems and components for geothermal district heating are the same companies providing equipments for the geothermal power sector for the underground part.
- For the surface system, we find the same suppliers of systems and components (pipes, pumps and stations) as in the district heating industry.
- Developers and operators are also similar.

All together the geothermal industry may be subdivided in several subsectors, which correspond broadly to a given aspect of geothermal projects: subsurface industry from exploration to well completion, including reservoir management; surface industry for the construction of surface equipment; legal and financial industry. More details are provided in the ETIP DG Report on Competitiveness

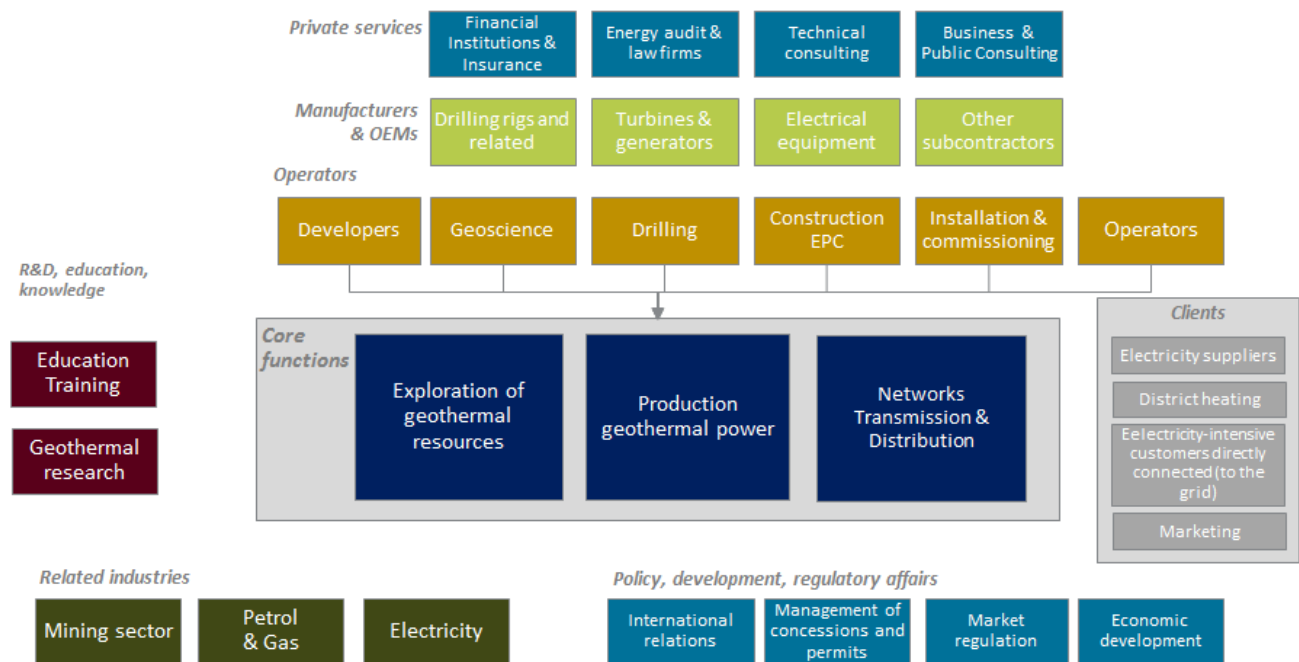
Most of the manufacturers are locally based. In the deep geothermal sector, all the supply chain is European. Leading countries in terms of sales are Italy, France and Germany. In particular, components provided through the geothermal supply chain are:

- Steam turbines (CHP) and ORC units
- Cooling towers

- Steel pipes
- pumps extracting and re-injecting water from/to the ground
- heat exchangers

The geothermal industry is composed by:

- Consultancy, engineering, services
- Geosciences, subsurface services
- Drilling companies, rigs manufacturers
- Equipment manufacturers (pumps etc.), turbine manufacturers
- Plant manufacturers
- Diversification: products, services and business portfolio
- Supply chain: owned/outsourced components, materials
- Business models
- Operators (well field, plant, heating distribution network...)



