Work Package 4: Framework Conditions for RD&I

Mapping of relevant policy and regulatory issues

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Author(s): Adele Manzella (1), Thomas Garabetian, Valentina Pinzuti, Philippe Dumas (2), Ben Laenen (3)
Author'(s') affiliation: CNR (1), EGEC (2), VITO (3)

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1. Introduction

Deep geothermal energy is a heavily regulated sector, and usually requires a specific support framework. When regarding the framework conditions for research in geothermal, it appears that they are highly influenced by the energy, climate and research policies. To improve this framework, it is necessary to influence these policies. It can be done by communicating and promoting the messages laid out in the ETIP DG Vision for geothermal, the ongoing Strategic Research and Innovation Agenda and the future Implementation roadmap to the relevant policy makers, at both regional, national and EU level.

In order to reach these objectives, the detailed Mapping of relevant policy and regulatory issues described in this report aims to set the context by presenting the policy and regulatory framework impacting geothermal RD&I. The goal is to highlight the main issues in order to make sure that the ETIP DG Vision and research priorities are translated into political priorities and coherent policy messages. The main barriers to deploying deep geothermal and especially RD&I projects will be tackled in the report on Strategic planning document for policy activities (Deliverable 4.2).

After an overview and a mapping of the main European policies and regulations applying to deep geothermal energy, this report provides an inventory of the main European funding streams for innovative deep geothermal projects, which also influence the regional and national frames.

When considering the European regulatory and policy framework, the various interlinked regulations and policies create a complex regulatory background. Although this may not necessarily result in an overregulation of geothermal projects, and may indeed provide a consistent and robust framework that allows confidence in deep geothermal deployment, the lack of readability may be a deterrent for the emergence of new geothermal markets.

Geothermal energy is promoted at the European level in the framework of the EU's Climate and Energy objectives, which aim to put the European economy on a pathway compatible with maintaining climate change below 2°C. As a renewable energy source, deep geothermal energy is indeed a solution that can contribute to meet this objective. However, the specific requirements of geothermal, namely drilling, geothermal fluid extraction and possible gas emissions, put deep geothermal projects within the scope of several European environmental legislations. In addition, as geothermal development is still new in many markets, deep geothermal projects usually benefit from European policies to support research, development and innovation.

The overview provided in this report aims to present the most general regulatory and policy framework, the European one, while acknowledging the role of national and regional authorities in providing additional frameworks that are adapted to local specificities. National and regional frameworks may indeed vary significantly from the European one, by proposing

more robust and more specific policies according to the issues specific to a territory. According to the principle of subsidiarity, the EU proposes regulations that leave large margin for national, regional and local authorities to set more ambitious thresholds or to implement a detailed framework.

This publication also explores several case studies of support frameworks for deep geothermal energy at the national and regional level. These case studies notably underline the importance of programming in supporting the emergence of deep geothermal in new market, and of dedicated facilities such as geological risk insurance schemes.

Secondly, this publication lists the regulatory and policy issues at the European, national and regional levels for geothermal energy, notably considering RD&I and environmental impacts. The objective is to present and analyse the policy and regulatory issues in order then to have recommendations and strategy papers in the report on Strategic planning document for policy activities, for tackling these issues.

Introducing and deploying geothermal technologies at large scale entails several non-technical challenges, notably as regards their initial high investment cost, their acceptance and the legal and financial barriers. The aim is to develop regulatory, financial, political and social solutions which can be implemented for overcoming barriers to the broad deployment of geothermal energy solutions.

2. Mapping of the policy and regulatory framework impacting geothermal RD&I

2.1. Methodology

Overview mapping: a tool for understanding barriers

This part of the publication presents an overview of the regulatory and policy framework that affects investments in RD&I in geothermal energy. To that end, three main policy and regulation areas have been identified as being instrumental:

- Climate and energy
- Research, development and innovation
- Environment.

Geothermal energy is a renewable energy source. It is among the resources that the EU's climate and energy aim to develop in order to mitigate climate change. As such the EU climate and regulatory framework is a major factor for geothermal RD&I developments. In addition, the general RD&I policy and regulatory framework in the EU is another factor, notably to provide funding from public institutions. Finally, the environmental policy and regulatory framework has a role in determining RD&I orientation, and somehow directing funding, as it sets objectives for mitigating the environmental impacts of projects, which may require innovation and research and development.

For the sake of this publication, which cannot be exhaustive due to the granularity and the diversity of policies and regulations across the European Union, three overview mappings have been realised to present the overarching structure of policies and regulations in the EU for the three areas identified as relevant. These mapping present the EU policies that are the basis for subsequent national policies that further precise a policy and regulatory framework. However, European policies are to be translated in national, or regional in case of some federal states, legislation in all EU Member States. As such the European policies are the right basis to define the policy and regulatory framework for geothermal RD&I.

The purpose of the proposed maps is to identify how general policy objectives translate into regulations and into RD&I funding. The purpose of this dynamic mapping is to identify the link between policies and RD&I public funding, which informs the purpose that geothermal RD&I investments should pursue.

Identifying case studies

For an easier understanding of the mapping, several case studies have been realised, assessing the specific framework for geothermal RD&I across different European Union

Member States. These countries where chosen in order to reflect the diversity of framework and geothermal markets across the EU, going from mature to emerging.

The country overview includes Italy, the major geothermal electricity market in the EU, France and Germany, the two biggest district heating markets with major developments in EGS, Hungary, a traditional geothermal country in Eastern Europe, the Netherlands, the most dynamic market for geothermal in Europe and a newcomer to geothermal energy, Poland, an emerging but promising market for geothermal in Europe, and the Flanders region in Belgium, which is an emerging market at early stages of development and illustrating a regional framework. The case studies are not exhaustive but aim to give a clear picture of the different types of frameworks for geothermal RD&I across Europe, for different geothermal market maturity.

The focus is on those countries which have a potential for developing deep geothermal power and heat technologies, but where these technologies are not fully developed due to some ongoing barriers. They are representative of the situation in Europe, and these case studies can be replicated elsewhere. In this sense, the conclusions on the main policy issues for deep geothermal coming from the case studies will be valid for all countries in Europe.

