# EUROPEAN GEOTHERMAL ENERGY COUNCIL

Brussels, 17th June 2016

**Subject: Input to European Commission's Issues Paper on DEEP GEOTHERMAL ENERGY**

Dear Sir or Madam,

On behalf of the European Geothermal industry, EGEC is sending its inputs to the *Issues Paper on Deep Geothermal*.

We welcome the publication of this document and the open consultation launched on 26th of May 2016.

The geothermal industry welcomes the ambition and support from the European Commission for deep geothermal energy. In particular, we share the view that the European industry in deep geothermal needs to maintain its competitive position in the global markets and develop the next generation of technologies.

## Vision

We are surrounded by inexhaustible energy resources which allow us to meet both our energy needs and those of future generations without taking uncontrollable risks with the life and well-being of our planet. Technological developments enable us to make use of these energy sources on a scale that meets the requirements and demands of modern civilisation.

A single technology, a single renewable energy, can never meet these demands alone. Each has its specific advantages and disadvantages, and has to be applied in an intelligent, targeted way, in synergy with other technologies in order to deliver at optimum strength. Only a tiny portion of the potential of geothermal energy yet is explored and in use in Europe. Increasing the use of geothermal energy and strengthening the geothermal industry will allow a substantial reduction of $CO_2$-emissions, savings in primary energy, and the creation and sustenance of a strong work force of various disciplines and on many skill levels.

Often forgotten today, one of the main arguments to promote renewable energy sources in Europe is the local aspect. The local production of energy leads towards a decentralised approach and eventually to a reduction of the system costs. It also ensures security of supply- and with carbon free sources of energy above all. Local production of energy also empowers the consumers which can become prosumers; the choice of the energy mix can be more democratic.

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Geothermal is indeed a local source of energy, producing power and heat for cities and rural communities. It allows for local economic development with many indirect positive effects such as job creation. Moreover, one cannot look anymore at an energy technology without considering its integration into the energy system and its role in the economy; here we can highlight the enriching role geothermal can play in both.

Geothermal power plants could be developed in all European regions and will contribute to grid stabilisation, thereby providing much needed security of supply. The current reform of the EU climate and energy framework, which is expected at the end of 2016 and includes the Renewable Energy directive, should take into account the advantages and specificities of geothermal (being base load and flexible; producing locally 24hours per day) through dedicated provisions. Indeed, the ability to provide flexibility at a regional level, a step between centralised and decentralised systems, is one of the key but less well known advantages of geothermal.

Geothermal will be one of the renewable sources providing solutions for clean, competitive, and secure heating, cooling, and domestic hot water. Indeed, geothermal has a key role to play in the decarbonisation of the heating and cooling sector, which has a much more complex structure than electricity sector. Many options are available and the market will decide on the mix of energy sources in each region, but both geothermal direct use (district heating etc.) and shallow geothermal are bound to become major technologies here.

If the energy transition is to be successful, we have to think about optimum scenarios in terms of cost and affordability for the customers and citizens.

For geothermal, a local and stable source of renewable energy, the systems costs and the external costs are very much reduced, and furthermore geothermal contributes to the development of the local economy.

## Research and Innovation to implement the Energy Union

The Energy Union is a very powerful concept as it brings together all the different streams of the EU energy and climate policy. Implementing the Energy Union implies, amongst other things, the full integration of its five dimensions.

In this regard, the fifth dimension "Research, Innovation and Competitiveness" is key for ensuring energy security, energy efficiency and the decarbonisation of the EU economy. It should contribute to make Europe the world number one in renewable energies and develop the next generation of renewable technologies for a competitive Europe.

This fifth dimension should be based on the Issues papers and the Integrated Roadmap of the SET Plan, which sets out the Research and Innovation (R&I) needs of the entire energy system. They must also be the basis of the energy R&I policy for the horizon 2020.

Deep geothermal for heating and cooling and for flexible electricity generation are important components of the future energy system and will contribute to achieving the objectives of the Energy Union.

To this end, further R&I is need, particularly in the following areas:

*Market uptake of mature deep geothermal heating and cooling technologies.* Geothermal district heating systems and conventional geothermal power are already competitive in some markets in Europe. There is the need to remove barriers for a market uptake all over Europe.

*Innovation for allowing the fuel switch in District Heating and for industrial process*. The industry and the DH sectors must switch to renewables, some innovations could speed up this transition, for example lower temperature systems, energy efficient devices etc.

