GEOENVI Project: Tackling the environmental concerns for deploying geothermal energy in Europe

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ABSTRACT

Deep geothermal has a great potential for development in many European countries. However, the advantages of using geothermal for power production and H&C (Heating and Cooling) are not widely known. Recently, deep geothermal energy production in some regions is confronted with a negative perception, particularly in terms of environmental performance, which could seriously hamper its market uptake. Thus, dealing properly with environmental issues is a prerequisite to the deployment of the deep geothermal resources. The concept of Life Cycle Assessment (LCA) allows analysis and comparison of the environmental impacts of different energy production technologies over their life cycle stages – from extraction of raw materials to production, transport, use and end-of-life. In the framework of the H2020 programme, GEOENVI project, starting in November 2018 for 30 months, aims at engaging with both decision-makers and geothermal market actors, to adopt recommendations on environmental regulations and to harmonize, simplify and promote the implementation of LCA methodology by geothermal stakeholders. A sub-objective is to map environmental risks and impacts as well as mitigation measures and to make these results available through a public database. Once available, these data will be useful to better deal with risks and impacts. They will make it possible to better communicate on environmental issues. It should help reducing obstacles coming from lack of knowledge on environmental issues. The objective of this paper is to present the overall content of the project, and to give insights into first results, notably concerning the online database.

1. INTRODUCTION

Geothermal energy is one of the most promising renewable energy sources for producing electricity and H&C. Geothermal energy will be a key component of the future European energy systems. Results from past projects assessing its potential (GEODH and

GEOELEC projects) show that geothermal energy could supply more than 10 % of EU energy consumption by 2050. Its main advantage is the possibility to offer a wide range of applications in the field of both electricity and H&C with the advantages of being non-intermittent, flexible and dispatchable. Besides it is not dependent on weather-related constraints.

However, the advantages of using geothermal for power production and H&C are not widely known. Recently, deep geothermal energy production in some regions has been confronted with a negative perception, and a special attention from some decision-makers, in terms of environmental performance, which could seriously hamper its market uptake.

Some recent incidents in geothermal energy production such as those in Staufen (DE), Basel (CH), St Gallen (CH), Lochwiller (FR), or local concerns such as in Monte Amiata (IT) provoked a debate on the use of geothermal energy especially about induced micro-seismicity, stimulation, non-condensable (NCG) and greenhouse (GHG) gas emissions, ground deformation, etc.

Among the potential environmental impacts, we can list the followings:

- Surface-visual effects (land use, landscape, flora and fauna);

- Physical effects (induced seismicity: micro-seismicity related to all the operational phases of the exploitation, including reservoir connection and fluid reinjection into the reservoir; subsidence; geological hazards; groundwater resource depletion; natural radioactivity)

- Acoustic effects (noise during drilling, construction and management);

- Thermal effects (release of steam in the air, ground heating and cooling for fluid withdrawal or injection).

- Chemical effects (gaseous emissions into the atmosphere, incondensable gases, pollution and emissions; re-injection of fluids, disposal of liquid and solid waste).

Media reports focus more on disadvantages than benefits. Moreover, there is a growing environmental and societal consciousness and a related fear about explorations into the earth's crust. As a result, decision makers and potential investors have concerns about possible environmental impacts and risks involved in implementing geothermal projects, and social resistance often results in practical obstacles - such as significant slowdowns – to the deployment of the deep geothermal resources.

The GEOENVI project aims at analysing and proposing solutions and tools for addressing concerns and highlighting benefits for the geothermal market uptake focusing on the environmental impacts. Power (mainly) and heat production from geothermal resources may have an impact on any environmental matrix (air, water, ground, ecosystems).

Environmental impact assessment is always a prerequisite to the authorization of geothermal plant. However, this sometimes results in biased perspective as the assessment is performed according to different methods and usually only considers partial life cycle stages. Thus, the results are not comparable to other renewable energy sources. When there are several energy production options to produce energy in the area (with and without renewable energy), it is not always possible to objectively compare their environmental impacts and clearly identify the most suited one. The same challenge also emerges when policy makers need to frame a subsidy, incentive, or labelling strategies.