2.2 Overview of the European regulatory and Policy framework

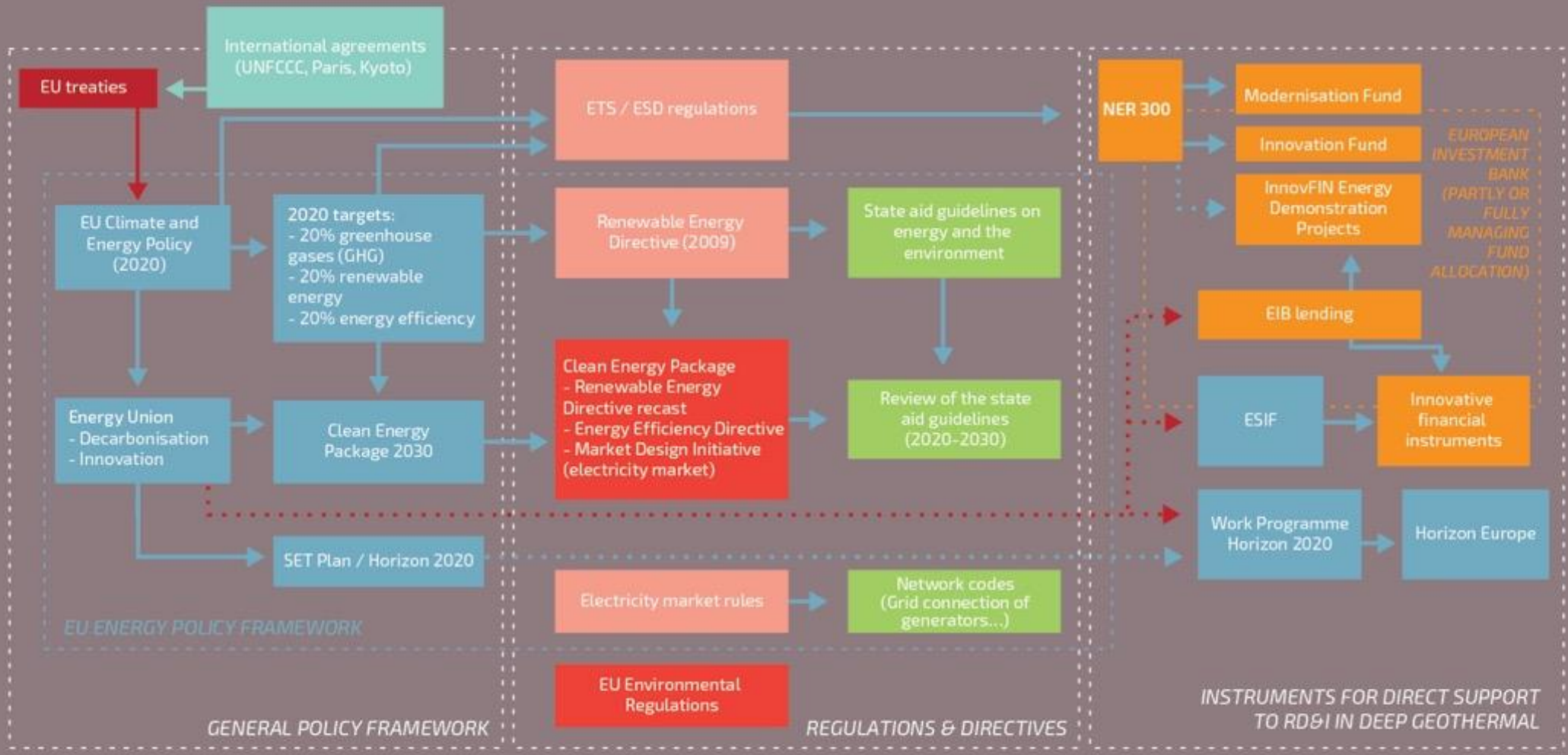
The next 3 pages give an overview of European policies:

on Climate and Energy for supporting deep geothermal

on Research, Development and Innovation relating to deep geothermal projects

on Environment, relevant to deep geothermal projects

OVERVIEW OF THE **EUROPEAN REGULATORY AND POLICY FRAMEWORK ON CLIMATE AND ENERGY** FOR SUPPORTING DEEP GEOTHERMAL



LEGEND

- Primary driver
- Partial driver
- European Commission as primary actor and enforcer
- EU laws
- EU Directives
- EU Regulations.: binding on Member States, although enforcement comes from the European Commission
- Guidelines: technical interpretation of Directives and Regulations by the EU Commission that shapes Member States application
- EIB managed financing
- International agreemetns

LIST OF ABBREVIATIONS

EIB: European Investment Bank
ESD: Effort Sharing Decision
ESIF: European Structural and Investment Fund
ETS: Emission Trading Scheme
SET Plan: Strategic Energy technology Plan
UNFCCC: United Nations Framework Convention on Climate Change