*Demonstration of flexible RES power plants:* To increase the robustness of the power system, flexible generation is essential and must be developed with renewable sources. Some renewables, including geothermal plants, usually run as base load, but new technology such as binary turbines allow them to be flexible in their production. More demonstration plants must be installed in different market contexts.

*Research and Development of the next generation of RES technologies such as EGS.* Breakthrough renewable technologies could be the future 'game changer' for decarbonising the energy system. Enhanced Geothermal Systems (EGS) is a technology already demonstrated but an Action Plan must be launched for increasing its contribution to the electricity mix.

*Towards a smart integrated energy system*. The future energy system should make a strong link between its three sectors: electricity, heating & cooling, transport. Smart energy grids will play an important role in the future smart cities and communities by ensuring a reliable and affordable energy supply to various customers with renewable energy carriers like geothermal energy.

In this framework, Horizon 2020 and R&D national programmes will be crucial. In the period beyond 2020, a strong boost could come from the new Innovation Fund (successor for the period beyond 2020 of the NER 300 programme) currently under discussion.

The NER300 has been a great support to the demonstration of innovative geothermal technologies, but with some limits. The new Innovation Fund should continue supporting renewable energy demonstration projects, learning from its limitations. In particular, upfront funding should be made available as soon as possible. In addition, the EU should bear part of

the project risks in the form of non-repayable grants and include heat only projects, notably for industrial process.

In the framework of the Energy Union, more regional cooperation between Member States and other levels of governance is welcome. Each EU Member State should report its contribution to the implementation of the Set-Plan Integrated Roadmap in its new national climate and energy plan.

## Conclusion

The European Commission has affirmed its objective of making the EU the world number one in renewable energy. Europe is already the leader in terms of geothermal heat pumps and district heating installed and is also leading in innovation such as in underground thermal energy storage, with the main competition coming from China and the USA. Last but not least, Enhanced Geothermal System (EGS) plants for electricity, CHP, or heat, are so far only in operation in Europe, whereas research projects are on-going in the U.S. and Australia.

The EU should continue supporting technological development in geothermal technologies to ensure that Europe retains its status as a world leader in the manufacturing and design, reinforcing its main competitive strengths. The full commercialization of EGS and next generation of deep geothermal technologies will provide Europe with a breakthrough technology able to produce power and heat 24 hours a day, independently from weather conditions. Compared to the past, more attention should be paid to the energy system as a whole, to the development of smart thermal grids and to technologies able to decarbonise the non-ETS sectors.

EGEC's inputs to the Issues paper on deep geothermal are given in the annexe.

Yours Faithfully,

Philippe Dumas,

EGEC secretary general

EUROPEAN COMMISSION
RTD - Energy
ENER - Renewables, R&I, Energy Efficiency
JRC – Institute for Energy and Transport
**SET Plan Secretariat**


# Integrated SET Plan Actions Nr.1&2

# ISSUES PAPER on DEEP GEOTHERMAL ENERGY

## Purpose of this document

This document[1] is intended to progress the implementation of the actions contained in the SET-Plan Communication[2] and specifically the actions concerned with the priority "Number 1 in renewable energy". It is part of a series of Issues Papers jointly prepared by the services of the European Commission and discussed with the representatives of EU member states and countries part of the SET Plan, working together in the SET Plan Steering Group.

The Issues Papers propose to stakeholders strategic targets in different areas of the energy sector. The input from, and positions of, stakeholders for each area will be used to come to an agreement on targets in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.
Stakeholders are invited to take position on the proposed targets in accordance with the guidelines set out in the paper "The SET Plan actions: implementation process and expected outcomes" and submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by **17 June 2016** at the latest. All relevant documents and material are available on the SETIS website https://setis.ec.europa.eu/ .

## Introduction – Geothermal Energy

Geothermal energy is a valuable and local source of energy that can cost-effectively provide base-load/dispatchable electricity, heat or a combination of both. It has great potential as a renewable source not only in Europe but also globally, in particular in some developing countries. It is convenient and accepted to divide the geothermal sector into "deep" geothermal and "shallow" geothermal sectors. The actual depth that marks the boundary between "deep" and "shallow" differs highly across regions and is to most extent dependent on the local geothermal gradient, ie. the temperature of the resource. Nevertheless, the reference to the deep/shallow terminology provides a general understanding of the technologies needed

[1] This document is a working document of the European Commission services for consultation and does not prejudge the final form of any future decisions by the Commission.
[2] Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation" (C(2015)6317).

and of the possible applications of the geothermal energy harnessed from the earth. This issues paper focuses on deep geothermal energy[3], which can be directly used as heat or converted into electricity.