These challenges can be tackled with the concept of LCA. The results of a LCA allow analysis and comparison of the environmental impacts of different energy production technologies over their life cycle stages – from extraction of raw materials to production, transport, use, and end-of-life. Assessing and managing the life cycle of processes provides the opportunity to accelerate the transition towards sustainable production. LCA can be used in decision making to generate information which helps to prioritize sustainable development. Information from LCA can be used to support decision making in both public and private sectors.

The overall objective of the GEOENVI project is to make sure that deep geothermal energy can play its role in Europe's future energy supply in a sustainable way. It aims at creating a robust strategy to answer environmental concerns (both impacts and risks):

- by providing an online public database to present clear and objective data concerning environmental issues,

- by setting an adapted methodology for assessing environment impacts and by implementing it on some case studies,

- by proposing recommendations on environmental regulations to the decision-makers and finally

- by communicating properly on environmental concerns with the general public.

2. COMPOSITION OF THE CONSORTIUM AND METHODOLOGY

The GEOENVI project is a project funded by the Horizon 2020 funding programme, under the grant agreement n° 818242. It gathers 16 partners from 6 different countries (Belgium, France, Italy, Iceland, Hungary and Turkey). GEOENVI started in November 2018 and will be on-going until April 2021.

Figure 1: GEOENVI project Logo

The project is coordinated by the European Geothermal Energy Council. Partners are national associations, national research institutes and operators: European Geothermal Energy Council (Belgium), Rete Geotermica (Italia), Enel Green Power (Italia), Consorzio perlo sviluppo delle aree geotermiche (Italia), Consorzio interuniversitario per lo sviluppo dei sistemi a grande interfase (Italia), Consiglio nazionale delle ricerche (Italia), Bureau de recherches géologiques et minières (France), ES-Geothermie (France), Association pour la recherche et le développement des méthodes et processus industriels (France), Islenskar orkurannsoknir (Iceland), Georg-Rannsoknarklasi I jardhita (Iceland), Orkustofnun (Iceland), Vlaamse instelling voor technologisch onderzoek VITO (Belgium), Jeotermal elektrick santral yatirimcilari dernegi JESDER (Turkey), Dokuz Eylul Universitesi (Turkey), Mining and geological survey of Hungary (Hungary).

Methodology

The first step of the project is to map environmental impacts and risks, and to make knowledge available in a public database. The database will be elaborated to enable efficient research, for instance depending on geography, geology, project characteristics, etc. In addition, information will be provided on mitigation measures and on regulations. This work will facilitate a common understanding of environmental risks and impacts within partners of the project, and will be a rich source of information for all stakeholders and for the public. Then, harmonized guidelines will be develop to conduct life cycle assessment and environmental impact assessment, using feedback and data from various European case studies. The engagement with decision-makers is an important part of the project, in order to promote recommendations for harmonisation of environmental regulations in the target countries and answer the policy and regulatory harmonization challenge. Harmonized guidelines to conduct life cycle assessment approaches and environmental impact methodologies will be promoted within the market actors in the target countries. Finally, a European dissemination of the results will enable a wide adoption and implementation of the project results.

GEOENVI looks into harmonizing existing regulations with LCA methodology by analyzing environmental impacts of geothermal plants in different geological settings throughout their lifetime. Simplified models which are suitable for pre-determined geothermal categorization are going to be developed, thus enabling less complex LCA assessment, with an acceptable degree of uncertainty. All stakeholders, such as decision makers, public institutions, and economic actors are going to be involved in the development. This will allow LCA assessment to be more integrated in the construction and implementation of regulations. Though leaving flexibility to adapt to the energy profile of different countries, and allowing an objective benchmarking with respect to other renewable energy technologies, the proposed approach will establish correct rules for the environmental costing of the two main outputs (electricity and heat) depending on the plant arrangement and on the general context. Collateral benefits to the project are the familiarization of life cycle thinking to a larger population, which in turns will bring its own socio-economic gain.