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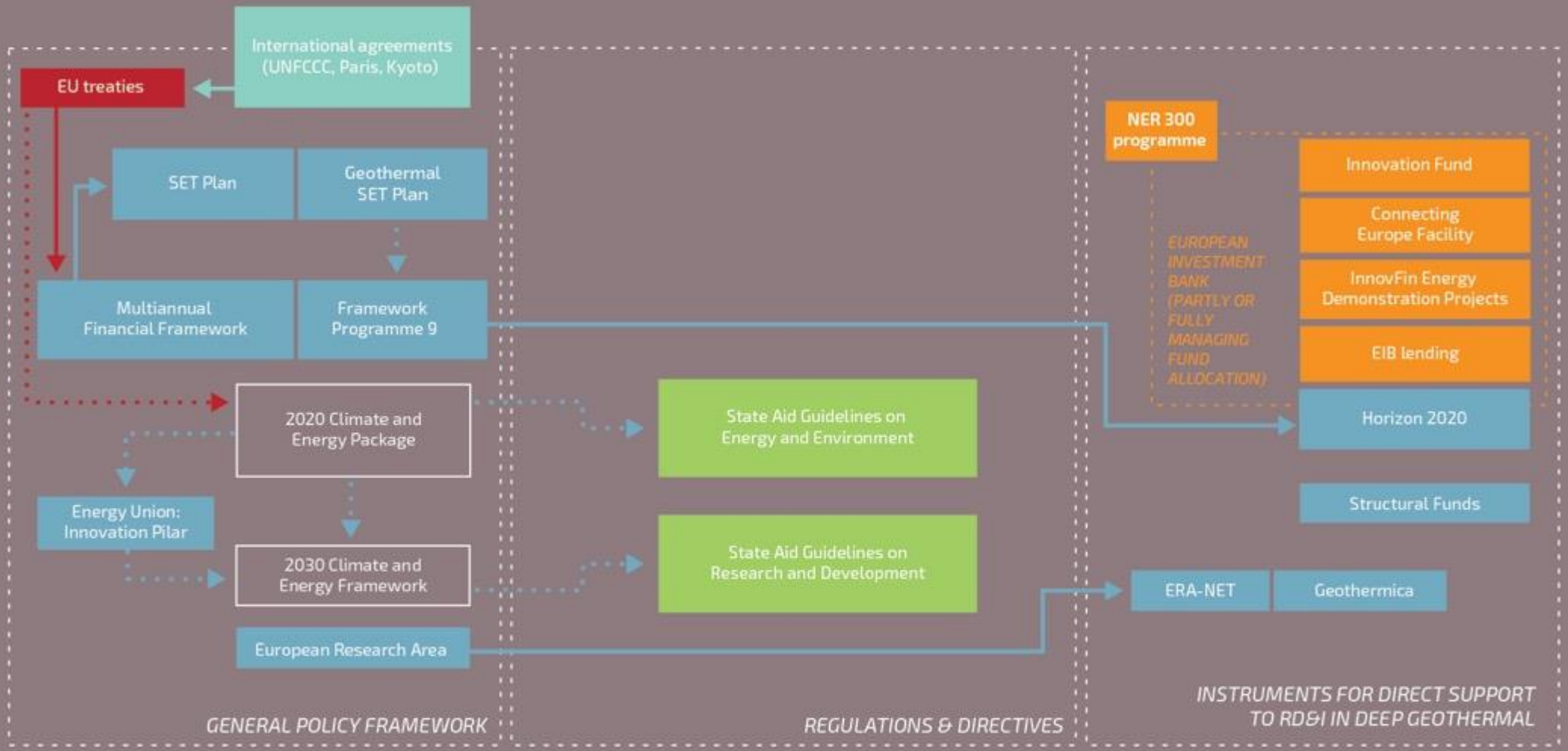
OVERVIEW OF THE **EUROPEAN REGULATORY AND POLICY FRAMEWORK ON RESEARCH, DEVELOPMENT AND INNOVATION** RELATING TO DEEP GEOTHERMAL PROJECTS



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ERA: European Research Area
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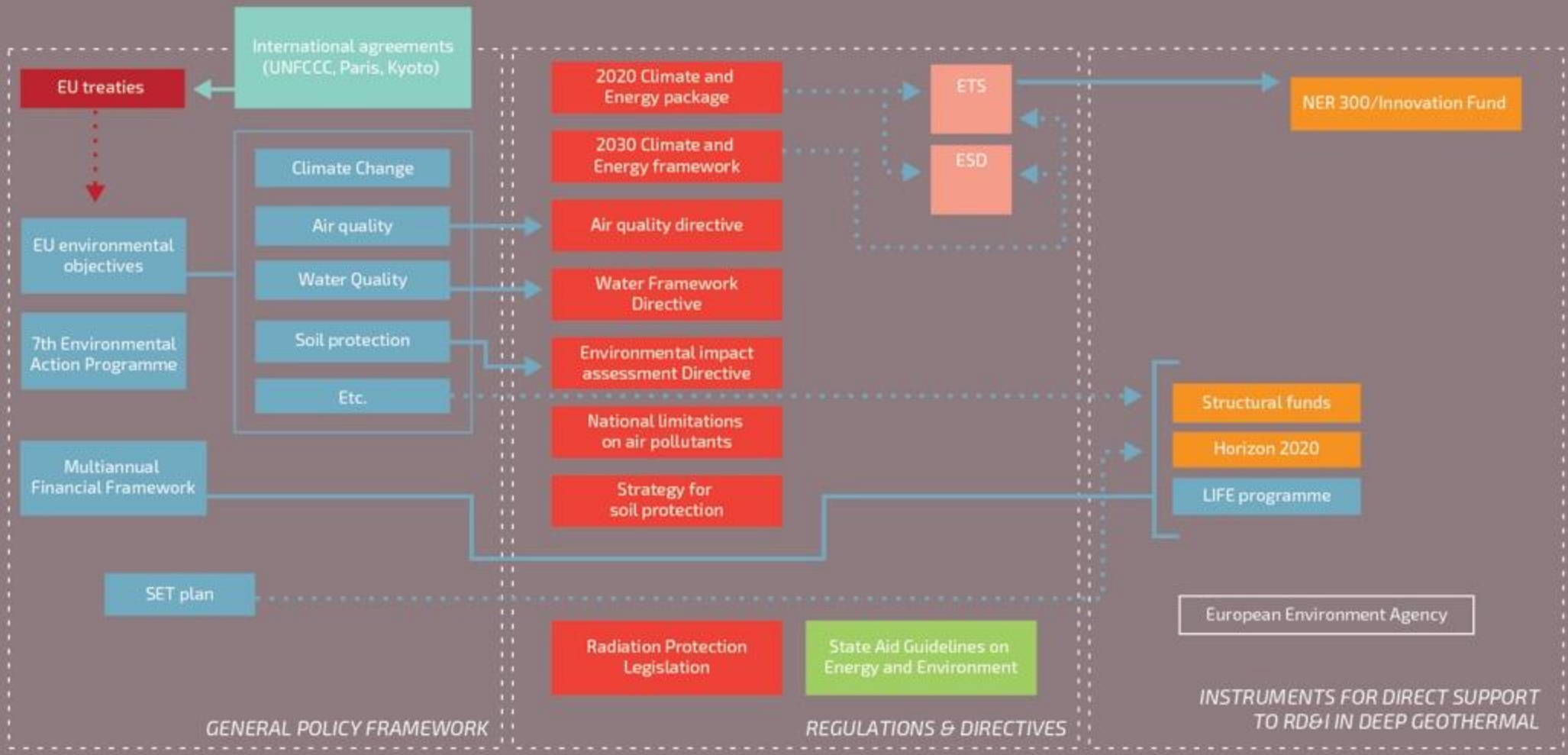
OVERVIEW OF THE **EUROPEAN REGULATORY AND SUPPORT FRAMEWORK ON ENVIRONMENT** RELEVANT TO DEEP GEOTHERMAL PROJECTS



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3. Survey on the European policy and regulatory framework for deep geothermal energy

3.1 European Climate and Energy Framework

The choice of the energy mix is done by the member states but energy policy is becoming increasingly a competence of the EU institutions. It is the response to critical supra-national issues such as climate change and security of supply that made the development of a more comprehensive EU energy policy indispensable.