Geothermal energy for direct use (e.g. hot water and space heating) is probably the oldest source of renewable energy, and the first geothermal plant for electricity production started operations in Italy already in 1904. Since then, the technology to use and transform geothermal heat coming from beneath the Earth's surface, the knowledge of the geology and also the understanding of the physical processes involved have greatly increased.

Deep geothermal energy can technically be extracted for power, heat or cogeneration from a variety of geological media although the effort and cost related to this extraction can vary greatly. A geological formation with natural fractures and/or a porous structure where water can move is termed hydrothermal reservoir. The technologies associated with hydrothermal power and heat production may be considered as mature and the large majority of geothermal energy stems from hydrothermal resources.

In many geological formations there is no natural hydrothermal reservoir because there is insufficient or little natural permeability or fluid saturation, in such cases heat is distributed by conduction. Through EGS (Enhanced or Engineered Geothermal Systems) it is possible to create or improve a hot water reservoir by increasing the permeability and injecting water at sufficient pressure into the subsurface where it is heated up. The hot water is then pumped back to the surface and used to produce power and heat, before being recycled and re-injected back into the subsurface. The EGS technologies are proven on small scale since 2007 but they are still in the development process.

Nowadays **geothermal heat** is directly used, depending on its temperature, in a number of sectors: from bathing and swimming to industry, agriculture and district heating. This latter being the most promising sector for geothermal heat. In Europe there are 257 geothermal district heating systems, with total installed capacity of 4.6 GWth (2015 data published by EGEC[4]). Data on direct use is difficult to find and statistically not homogenous[5], yet the growing importance of geothermal heat as a local source of energy is evident.

According to the EGEC Market Report Update, in 2015 the total installed capacity for **geothermal electricity** generation in Europe was about 2.2 GWe, generated by 84 power plants (thereof, 0.95 GWe in 51 plants in EU28). The total installed capacity is expected to reach 3.5 GWe in 2018, mainly thanks to the very promising Turkish market. In the world, the total installed capacity in 2013 was 12 GWe producing 76 TWh/y and, according to IEA-GIA projections, it could increase to reach 1,400 TWh/y (equal to 3.5% of global electricity production) by 2050[6], half of it produced by EGS (Enhanced Geothermal System) plants. The geothermal power market is particularly interesting in the USA, Philippines, Indonesia, Mexico, Kenya and can be made interesting in the near future in the EU if EGS will be commercialised under various geological conditions.

[3] The shallow geothermal sector will be covered in a separate issues paper.
[4] EGEC, Market Report 2015.
[5] According to the IEA-GIA 2013 report geothermal heat production reached about 150 TWh/yr in 2013 and it is projected to reach about 1,600 TWh/yr in 2050.
[6] IEA-GIA, Trends in Geothermal Applications 2013 and IEA, Technology Roadmaps - Geothermal Heat and Power, 2011.

Recent modelling results[7] by the JRC-EU-TIMES model predict geothermal power production of 540 TWh in 2050 under a long term decarbonisation scenario. This would mean that geothermal power could provide 12.5 % of the EU electricity demand while exploiting about 20 % of the available geothermal technical potential[8]. This market share might be increased significantly if cost reductions associated with drilling will be realised. In volcanic islands geothermal energy could provide the highest share of renewable heat and power.

Geothermal installations are characterized by low OPEX and high CAPEX, used mostly to cover the costs of exploration and drilling and the plant construction. In addition financing costs are high due to the need for mitigating the geological ~~high~~ risks during exploration. High capacity factors and low OPEX, near zero system costs and externalities, result in LCOE very similar to other renewable technologies[9].

Power, heat or a combination of both are traditionally generated in areas where hydrothermal, high temperature, resources are available. However, recent technological developments are now allowing the valorisation of resources with lower temperatures. In order for geothermal energy to fully meet its potential in the renewable energy mix it is necessary for EGS technology to be commercially available to allow the exploitation of so far untapped geothermal resources[10].