3. CONTEXT

The deep geothermal potential is rather large as highlighted by GEODH and GEOELEC projects. Geothermal power generation has its roots in Europe, where the first test in 1904 and the real beginning of power generation in 1913 took place in Italy. Since then, have been observed within the last five years (2012-2017), after nearly a decade of only small development in capacity in the deep geothermal sector both for electricity and for heat supply (mainly district heating). The development of geothermal technologies has been slow but steady, having 127 geothermal power plants in operation, with a capacity of 3 GWe in 2016, and 300 geothermal district heating in operation with a capacity of 5.1 GWth in 2018. Globally, the installed power capacity reached 14 GWe and was about 70 GWth in 2017. The level of penetration of deep geothermal is currently limited because of both socio-economic and market conditions. One of the reasons of this trend is that the role of deep geothermal technologies is not sufficiently taken into consideration today in energy policies. In consequence, the conditions are not set for stronger market development in the next years.

However, current market conditions do not allow this development; many non-technical barriers still need to be removed. Besides, a new generation of geothermal technologies is also needed for answering the challenges of the next decade for the European energy system.

If Europe wants the energy transition to be successful, we have to think about an optimal scenario in terms of costs and affordability for customers and citizens. Geothermal will then be a key enabler, a local and stable source of renewable energy, and its role could be crucial in the future energy system.

More than 300 geothermal district heating (DH) projects are now operating. There are also more than 200 power projects currently under development or investigation, which means that the number of plants operating in Europe could double in the near future. Yet, the geothermal power market is not developing as quickly as expected. As experience from past projects shows, there are several reasons for this.

In particular, non-technical barriers such as environmental concerns still need to be removed and thereby there is an urgent need to increase awareness of its advantages especially among decision makers, civil society and investors. Environmental concerns are one of the important barriers for deep geothermal market development. Geothermal should be a safe, reliable, and environmentally benign renewable energy source. However, all man-kind activities have somehow an impact on nature, including the construction of a deep geothermal plant. The environmental impact of all infrastructure projects should be rightly considered, and environmental regulations are important tools for the development of geothermal. Such a sustainable development of the geothermal sector would facilitate public acceptance.

Policy and regulation are keys to the growth of renewable energy and it is necessary to understand the impact in the future to be able to come up with regulations or policies favouring energy production technologies that have relatively the least negative environmental impact. LCA (Life Cycle Assessment) has emerged as an approach to quantify and account for environmental impacts (McMannus et al, 2015). Originally focused on accounting for current or past impacts in existing projects, LCA is becoming forward looking to assess future impacts of a more consequential nature. LCA is a valuable tool to help formulate policies and to help taking decisions in creating environmental regulation (Grisel and Osset, 2004). Information from LCA are useful to draft different policy instruments that concern economic actors and consumers, such as label, standard, taxation, incentives, subsidy, etc. It also helps to establish the prices of energy that reflects the cost of the associated environmental damages (Bicalho, 2014). One example of adoption of LCA exists in the EU renewable energy directive (EU 2009) to determine the sustainability criteria for biofuel and bio liquids production. This directive defines the requirement of greenhouse gas emission savings from the use of biofuels and bioliquids and, at the same time, the detailed rules and guidelines on how to quantify their CO_2 emissions during the life cycle. While it is necessary to have environmental impacts from renewable energy sources identified, the downside is often found in the execution side as primary data is either unavailable or too time consuming to gather (Hetherington et al. 2014). This falls on the burden of the practitioners or the reporters who use the guidelines for compliance and study. Therefore, database and software packages are the most accessible solution for the practitioner.

When it comes to renewable energy, there are complexities in integrating LCA into regulations. LCA standards described in ISO 14040 are open for interpretation. The methods of assessment between studies differ considerably in their system boundaries, co-product and waste definitions and methods of allocation of environmental impacts. Therefore some guidelines have to be established in order to achieve more homogenized results which will, in turn, allow a fair competition between renewable energy market actors. Furthermore, this integration equally demands LCA to be implemented in broader context, in a more practical way, and without adding too much burdens to either the policy / decision makers or the practitioners. In the geothermal sector, one needs to be even more cautious with different geological characteristics between geothermal sites. Moreover, the purpose itself and the functional unit of the geothermal plant have to be defined, as there are significant differences between plants oriented to production of electricity and those where production of heat is dominant. These factors add variance on top of the different technologies available to extract from deep geothermal energy and convert it to electricity and heat. This is one of the challenges of the GEOENVI project as it covers several countries with different geological characteristics, employing various geothermal technologies, and committed to development of geothermal systems for different purposes.