**Figure: Geothermal industry overview. Source: GEOELEC, adapted from Capgemini Consulting and canmetenergy**

There are however extensive data available on public support towards the geothermal energy utilisation, especially at the European level. Altogether, there were 30 Horizon 2020 projects focused on deep geothermal or geothermal heat pumps, amounting for an aggregated R&D investment of around 700 million euros over the 2014/2018 period, of which 160 million euros are funded by the European Commission. These projects are mostly led by industry and aim to demonstrate new techniques, reduce costs (notably of drilling) or improve the environmental impacts of the projects. In addition, the European Commission

funds 6 projects, notably in geoscience that have very direct impacts on the geothermal sector (and where geothermal energy is identified as a key focus of the project's outcomes) with 21 million euros.

In addition to the type of direct R&D effort that can receive funding under programmes like Horizon 2020, the demonstration of new geothermal technologies is considered as an R&D investment. In that regard, the NER300, which finances projects at a high level of technology readiness is quite instrumental at the European level. It indeed provided 71 million euros of support for three projects in France, Croatia and Hungary.

At the national level, further frameworks are set into place to incentivize investment in geothermal energy R&D. These for instance include the Energy Research programme in Germany (near 20 million euros for geothermal energy research in 2016), or the Polish National Fund for Environmental protection which invests 45 million euros in exploratory well drilling to develop new geothermal energy production area in the country.

In order to implement the Geothermal Roadmap of ETIP-DG, industry must spend around € 700 million across the 2020-2030 period on R&D funding for geothermal.

## ESTIMATION – YEAR 2019

For the year 2019, the private investment in research and innovation is estimated to be:

- **Cofunding in European public-private R&I projects= 30 Mln Euro**

It is assumed a volume higher than € 85 millions (see table on page 21) invested by the private sector in Research & Innovation for deep geothermal for the 3 years period 2018-2020. It means around 30 Mln Euro on a yearly basis.

- **Cofunding in national public-private R&I projects= 40 Mln Euro**

Deep Geothermal IWG reporting 2020 to the SET Plan shows a total project public budget of 512.2 Mln Euro in geothermal for the period 2017-2022, from which € 207 Mln are from private contribution.

The private cofunding has an annual basis of ca. 40 Mln Euro. Geothermal companies already involved in R&I activities are presented in the report “Map of geothermal market actors A mapping of the private stakeholders potentially active in RD&I on geothermal deliverable 4.1”.

For the period 2017-2022, about € 50 Mln is invested by the geothermal industry in EU projects and around € 150 Mln at national level or in transnational activities. In France, Germany, Iceland and The Netherland the private contribution is very significant

(between 26 to 55 millions of euros) and represent nearly 50% of the project funding. In Switzerland, this share increases to 75% (€13.5 Mln on € 19.8 Mln)

Country/EU	Total projects funding (€ Mio)	% of private contribution <sup>1</sup>
<b>Total</b>	512,2	40%
<b>EU</b>	225,3	23%
<b>National</b>	286,9	54%
<b>Austria</b>	5,8	7%
<b>Belgium</b>	7	0%
<b>Czechia</b>	0,7	0%
<b>France</b>	101,7	40%
<b>Germany</b>	113,1	46%
<b>Hungary</b>	4,2	0%
<b>Iceland</b>	70	38%
<b>Ireland</b>	0,7	29%
<b>Italy</b>	23,6	29%
<b>Norway</b>	9,7	na
<b>Switzerland</b>	19,8	68%
<b>The Netherlands</b>	106,7	52%
<b>UK</b>	49,2	5%

- **Estimation of Private investment in R&I (direct)= 11.60 Mln Euro**

<sup>1</sup> Private contribution is the part of the budget not coming from the public funding. Although, it is essentially coming from the industry, in some projects this part is also covered by own funding of research institutes and other public organisations (geological surveys etc.).

In top, the private investment in R&I (indirect) has to be added. It means a share of the R&D investment done in drilling, subsurface services, equipments.

According to our estimation, the total turnover of geothermal industries in the EU was € 2.7 billion in 2019. Nearly all private R&D investments are currently carried out by material and equipment manufacturers: the turnover generated by the sale of services (e.g. installation, planning, maintenance) has therefore been excluded from the following calculations. The ratio of R&D expenditure to net sales varies significantly, however for most companies this is in the range of 1% to 3%.