**Why taking action now on geothermal energy?**

Geothermal energy has an excellent potential in Europe, and in a number of NREAP (National Renewable Energy Action Plan) there are ambitious, yet far to be reached, targets for it. Recent technological developments (binary plants) have made possible to cost-effectively produce electricity with fluids at lower temperatures and there is an increasing awareness of the potential of geothermal heat. In order to allow the widespread diffusion of geothermal energy the following issues need to be tackled to improve performance and reduce costs:

- improve the overall efficiency of geothermal installations primarily by ensuring sufficient mass circulation flow through the reservoirs enabling high heat transfer to the surface installations and by succeeding in optimal reservoir management; increase in turbines efficiency and flexibility
- reduce exploration and drilling costs in order to lower CAPEX and ~~the risk of project failure~~increase exploration accuracy to improve the success rate of deep geothermal projects .
- develop innovative geothermal DH systems in dense urban areas: lower temperature, more efficient, cooling; development towards and integration into smart thermal grids
- provide competitive solutions to provide H&C for the industry (high temperature, storage)

In addition it is necessary to bring EGS ~~a~~to commercial scale, reduce its costs~~, and~~ increase its performance and upscale plant size~~,~~ to allow for widespread harnessing of geothermal energy. Moreover, research on the next generation of geothermal technologies (hybrid systems, Unconventional Resources etc.) should be pursued.

[7] 2015 JRC Geothermal Energy Status Report. The JRC-EU-TIMES[7] - a system cost optimization model for technology deployment - is used to assess how different exogenous policy-driven decarbonisation pathways affect the power sector's technological deployment until 2050.

[8] Highly energy efficient scenario with constrained total primary energy consumption of 1319 Mtoe in 2050 and a full decarbonisation of the power sector.

[9] 2014 JRC Geothermal Energy Status Report.

[10] 2015 JRC Geothermal Energy Status Report.

**Targets**

Building on the Integrated Roadmap of the SET Plan, public (EC and Member States/Regions) and private investment must focus on targeted R&I actions to achieve the following goals in terms of performance and cost-reductions. The proposed targets are as follows:

Related to cost reduction:

1. Reduce the exploration costs by at least 25% in 2020, and by 50% in 2050~~, expressed as reduced number of abandoned projects~~;
2. Reduce the drilling costs by 15% in 2020, 30% in 2030 and by 50% in 2050.
3. Increase success rate of deep geothermal projects in green field and in operated fields, and reduce exploration risk, expressed as reduced number of abandoned projects

Related to performance improvements:

4~~3~~. Improve the overall efficiency of geothermal installations, increase reservoir management and ensure sustainable yield predicted for a given period +/- 20 years by 2030.

Related to cost reduction and to performance improvements:

5~~4~~. Reduce EGS production costs below 12 €ct/kWh by 2020; establish 5 EGS plants in different geological situations, of which at least one plant of capacity 20 MWe or 40 MWth, for the technology to reach commercial-scale stage.

6. Develop 5 demonstration flexible/dispatchable geothermal power plants: able to respond to commands from a system operator, at any time, within certain availability parameters, and to increase or decrease output over a defined period. For increasing the robustness of the power system, flexible generation is essential and must be developed with renewable sources.

7. Develop 10 flexible, efficient, multifunctional and cost-effective smart thermal grids based on geothermal heat: Smart thermal grids can play an important role in the future Smart Cities by ensuring a reliable and affordable heating and cooling supply to various customers

## Annex: Relevant actions of the document 'Towards an Integrated Roadmap ' needed to achieve the targets

Concrete targeted R&I actions for the long, medium and short term for geothermal energy development in general are proposed in the Annex 2 of the 'Towards an Integrated Roadmap' document. Action 1 from the Advance Research Programme, Action 1 and 2 of the Industrial Research and Demonstration programme and Action 1 of the Innovative and Market-uptake Programme seem to be the most relevant for realising the targets defined in the Issues Paper.

**A. Proposed targeted R&I actions**

***Advanced Research Programme***

**Action 2: Improving deep geothermal production technologies: reservoir stimulation and management**

**Scope**: Natural permeability of reservoirs is one of the key factors to determine the energy output of geothermal systems by controlling the productivity of a well. Existing stimulation methods need to be refined to increase rate of success, to improve predictability of results, to remove well and formation damage, to develop and prop fracture networks, and to reduce environmental hazard (pollution of aquifer, induced seismicity). Research should focus on understanding the underlying processes leading to improved permeability and develop concepts to minimise unwanted side effects. These concepts include the use of non-hazardous materials and soft stimulation approaches.

**Deliverables**: Design and field implementation of hydraulic, chemical, thermal stimulation techniques in selected rock and structural settings (sedimentary/stratified, volcano/tectonic, crystalline/metamorphic). Improved prediction and monitoring of chemical and hydraulic developments.