4. TARGET COUNTRIES AND CASE STUDIES

The GEOENVI project focuses on six key countries with varying deep geothermal potential, markets maturity, and geological settings: France, Italy, Belgium, Iceland, Turkey and Hungary. These countries have been selected because they have a potential for deep geothermal and there are plants already operating or under development.

Figure 2: Six target countries (France, Italy, Belgium, Iceland, Turkey, Hungary)

They also present different and complementary geological settings, as well as profiles of environmental concerns. By collecting information in these countries, knowledge gained in experienced markets can be made accessible and transferred to stakeholders in less developed markets all over Europe.

Case studies have been selected to be treated in the project: they are located in Iceland (Theistareykir geothermal power plant), France (Soultz-sous-Forêts and Rittershoffen geothermal power and heat plants), Italy (Bagnore 3&4 geothermal power plants located in Amiata), Turkey (Kizildere plant, Sinem-Deniz-Kerem plants, Dora-2 and Babadere Tuzla plants), Belgium (Balmatt geothermal plant) and Hungary (Szeged district heating system).

This mix of case studies allows to combine projects at different phases of development, with difference about the most important environmental impacts and concerns, difference in the stakeholders involved, and with different geothermal technologies and geology.

5. MAP ENVIRONMENTAL IMPACTS AND RISKS

A first objective is to elaborate a public database to give information and data concerning the different environmental impacts and risks.

This needs elaborating a common categorization of risk and impacts, distinguishing consequences (for instance “health deterioration”), impacting phenomena (for instance “seismicity”) and causes (for instance “hydraulic stimulation”). Some environmental concerns may constitute an impact (something that occurs for sure) or a risk (an unexpected event that may occur, with a probability), but the boundary may sometimes be tricky. As far as possible, we will try to propose clear view of these issues. We will also try to identify the “favouring situations”, that may favour the occurrence or the intensity of the different environmental issues (for instance the fact that stimulation may increase induced seismicity). These favouring situations could be geographical, geological, technological, etc. For each impact/risk, we will also investigate the monitoring measures as well as the mitigation solutions. The objective is indeed to give transparent information, but also to go forward reduction of risk and impacts. Information concerning the perception of risk and impacts may also be presented in the online database. This work requires an important literature review, already in progress.

In addition to this kind of “wiki-database”, a “sites database” will be elaborated, with description of specific-sites characteristics, and with information on all environmental issues (Environmental Impact Assessment, Risk Analysis, Life Cycle Analysis, incidents with environmental consequences).

The work is currently on going, and the database should be available at the end of 2019. It will be public, dedicated notably to all stakeholders of deep geothermal projects. A public report will also be prepared.

Finally, in order to broaden the common understanding of environmental aspects of deep geothermal energy, the environmental impacts and risks will be discussed with regard to other renewable energies (and other fields, whenever considered of relevance).

6. HARMONIZATION OF ENVIRONMENTAL IMPACTS ASSESSMENT METHODOLOGY ENVIRONMENTAL IMPACTS AND RISKS

LCA (Life Cycle Assessment) has emerged as an approach to quantify and account for environmental impacts (McMannus et al, 2015). Originally focused on accounting for current or past impacts in existing projects, LCA is becoming forward looking to assess future impacts of a more consequential nature. LCA is a valuable tool to help formulate policies and to help taking decisions in creating environmental regulation (Grisel and Osset, 2004). Information from LCA are useful to draft different policy instruments that concern economic actors and consumers, such as label, standard, taxation, incentives, subsidy, etc. It also helps to establish the prices of energy that reflects the cost of the associated environmental damages (Bicalho, 2014). One example of adoption of LCA exists in the EU renewable energy directive (EU 2009) to determine the sustainability criteria for biofuel and bio liquids production. This directive defines the requirement of greenhouse gas emission savings from the use of biofuels and bioliquids and, at the same time, the detailed rules and guidelines on how to quantify their CO_2 emissions during the life cycle. While it is necessary to have environmental impacts from renewable energy sources identified, the downside is often found in the execution side as primary data is either unavailable or too time consuming to gather (Hetherington et al. 2014). This falls on the burden of the practitioners or the reporters who use the guidelines for compliance and study. Therefore, database and software packages are the most accessible solution for the practitioner.