The 2020 package

To contribute to the global efforts to mitigate climate change the EU has the objective of reducing greenhouse gas (GHG) emissions by 80-95% by 2050 compared to 1990 (European Council, October 2009). These objectives have been translated in 2007 by an EU agreement on the 2020 targets, the 20-20-20 goals, that are:

1) Reduction of at least 20% in GHG emissions compared to 1990 levels;
2) 20% of the final energy consumption to come from renewable sources;
3) Improvement of energy efficiency by 20% compared to 2007 projections.

A set of legislations have been adopted in the package:

1) Directive on the promotion of the use of energy from renewable sources (2009/28/EC), setting national binding targets until 2020;
2) Directive on energy performance of buildings (2010/31/EU), setting minimum requirements for new and refurbished buildings;
3) Directive on energy efficiency (2012/27/EU) promoting renovation and energy savings through obligations and behavioral changes;
4) Directives on eco-design requirements (2009/125/EC) and energy labelling (2010/30/EU), promoting efficiency of products.

The Directive 2009/28/EC (RES Directive) is designed to ensure the achievement of the 2020 renewable energy targets. It addresses a number of key barriers for the deployment of geothermal such as lack of a widely accepted definition of geothermal energy, removal of administrative barriers, spatial planning, and certification of small-scale shallow geothermal installers. Moreover, it translates the EU target into legally binding national targets. In addition, the directive requires governments to submit national renewable energy action

plans (NREAPs) including a qualitative analysis relating to the planned policy measures and a quantitative analysis showing sectorial targets and projections for each technology in electricity, heating and cooling, and transport.

The European Energy Union

In 2015, the European Commission has reorganised all the EU actions in the field in a framework strategy towards the establishment of a 'resilient Energy Union with a forward-looking climate policy'. The strategy is being built around the following five dimensions:

1) Security, solidarity and trust: diversifying Europe's sources of energy and ensuring energy security through solidarity and cooperation between EU countries;

2) A fully integrated internal energy market: enabling the free flow of energy across the EU through adequate infrastructure and without technical or regulatory barriers;

3) Energy efficiency: improved energy efficiency will reduce dependence on energy imports, lower emissions, and drive jobs and growth;

4) Decarbonising the economy: the EU is committed to a quick ratification of the Paris Agreement and to retaining its leadership in the area of renewable energy;

5) Research, innovation and competitiveness: supporting breakthroughs in low-carbon and clean energy technologies by prioritising research and innovation to drive the energy transition and improve competitiveness.

Clean Energy for All European Package

This new dimension for the energy policies set the frame for having an energy system approach in the climate and energy package 2030 and in the Energy Roadmap 2050.

The Clean Energy for All European Package was presented by the European Commission in November 2016. Nearly two years later, after much debate, a final agreement was reached on the recast Renewable Energy Directive, the review of the Energy Efficiency Directive and on the Governance Regulation.

The agreement reached on the legislative texts for Renewables, Energy efficiency and Governance introduces key signals that, while not extremely ambitious or even aligned with the objective of the Paris Agreement on climate change, allow for the renewable energy industry to grow. It gives room for the greater emergence of geothermal energy with rules for support schemes that include the possibility to support differently different energy sources and to have specific schemes for innovative technologies.

In terms of ambition, the European Union is aiming for a share of renewable energy of at least 32% in 2030, alongside a 32.5% improvement in energy efficiency compared to a baseline. Altogether, these targets should put the EU on track to overshoot its 40% greenhouse gas emission reduction objective (compared to 1990).

Unlike the 2020 framework however, these EU targets do not translate into national ones. Member States will have to comply to the Governance framework that was also agreed upon, proposing National Energy and Climate Plans that lay out their national contributions to the EU objectives (which should amount to meeting the EU targets when all the Member States contributions are aggregated).

3.2 Environmental regulations relevant to deep geothermal projects

Geothermal energy, as defined in the Renewable Energy Directive, is subjected to a wide array of environmental legislations that minimise the possible environmental impacts linked to the development of an industrial activity such as developing geothermal resources.

The European, national and regional regulations about geothermal energy technologies aim to avoid environmental impacts for any segment of the value chain, from drilling to f-gas used in heat pumps for individual geothermal heating systems. These regulations can be laid out at the European level, through directive or regulations, and may be monitored by the European Environmental Agency. Enforcement however usually happens at the local level where national and regional authorities and agencies play a key role of advising new projects, monitoring existing installations and enforcing regulations in case of infringement.

Negative environmental impacts associated with geothermal energy are minor, especially if compared with conventional fossil fuels and nuclear power plants in a lifecycle analysis. As a matter of fact, a geothermal plant is located right above the resource and does not imply mining, processing, transporting the fuel over great distances, and combustion. Furthermore, the visual and land use impact can be negligible.