**Action 3: Improving deep geothermal production technologies: New materials**

**Scope:** Corrosion and scaling are among the main problems during operation of deep geothermal plants, jeopardising plant efficiency and longevity. Corrosion and scaling are not stand alone processes but a matter of the system. Therefore, the interaction of technical materials with terrestrial fluids has to be systematically investigated by basic research to prevent design shortcomings and secure well/equipment integrities.

**Deliverables:** Design and testing of low cost high temperature, high pressure mechanically resistant metal, alloys, and composite materials. Study of interaction of geothermal fluids from different geological environments with standard and newly developed specific alloys and composite materials as technical system components of the thermal cycle (e.g. Tubing, cements, sealing, well head, heat exchanger).

**Action 4: Costs reduction of deep geothermal drilling technologies: develop novel drilling technologies**

**Scope**: Novel drilling concepts at the technological frontier are expected to allow for dramatic drilling time/cost breakthroughs in an unforeseeable future. The concepts should be investigated today (2014-2016), and basic (and later applied: 2016-2020) research supported in order to have these techniques available for geothermal drilling in the medium/long term timeframe. A non-exhaustive list of concepts comprises: millimetre wave deep drilling, hydrothermal and instant steam spallation drilling, robotic, ultra-

deep, high temperature/pressure drilling technologies. Other technologies as laser drilling and fusion drilling should first be analysed by reliable assessment studies to prove their basic viability.

**Deliverables**: selected prospective drilling technologies.

**Action 5: Improve exploration technologies**

**Scope**: Exploration technologies for subsurface imaging are crucial prior to locating drilling targets. The goals are delineation of the geologic structure and characterization of bulk properties of the reservoir. Heat transfer processes, the stress field and fracture patterns related to fluid flow in the reservoir are important. Full-scale investigations of the basic hydraulic, mechanical and chemical processes are required.

**Deliverables**: Development of innovative, cost-effective, subsurface imaging tools capable of investigating down to reservoir depth including application of new geological and geophysical methods. Evaluation of the EU EGS potential.

***Industrial Research and Demonstration Programme***

**Action 2: Improving deep geothermal production technologies: innovation in monitoring and operation**

**Scope**: Downhole instrumentation is required to improve performance, reduce environmental impact and increase public acceptance. A reliable and expanded monitoring system should be developed and installed at geothermal sites under development and in operation. That way, hazards of induced seismicity, of radioactivity from the deep thermal waters and the protection of drinking water can be better controlled and measures to mitigate unwanted side effects of geothermal development and operations can be defined. For the successful operation of most geothermal projects in non-volcanic environments, there is a need to improve pump efficiency and longevity, to secure production reliability, to develop tools for avoiding two- phase flow in wells, etc., in order to upgrade exploitation economics. The harsh geological environment of geothermal installations can lead to corrosion and precipitation from thermal waters, processes accelerating the decline in productivity.

**Deliverables**: Application of new monitoring networks including surface installations to measure seismic and other physical properties of the subsurface. Development of high temperature resistant, high efficiency pumps and instrumentation. Measures to reduce corrosion and scaling in operating geothermal plants inclusive new developed inhibitors.

**Action 3: Launch an EGS flagship programme**

**Scope**: EGS is a technology for accessing the heat in hot but impermeable basement rock. Once fully developed it will provide a major increase in the geothermal resource base, both for heat and electric power. At each stage of EGS development, proven methodologies can be applied and bottlenecks identified. The expected outcome will be the development of cost-effective and reliable large EGS plants to make geothermal power fully competitive. Upscaling projects often lead to the development of better or less expensive applications (cascading effect for drilling).

Deliverables: Demonstration sites in different geological settings (3 plants of 5 MWe-10MWth) and upscale (1 plant=10 MWe-20MWth and 1 plant=20 MWe-40MWth) and establish a network of European EGS test laboratories.

**B. Framework conditions – policy measures**

***Innovative and Market-uptake Programme***

**Action 3: Mitigate geological risk associated with geothermal**

**Scope**: Several risk factors (e.g. technical, financial, and environmental) need to be carefully evaluated during the exploration phase while the subsurface model is not well understood, the resource not completely proven and the development scenarios not yet clearly defined. In particular, seismic risks associated with EGS projects and ground deformation associated with exploitation of shallow reservoirs should be addressed and mitigation actions identified accordingly in stimulation planning. It is assumed that in early exploratory stages a framework insurance policy would be promoted to mitigate the exploration risk. It should act as a stimulus until, after the initial high level risk be mastered, developers carry out exploration/development issues under their own responsibility and resources.

**Deliverables**: a European and/or Geothermal Risk Insurance Funds for reducing the geological risk.