When it comes to renewable energy, there are complexities in integrating LCA into regulations. LCA standards described in ISO 14040 are open for interpretation. Arguably however, modern LCA methodologies tend to be oriented to establishing the environmental cost of a service to a community, rather than calculating the environmental costs – possibly in different categories – of a product or a process. For instance, geothermal plants should be evaluated in terms of capability of satisfying the electricity and heat needs of a community (local, regional or larger scale), taking into consideration the competitiveness (economically and in life-cycle environmental performance) with other options (fossil or renewables). The methods of assessment between studies differ considerably in their system boundaries, co-product and waste definitions and methods of allocation of environmental impacts. Therefore some guidelines have to be established in order to achieve more homogenize results which will, in turn, allow a fair competition between renewable energy market actors. Furthermore, this integration equally demands LCA to be implemented in broader context, in a more practical way, and without adding too much burdens to either the policy / decision makers or the practitioners. This is where LCA needs to be simplified.

Based on the selected case studies covering both operating power plants and district heating ones using geothermal, GEOENVI will build harmonized guidelines for environmental impacts assessment. These guidelines will integrate life cycle assessment approaches tailored to geothermal installations to be further adopted at the European and possibly at the international level.

As a second stage the interest of LCA alternatives will be investigated with stakeholders, using simplified models dedicated to non LCA experts. A simplified model generated for GEOENVI use cases will serve as example to pave the way towards this new type of tools. A protocol to generate such types of simplified tools will be provided. Both objectives aim at enlarging the dissemination of knowledge on environmental issues linked with geothermal installations by providing stakeholders with relevant tools and harmonized methodologies.

One key issue is evaluating the environmental costs for different products, such as heat and electricity, which are produced by geothermal plants. The proportion of the two productive outputs is widely different depending on the specific site and technology employed. The problem is common to other systems providing Combined Heat and Power (CHP): in this light, GEOENVI will take advantage of existing regulations (Directive 2004/8/CE) introducing a common reduction to the Primary Energy Saving (PES). Moreover, the value of heat as a product is heavily associated to its exergy content and to the use of material streams to produce it: an exergy-environmental approach based on LCA evaluation of the environmental costs will be applied. The required detailed Life Cycle Inventory (LCI) will be reverse-engineered from global LCI in order to allow application of this methodology also to the Simplified Life Cycle Analysis.

7. ENGAGE DECISION-MAKERS AND MARKET ACTORS

GEOENVI aims at engaging with both decision-makers and geothermal market actors, to adopt recommendations on regulations and to see the LCA methodology implemented by geothermal stakeholders. The engagement with stakeholders includes sharing of knowledge by adopting an open and FAIR (findable, accessible, interoperable, reusable) data approach. The aim is to contribute to the development of a calm, transparent and trustworthy climate to discuss environmental concerns, thus favouring a solid deployment of future projects. It is essential to engage strong interactions with strategic groups, including political decision makers, project developers, investors, the general public, and local communities, in order to remove environmental impacts. Indeed, it is responsibility also of decision and policy makers to ensure that the growth of renewable energy is in line with sustainability.

As a result, the environmental risks and impacts of geothermal energy projects shall be reduced while maximizing the benefits derived from the project to local communities. A monitoring tool will be developed to measure how these objectives have been achieved.

In order to engage with decision-makers, the best strategy to harmonize and empower the existing environmental regulations, adapting life cycle thinking is also engaging the relevant national and local authorities (e.g. environment ministries, mining authorities) in order to facilitate the change. At this point, other relevant countries outside the consortium that has strong activity in geothermal energy (Germany, the Netherlands, etc) are going to be included in the scope. Decision makers such as energy or environmental ministries, mining authorities, public funding, local authorities are going to be mapped. Furthermore, for an efficient engagement, it is important to set some prioritization strategy by analysing relevant existing regulations, and identifying the owners of the regulations, their level of influence or authority and their openness to changes in the countries of the consortium. By having them identified, engagement efforts could be focused to the ones having higher influence to the success of changes implementation.

8. CONCLUSION

By creating a database of environmental impacts and risks and analysing their mitigation measures, GEOENVI will facilitate the harmonization of environmental impacts assessment methodology in a life cycle approach. The adoption of the outcoming recommendations of the GEOENVI project by decision-makers and market actors will support the increase of geothermal energy in the future energy mix, first in the target countries of the project, and then in all Europe.

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