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

SET Plan - Declaration of intent on Strategic Targets in the context of an Initiative for Global Leadership in Deep Geothermal Energy

Purpose of this document

This document[1] is intended to record the agreement reached between representatives of the European Commission services, representatives of the EU Member States, Iceland, Norway, Turkey and Switzerland, and representatives of the SET-Plan stakeholders most directly involved in deep geothermal energy[2], on the implementation of the actions contained in the SET-Plan Communication[3], and specifically the strategic targets for the priority "Number 1 in renewable energy" for what concerns deep geothermal energy.

This agreement follows consultations with two European Technology and Innovation Platforms, the ETIP Deep Geothermal (which includes the views of the industry, of the research community and of the Member States that participate in the Geothermal ERA NET[4]) and the Geothermal Panel of the ETIP Renewable Heating and Cooling and with the European Geothermal Council (EGEC). Direct inputs received from the Geothermal ERA NET are also taken into account. In addition, inputs were received from the DHC+ Technology Platform, from EUA-EPUE, the European Platform of Universities in Energy Research & Education and from Ross Offshore, DK and a public consultation was held via the SETIS website[5] on the Issues Paper prepared by the Commission services (see annex 1). It takes into consideration all the received input papers and public comments available on SETIS and discussions in the SET-Plan Steering Group on 12 July 2016 with the participation of the SET-Plan stakeholders most directly involved in deep geothermal energy.

The stakeholders agree to ambitious targets in an endeavor to maintain global leadership in the sector, to put forward their best efforts in a coordinated way between public and private sectors, and to jointly address all relevant issues in order to attain these targets.

Brussels, 14 September 2016

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1 This document is not legally binding and does not prejudge the process or final form of any future decisions by the European Commission.

2 The ETIP Deep Geothermal, the ETIP RH&C, the EERA JPGE, the European Geothermal Council.

3 Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation" (C(2015)6317).

4 Iceland, Netherlands, Italy, Germany, France, Slovakia, Hungary, Slovenia, Portugal (Switzerland and Turkey also participate in the ERA NET).

5 Strategic Energy Technology Information System website https://setis.ec.europa.eu/

Introduction – Deep 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. With these features, it has the potential to provide real alternatives to replace fossil fuel based power plants and fossil fuel based heating not only in Europe but also globally, in particular in some developing countries. In addition, geothermal reservoirs may also act as sites for energy as well as CO_2 storage. It is convenient and accepted to divide the geothermal sector into "shallow" geothermal and "deep" geothermal sectors. The actual depth that marks the boundary between "shallow" and "deep" differs highly across regions and it is to most extent dependent on the local geothermal gradient, i.e. on the temperature of the resource. The distinction between the two usually corresponds to whether or not primary use of the energy requires the use of heat pumps. The reference to the shallow/deep terminology is used here as it provides a useful and general understanding of the technologies needed and of possible applications of energy harnessed from the earth. This document focuses on deep geothermal energy[6], which can be directly used as heat or converted into electricity.

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. The latter being the most promising sectors for large-scale uptake of geothermal heat. In Europe there are 257 geothermal district heating systems, with total installed capacity of 4.6 GW_{th} (2015 data published by EGEC[7]). Data on direct use is difficult to find and statistically not homogenous[8], yet the growing importance of geothermal heat as a local source of energy is evident. There is great potential for the utilization of geothermal energy for heating in Europe. There are many locations in Europe with district heating systems that can easily be adapted to use local geothermal resources instead of relying on imported fossil fuels. This can increase energy security and price stability as well as independence from fossil fuel sources. In addition, there is also a potential for an increased use of geothermal heat in industry and agriculture. The unlocking of this potential will be enabled by research and innovation focused on the improvement of technology and its incorporation into the energy system. In this way, geothermal energy (together with underground heat storage) will become one of the key options for the transition towards a 100% renewable heat supply in Europe.

According to the EGEC Market Report Update, in 2015 the total installed capacity for **geothermal electricity** generation in Europe was about 2.2 GW_e, generated by 84 power plants (thereof, 0.95 GW_e in 51 plants in EU28). The total installed capacity is expected to reach 3.5 GW_e in 2018 including the rapidly growing Turkish market. Globally, the total installed capacity in 2013 was 12 GW_e 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[9], half of it being produced by EGS (Enhanced Geothermal System) plants. The geothermal power market is particularly dynamic in the USA, Philippines, Indonesia, Mexico and Kenya, and could be invigorated in the near future in the EU if unconventional geothermal resources (e.g. supercritical, magmatic, geopressurized, off-shore), including EGS, can be successfully commercialised under a wider range of geological conditions.

[6] The shallow geothermal sector will be covered in a separate issues paper.
[7] EGEC, Market Report 2015.
[8] 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.
[9] IEA-GIA, Trends in Geothermal Applications 2013 and IEA, Technology Roadmaps - Geothermal Heat and Power, 2011.