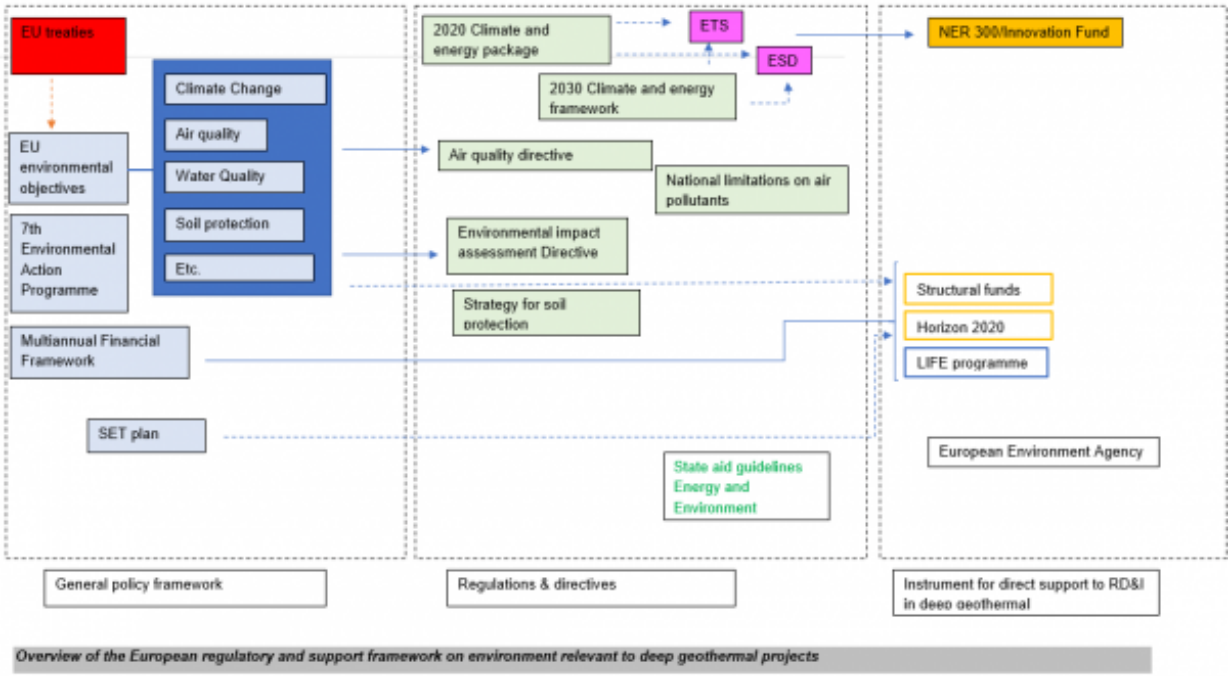
However, as for every industrial activity, some potential and adverse effects exist such as some forms of gaseous emissions, induced seismicity, ground subsidence, noise during the construction phase, and temperature anomalies in the subsurface and the groundwater. These potential impacts vary depending on the geological settings as well as on the size and type of application. In all circumstances they can be avoided thanks to sound practice, technology developments, and compliance with environmental regulations.

For the geothermal sector, the most relevant EU directives are the following:

- Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive);
- Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (SEA Directive);

• Directive 2000/60/EC establishing a framework for Community action in the field of water policy.

The European environmental regulatory framework for geothermal energy can be summarised in the following mapping:



Overview of the European regulatory and support framework on environment relevant to deep geothermal projects

3.3 Research, development and innovation relating to deep geothermal projects

Emissions Trading Scheme, Effort Sharing Decision, NER300 and Innovation

The Emission Trading Scheme is the European carbon market for large facilities. The Effort Sharing Decision governs how “non-ETS” emissions reductions should be allocated among EU Member States. Within the Directives setting the ETS and the ESD, facilities to support the development of innovative renewable energy projects have been set up. Among those, the NER300 (which provided grants to renewable energy and CCS projects) has notably proven a major tool for supporting geothermal projects. From 2020 onwards, the NER300 will be replaced by an Innovation Fund and a Modernisation Fund.

The Modernisation Fund is addressed at lower income European Member States for the modernisation of energy or industry facilities. It allocates 2% of the total ETS revenues. The Innovation fund meanwhile is expected to replace the NER300 facility in using European Trading Scheme revenues to fund innovative energy projects. It should rely more heavily on

financial instruments than its predecessor (which awarded all support through grants). Funding would come from the revenues from 400 million carbon allowances in the ETS.

European Structural and Investment Funds (ESIF) – Cohesion policy

The 'Cohesion policy' is behind the hundreds of thousands of projects all over Europe that receive funding from the European Regional Development Fund (ERDF), the European Social Fund (ESF) and the Cohesion Fund (Cohesion Fund applies to EU Member States which have a GDP lower than 90% of the EU-27 average – the average is calculated not including Croatia).

Economic and social cohesion – as defined in the 1986 Single European Act – is about 'reducing disparities between the various regions and the backwardness of the least-favored regions'. The EU's most recent treaty, the Lisbon Treaty, adds another facet to cohesion, referring to 'economic, social and territorial cohesion'.

EU Structural and Investments Funds dedicated to Cohesion policy of interest for the geothermal sector are the following ones:

- The Cohesion Fund
- The European Regional Development Fund (ERDF)
- The European Social Fund (ESF)
- The European Agricultural Fund for Rural Development (EAFRD)

The funds of the Cohesion policy are allocated by seven-year programming periods, which are defined in the European budget. EUR 351.8 billion are set aside for cohesion policy measures in the 28 EU member countries for the 2014-2020 period. This amounts to about one third of the EU budget.

Financial Instruments (FI)

Financial instruments take an increasing importance in the attribution of Cohesion Policy funds, as the European Commission sees them as a solution for a "more efficient" use of the Structural Funds. For the European Institutions, Financial Instruments are a solution to maximise the impact of the Structural Funds by relying on mechanisms other than grants. Typical examples of financial instruments include technical assistance (such as pioneered by ELENA), soft loan schemes or revolving funds. For the 2014/2020 programming period, about EUR 4 billion of the European Structural and Investment Funds are channelled through the so-called Financial Instruments.

The definition of these instruments allows a "bottom-up" deployment, where the Managing Authorities of the ESIF, or the project leaders, can set up a Financial Instrument to fit their purposes. Their establishment does not require a modification of the Operational

Programme, which makes it easy for a Managing Authority to repurpose ESIF funds to set up a FI.

Horizon 2020

Horizon 2020 is the main EU Research and Innovation programme with nearly EUR 80 billion of funding available over 7 years (2014 to 2020). It serves the "Innovation Union", a EU initiative that aims at promoting Europe's competitiveness.

Funding opportunities under Horizon 2020 are set out in multiannual work programmes, which cover a large array of issues across different EU priorities, from education to climate action, including the digital economy. The work programmes are prepared by the European Commission within the framework provided by the Horizon 2020 legislation.

European Investment Bank

The EIB is the European Union's bank. It is owned by the Member States and acts according to their policy priorities. The Bank works closely with other EU institutions to implement EU policy. It focuses on specific priorities including climate action and strategic infrastructure.

The EIB can intervene to support project through different channels such as:

- Loans: recipients range from large corporations to municipalities and small and medium-sized enterprises;
- Technical Assistance: which is provided by a team of experts (economists, engineers and sectoral specialists) to complement EIB financing facilities;
- Guarantees;
- Venture Capital: channeled through intermediaries.