The table below illustrates the total level of investment estimated from the private sector in 2019, calculated as a proportion of the net sales of the component industries:

	<b>Deep Geothermal</b>
<b>Total installed capacity:</b> Deep GT H&C (GWth, year 2019) Electricity (GWe, year 2019)	130 MWth and 158.38 MWe
<b>Investment costs (average)</b> H&C (€/MWth, year 2019) Electricity (€/MWe, year 2019)	€1,5m/MWth & €4m/MWe
<b>Annual capital costs reduction</b>	2-10%
<b>Turnover of the entire sector, including services (Mln Euro in 2019)</b>	195 Mln Euro in h&c 633.52 Mln Euro in electricity =828.52 Mln Euro
<b>Share of manufacturing industry on sector turnover</b>	40%
Annual turnover manufacturing industry (Mln Euro in 2019)	331.41 Mln Euro
<b>Share of R&amp;D on turnover of manufacturing industry only (average)</b>	3-4%
<b>Annual R&amp;D investments of manufacturing industry (Mln Euro in 2019)</b>	11.60 Mln Euro

- **Estimation of Private investment in R&I (indirect)= not available for 2019**

RD&I performed by other sectors like in geosciences (oil&gas), deep drilling, and equipments such as turbines and heat pumps is currently assessed and it will be reported for the 2nd report in 2021.



## Conclusion

In 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.

It is already assumed a volume higher than 80 Mln Euro invested by the private sector in Research & Innovation for deep geothermal in 2019:

- Cofunding in European public-private R&I projects= 30 Mln Euro
- Cofunding in national public-private R&I projects= 40 Mln Euro
- Estimation of Private investment in R&I (direct)= 11.60 Mln Euro
- Estimation of Private investment in R&I (indirect)= not available for 2019

The geothermal sector is a diverse, highly innovative sector, which leads to many different types of actors who are engaged in fostering the R&I priorities identified by the SET Plan Implementation Working Group Deep Geothermal. Many of these actors are engaged, usually in partnership with non-industrial actors such as the research communities in public funded projects, for instance programmes such as Horizon 2020 or Geothermica. Meanwhile, as the geothermal sector remains very competitive, industrial actors also often carry out innovation in the various projects they are developing commercially as they seek to decrease the cost of producing geothermal energy. All industrial actors are therefore susceptible to engage in the implementation of the R&I priorities for deep geothermal.

Meanwhile, the geothermal sector, while not necessarily a very concentrated community, remains structured by key organisations and events, which constitute relays of the geothermal industry, where experience sharing happens, and cooperation emerge, fostering innovation. These institutions of the geothermal community are crucial in identifying the key industrial actors of the geothermal sector.

## Annex 1: Questionnaire 2020 on 2019 activities

The questionnaire is distributed during the second semester of 2020 to report 2019 activities.

It targets companies already active in research and innovation and identified in the report “Map of geothermal market actors: A mapping of the private stakeholders potentially active in RD&I on geothermal (deliverable 4.1)”.

# Private R&I funding in geothermal energy sector

## Questionnaire

### OBJECTIVE

This questionnaire is addressed to private companies that are working in geothermal Research & Innovation. 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 ?
3. What is the geographical covering 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 (includes exploratory) \_\_\_\_\_ %  
 Applied research/technology development \_\_\_\_\_ %  
 Development for market launch/uptake \_\_\_\_\_ %  
 Development of digital tools/data \_\_\_\_\_ %  
 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?

### 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<sup>2</sup>

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:

\_\_\_\_\_

<sup>2</sup> In the SET plan, Europe has set its renewable energy ambitions, including for geothermal. A specific geothermal Implementation plan has been released and is now executed. In order to reach the goals of placing Europe at the forefront of the low carbon energy scene, an [Implementation Working Group \(IWG\)](#) is created to move forward the [Deep Geothermal Implementation Plan \(DG-IP\)](#), currently revised and under consultation.

- 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 AND HEATING & COOLING GENERATION
  - CLOSED LOOP ELECTRIC AND HEATING & 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