Recent modelling results[10] indicate that geothermal power production could reach up to 540 TWh in 2050 under a long term decarbonisation scenario provided that EGS can be deployed on a large scale. 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[11]. This market share might be increased significantly if cost reductions associated with drilling are realised. On volcanic islands geothermal energy could provide the highest share of renewable heat and power.

Geothermal installations are characterized by low OPEX but high CAPEX, used mostly to cover the costs of exploration and drilling and of the plant construction. In addition, financing costs are high due to high geological risks associated with costly drilling during early-stage exploration. Market financiers generally are unwilling to take up these early stage risks and costs, which represents one of the major barriers for geothermal project developers. However, high capacity factors (far higher than for most other renewables) and low OPEX, near zero system costs and externalities, result in costs very similar to those of other renewable and low-carbon technologies[12].

EU industries and operators experience and leadership, as well as European scientific excellence are recognized worldwide. In order to stimulate the uptake of geothermal energy it is necessary to reduce costs and to improve performance. It is also necessary to widen the geological conditions in which technologies can be applied and make technologies to harness unconventional resources, including EGS, available for the market. In addition, hybrid systems able to integrate energy production from different renewable sources and flexible systems that smooth the geothermal electricity load profile need to be demonstrated. Environmental performance (development of closed-loop systems that avoid the release of non-condensable gases to the atmosphere) and social acceptability must be improved.

The worldwide importance of geothermal energy has recently become acknowledged at the political level with the launch, at COP21, of the Geothermal Global Alliance. This is a coalition of 38 countries and over 20 development and industry partners that have joined forces to increase the share of geothermal energy in the global energy mix. The Geothermal Global Alliance aspires to achieve a 500 per cent increase in global installed capacity for geothermal power generation and a 200 per cent increase in geothermal heating by 2030[13]. The opportunity for Europe and the European industries, with their knowledge and leadership, in reaching these goals should not be missed.

Strategic Targets

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

[10] 2015 JRC Geothermal Energy Status Report. The JRC-EU-TIMES[10] - 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.

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

[12] 2014 JRC Geothermal Energy Status Report.

[13] http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=438

Agreed strategic targets in deep geothermal energy

1. Increase reservoir performance[14] resulting in power demand of reservoir pumps to below 10% of gross energy generation and in sustainable yield predicted for at least 30 years by 2030;
2. Improve the overall conversion efficiency, including bottoming cycle, of geothermal installations at different thermodynamic conditions by 10% in 2030 and 20% in 2050;
3. Reduce production costs of geothermal energy (including from unconventional resources, EGS, and/or from hybrid solutions which couple geothermal with other renewable energy sources) below 10 €ct/kWh_e for electricity and 5 €ct/kWh_{th} for heat by 2025[15];
4. Reduce the exploration costs by 25% in 2025, and by 50% in 2050 compared to 2015;
5. Reduce the unit cost of drilling (€/MWh) by 15% in 2020, 30% in 2030 and by 50% in 2050 compared to 2015;
6. Demonstrate the technical and economic feasibility of responding to commands from a grid operator, at any time, to increase or decrease output ramp up and down from 60% - 110% of nominal power.

In order to reach these strategic targets and to increase the contribution of geothermal electricity and heat to the energy mix, technological advance must be supplemented and complemented by other factors. These include other technological and non-technological factors:

- *Transparent and harmonized methods and instruments for technical and financial risk management.*
  In early exploratory stages a framework insurance policy would mitigate the exploration risks and acts as a stimulus until, after the initial high level risk be mastered, developers carry out exploration and further development under their own responsibility and resources.

- *Increased social acceptability and mitigation of unsolicited side effects (induced seismicity, emissions to the environment).*
  Unsolicited side effects in reservoir, including induced seismicity, and plant management must be mitigated to address social concerns and increase social acceptability of geothermal installations. New technologies should be developed to improve the environmental performance of high-temperature geothermal power generation systems, avoiding the release of steam and potentially hazardous chemical compounds into the atmosphere from the cooling tower, as well as non-condensable gases (NCGs) like carbon dioxide. In particular the feasibility of closed-loop reinjection of liquid and NCGs for gas-reach resources should be demonstrated.

In addition large scale demonstration and deployment to prove innovative concepts and their integration in the energy system are needed to make technologies available for the market.

[14] Reservoir performance includes underground heat storage.
[15] Costs have to be confirmed establishing at least 5 plants in different geological situations, of which at least one with large capacity (20 MW_e or, if for direct use only, 40 MW_{th}).

Next steps

The stakeholders agree to develop, within 6 months, a detailed implementation plan for the delivery of the above targets. They agree to define joint or coordinated actions, identify ways in which the EU and national research and innovation programmes could most usefully contribute, identify contributions of the private sector, research organizations and universities. They also agree to identify all issues of a technological, socio-economic, regulatory or other nature that may be of relevance in achieving the targets. Finally, the stakeholders agree to report regularly on the progress so that the achievement of the targets can be monitored and, where and when necessary, a corrective action can be taken.

The stakeholders intend to use the European Technology and Innovation Platform on Deep Geothermal energy as the main vehicle for discussing and agreeing on the implementation plan.