The EIB lending policy forces the Bank to account for issues such as the climate impact of its investment portfolio. The Bank's annual climate action target is currently set at 25% of total Bank lending based on a clearly defined set of eligible sectors and projects. Over the last few years, renewable energy and energy efficiency projects constituted approximately one half of the Bank's climate action projects, equivalent to around 40 percent of total climate action lending[1].

[1] European Investment Bank, Energy Lending Criteria, 2013

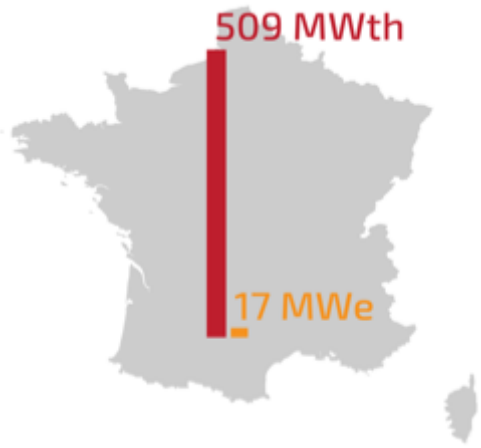
4. Case studies of selected national frameworks

The objective is to have an understanding of national regulations all over Europe, and a common agreement on the main issues. It imposes to cover a set of representative countries. The survey is then targeting seven countries: France, Germany, Italy, Hungary, The Netherlands, Poland and Belgium with a regional case: Flanders.

The focus is on those countries which have a potential for developing deep geothermal power and heat technologies, but where these technologies are not fully developed due to some ongoing barriers. The survey is on countries with different levels of deep geothermal energy technologies deployment and market uptake (from Italy, Germany and France: mature markets for geothermal power and heat respectively with already established schemes; transitory markets in Hungary and the Netherlands and juvenile markets in Belgium and Poland, with the objective to list relevant issues also for the rest of Europe with also different deep geothermal market maturity.

FRANCE

Highlights on the national situation



Overview of the deployment of geothermal energy

In 2017 the total thermal installed capacity in France is estimated to be 509,5 MWth[2] with 60 plants in operation. The installed geothermal electricity capacity is 17 Mwe.

A leading market in Europe for deep geothermal energy, thanks to significant potential, a long tradition of utilizing this resource and a large established capacity for district heating, France is also at the forefront of innovation for geothermal energy. It is notably in Alsace, in Soultz-sous-Forêt that the first demonstration EGS power plant was successfully developed. Overseas territories such as Guadeloupe benefit from favourable conditions for geothermal development, which contributes to the energy security of these Islands.

[2] EGEC Market Report 2017

In 2017, France was the theatre of another ground-breaking innovation in deep geothermal: in December, the successful completion and test of a sub-horizontal geothermal well on the Paris suburban Cachan site was announced. It was followed by a second well in March 2018. The well, which will serve as the injection unit of the local Geothermal District Heating doublet, is a world premiere in geothermal well engineering.

Stated objectives: policies and prospects

France's energy objectives are defined by the Multiannual Energy Planning[3] ("*Programmations Pluriannuelles de l'Energie"*). This 5-year plan, currently covering the 2018-2023 period, notably lays out objectives for the development of each energy technology.

For geothermal for electricity, the programming builds on the establishment of a geological risk insurance scheme, and on support tariffs adopted during the year 2017. For geothermal for heating, the GEODEEP Fund is also put forward, with objectives to extend the use of this resource beyond its "traditional" area around Paris.

On heating and cooling, the use of deep geothermal in France is planned to at least double in the next 5 years (from 200 ktoe in 2018 to 400-550 ktoe in 2023) in the mainland. For electricity, capacity in the mainland is planned to grow from 8 MW to 53 MW over the programming period.

Programmes on geothermal energy in France

NAME	MANAGED BY	OBJECTIVES	BUDGET
Call for R&D proposals-renewable energies including geothermal	ADEME (French Environment and Energy Management Agency)	Financial support for geothermal R&D projects.	N.A
Investments for the Future programme	ADEME is responsible for innovation for energy and ecological transition; the implementation is steered by the General Investment Commission (CGI)	Specific call for proposal based on two pillars: Axis 1: geothermal development Axis 2: demonstration projects The 2018 calls opened on February and has three closing dates: June 14, 2018, 5 pm, October 25, 2018, September 19, 2019.	Global budget for projects: EUR 3.17 [4]Billion

[3] Programmations Pluriannuelles de l'Energie, 2018-2023. (2016) https://www.ecologique-solidaire.gouv.fr/sites/default/files/PPE%20int%C3%A9gralit%C3%A9.pdf
[4] 2017 figures from ADEME Bilan 2010-2017

Call for R&D proposals – energetic uses of underground	ANR (National Agency for Research)	Financial support for R&D projects, including geothermal. The 2017 call was launched in September and will close at the end of March 2018.	N.A
Geothermal risk insurance	GEODEEP	Insurance for projects at early stage to mitigate the risk of well failure. Established in 2015.	EUR 50 million

In 2010, following the conclusions of a commission on strategic investment priorities and domestic borrowing, the government decided the allocation of EUR 35 billion for the support of investments in several sectors such as higher education and research as well as sustainable development. The "Investments for the Future" programme ("*Investissements d'Avenir*") was created to promote innovation and creating non-relocatable jobs in these sectors. They are managed by the French Energy Agency ADEME, which is responsible for the implementation of the environmental and energy transition. As such, it publishes calls for expression of interest for companies, and has granted a budget of EUR 3.1 billion in the 2017 to support innovative projects for the developments of smart grid and renewable energies.

France RD&I framework covers a wide range of topics related to geothermal energy development and demonstration projects. The general French regulatory and support framework includes facilities for geothermal risk management and mitigation and support to district heating and electricity projects.

GERMANY

Highlights on the national situation

Overview of the deployment of geothermal energy

There are 33 geothermal plants in operation across Germany in March 2018. Most of these plants exclusively generate heat, with 336 MWth of thermal capacity installed. Nine of the geothermal plants generate electricity. They have a combined installed electrical capacity of 38 MWe.

Germany is a key market for the current development of deep geothermal in Europe due to ambitious objectives set at the local level, for

instance by local authorities such as Munich, which aims for a fully renewable based district heating network, to a large extend using geothermal energy.

Stated objectives: policies and prospects

At the national level, the *Energiewende* aims at decarbonizing the economy and has made Germany a world leader in investment in renewables. The general objectives are that by 2025, at least 40 to 45 % of Germany's energy is to be sourced from renewable energy and aiming at raising this target to at least 80% by 2050. Investments in research and development for geothermal, if they are significant at the European scale, are far from the scale of funding channelled towards bringing other renewable to market. Germany remains a European leader for innovation, being the site of some of the first EGS projects developed and being among the most advance market in terms of TRL for this technology.

The Renewable Energy Sources Act adopted in 2017 lays out targets for renewable energy deployment of 40-45% in 2025, 55-65% in 2035 and at least 80% by 2050[5]. To meet these objectives, the Act sets values for feed-in-tariffs and premium for geothermal electricity, notably geothermal, which are designed to incentivise investments. It also proposes specific (though limited) tendering provisions for innovative projects.

Programmes on geothermal energy in Germany

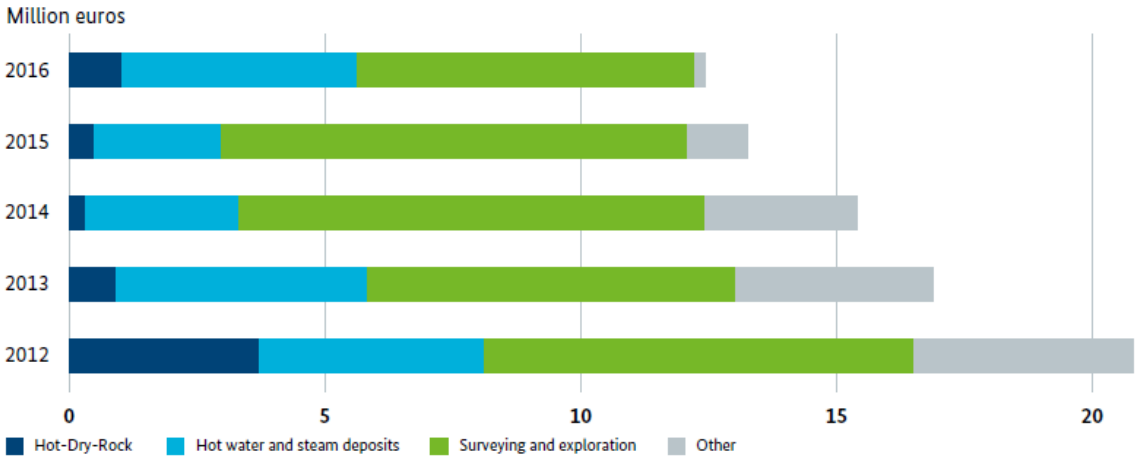
NAME	MANAGED BY	OBJECTIVES	BUDGET
6th Energy Research Programme of the Federal Government	Jülich (PtJ)	Research for an environmentally sound, reliable and affordable energy supply and accelerate the adoption of renewable energy. Wide range of activities, from public awareness to funding.	EUR 875.98 million in 2016

In charge of economic, technology, industrial and energy policies, the Federal Ministry of Economics and Technology (BMWi) acts as the coordinating agency in setting the programmatic direction of the energy research policy and the Federal Government's Energy Research Programme. In 2011 the German government launched the 6th Energy Research Programme. Entitled 'Research for environmentally sound, reliable and affordable energy

5 https://www.bmwi.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf?__blob=publicationFile&v=3

research', it sets out the guiding principles and priorities of the government's support policy in innovative energy technologies. In geothermal research, the BMWi approved funding for 22 projects amounting to EUR 19.55 million in 2016 (2015: 21 projects for around 17.3 million euros). EUR 12.5 million were also allocated to ongoing research projects on deep geothermal.

Figure 1: Funding for deep geothermal in Germany (BMWi[6])



Consultation process for the 7th Energy Research Programme is ongoing[7]. In light of the downward trend in funding for deep geothermal energy research in Germany under the 6th Energy Research programme, there is a risk of constraining innovation in Germany for the coming years.

Beyond direct support for innovation under the energy research programme, Germany is also supporting the development of deep geothermal energy projects through a feed in premium of 25.2 €ct/kWh for electricity, and by awarding repayable grants or subsidised loans to deep geothermal heating and cooling projects through the KfW. A quota for minimum levels of renewables in the domestic sector also contributes to supporting innovation in deep geothermal.

Case study: Munich - project "GRAME"

The BMWi funds projects that contribute to the development of geothermal energy. Amongst other projects, the GRAME research project run by Stadtwerke München was started in 2015 and has received funding of around EUR 4.6 million from the BMWi. The aim of GRAME is

[6] BMWi, Report of the Federal Government on Energy Research 2017
[7] Report of the Federal Government on Energy Research

to provide the entire district heating for Munich from renewable energies by 2040, with the majority being sourced from geothermal energy. Munich has the ideal geological conditions for this purpose.

ITALY

Highlights on the national situation

Overview of the deployment of geothermal energy

In 2017 the total thermal installed capacity in Italy is estimated to be 195,9 MWth[8] with 22 geothermal district heating plants in operation. The installed capacity for electricity is the highest in Europe and the European Union with 915,5 MWe. Italy is a major historical actor in the development of geothermal energy: the first ever geothermal power plant was set up over a century ago in Tuscany. Today the country remains at the forefront of geothermal innovation, exploring cascading uses of heat, hybrid and zero-emission plants.

Stated objectives: policies and prospects

Renewable energy sources represent 17% of Italy's energy demand. The objective to 2030 is 28%, with 55% in the electricity sector and 30% in heating and cooling. Being rich with significant geothermal resources, further deployment of geothermal electricity and heating and cooling is a mean to achieve the objective.

[8] EGEC Market Report 2017

Programmes on geothermal energy in Italy

NAME	MANAGED BY	OBJECTIVES	BUDGET
National Operative Programme – Enterprises and Competitiveness	Ministry of Economic Development	Incentives aimed at reducing energy consumption and climate-changing gas emissions of companies and production areas, including the installation of plants for producing energy from renewable sources for self-consumption, giving priority to high efficiency technologies. The Axis IV, dedicated to Energy Efficiency, supports the transition towards a low carbon economy in all sectors.	EUR 375 million

The Italian national programmes for energy are central programmes for increasing renewable energy utilization. The programmes have a broad scope of operation, and geothermal energy is put forward as a key tool for meeting renewable objectives.

The Interregional Operational Programme Renewable Energy and Energy Saving (POI Energy) was financed by the European Regional Development Fund (ERDF) in the 2007-2013 programming period. It produced one geothermal assessment project of four southern Italian regions and 80 funded projects related to geothermal energy. Its success lead to the continuation of the programme to the NOP Enterprises and Competitiveness. During this 2014-2020 programming period, Regions and businesses will still have the opportunity to acquire and enhance the studies, plant proposals and diagnoses carried out by the “POI Energia”, in order to exploit the high potential of resources such as geothermal sources, or to enhance the economic benefits deriving from energy savings.

Case study: Deep geothermal and environment regulations in Italy

In Italy, geothermal power production has been part of the energy system for more than a century. The development in the Monte Amiata region date back from 1955. For a century geothermal energy has been avoiding the use of fossil energy in Tuscany for power production and for heating replacing fossil fuel boilers.

Considering the strategic role played by geothermal energy, local administrations and the government have enforced national legislation, providing guidelines for the correct exploration, operation and management of geothermal resources. In Tuscany, where all the geothermal power plants in operation are located, the regional government implements strict controls on environmental aspects, obtained by applying the most advanced mitigation techniques at the plants and periodic environmental monitoring and quality check. The environmental regulations applicable for Geothermal energy in Tuscany are the following:

- Legislative Decree no. 152/2006 « Environmental standards »

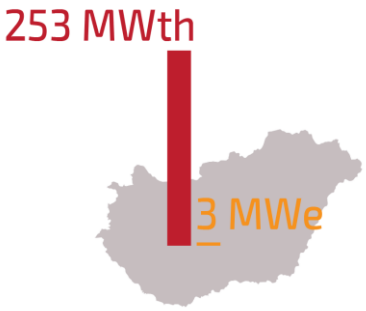
- Legislative Decree no. 22 of 11/02/2010 « Reorganisation of the regulations on the research and production of geothermal resources, in accordance with article 27, paragraph 28, of Law no. 99 of 23 July 2009 »
- DGRT (Resolution of Tuscany Regional Council) no. 344 of 22/03/2010 « Guideline criteria for the containment of atmospheric emissions from geothermal power plants ».
- Tuscany Region Resolution no. 229/2011 Legislative Decree 152/06 and amendments, art. 26 Statement on the environmental compatibility of the project for the "Rehabilitation of the Geothermal Area of Piancastagnaio", in the Municipality of Piancastagnaio (SI), submitted by Enel Green Power s.p.a.

Considering that the operation of geothermal power plants represents a peculiarity of the Tuscan territory, the Region of Tuscany has adopted a specific sector legislation, DGRT no. 344 of 22/03/2010, which performs, to a certain extent, the function of a B.A.T. document (Best Available Technology) for this specific category of plants. Regional legislation (DGRT n. 344 of 22/03/2010), in ARPAT's (regional environmental authority) reports it was chosen to refer to a lower value of 0.2 µg/m³ (200 ng/m³) averaged over a period of one year. Such value is consistent with the relevant health guidance levels developed by the US Agency of Toxic Substances and Disease Registry (ATSDR), similar to the US Environmental Protection Agency (EPA)'s threshold values for the non-carcinogenic effects of chemicals in the environment to assess contaminated sites (2007).

ARPAT releases every year the results of its controls on emission from geothermal power plants in Tuscany.

HUNGARY

Highlights on the national situation



Overview of the deployment of geothermal energy

Hungary has a tradition of using geothermal energy, notably in spa resorts. However, the country is also prominent is the use of its geothermal resource through district heating in Europe. There are over 254MWth of geothermal heat capacity in Hungary. The country is also investing in innovation, having inaugurated in 2017 its first geothermal combined heat and power in the Budapest area. Two additional combined geothermal heat and power

plants are being developed, with planned capacities of 18 MWe for electricity and 34 MWth for heat.

Stated objectives: policies and prospects

Hungary's first National Climate Change Strategy (NCCS) for 2008-25 was adopted by the parliament in 2008. It includes a greenhouse gas emissions reduction target of 16% to 25% for 2025 compared to 1990. The NCCS emphasized the government's obligation to create the necessary regulatory framework, to review and adjust subsidy systems and to raise awareness of sustainability in the society. The residential sector was given high priority. In 2011, Hungary issued a National Energy Strategy to 2030, including an objective for 25% renewables (notably geothermal) in heating and cooling, or to increase the use of geothermal for reducing agriculture's carbon footprint. The strategy estimates that geothermal could cover up to 5% of Hungary's energy needs on the long term.

Programmes on geothermal energy in Hungary

NAME	MANAGED BY	OBJECTIVES	BUDGET
Environment and Energy Efficiency Operative Programme (EEEOP)	National Development Agency and the National Environment and Energy Centre	The Environment and Energy Efficiency Operative Programme is one of the 15 operational programmes of New Hungary Development Plan; in the 5th priority axis, there is the increased energy efficiency and renewable energy application, specifically geothermal energy utilization.	EUR 3.7 billion (EUR 845 million for energy)

The Environment and Energy Efficiency Operative Programme (KEHOP in Hungarian) is a EU co-funded programme that provides funding for the 2014-2020 period. It benefits from the Cohesion Fund (CF) and Regional Development Fund (ERDF). Energy efficiency improvements, production of heat energy, especially in the building sector, using renewable energy sources including geothermal, support of renewable energy solutions and adaptation to climate change are among the priority areas of the programme.

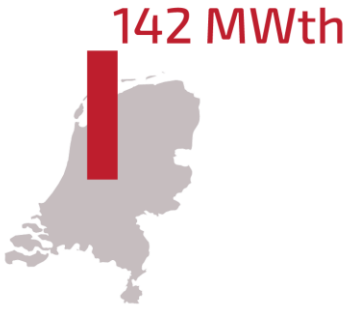
In the framework of the EEA and Norway grants financial Mechanisms, the EEA FM-PA 6 Renewable energy programme area, there were two calls issued during the first quarter of 2014 and are currently under implementation:

- Increased renewable energy production: Implementation of Geothermal Based District Heating Systems – Replacing Existing Fossil Fuel Based District Heating;
- Increased awareness of and education in renewable energy solutions - Grant for Supporting Participation in Courses on the Utilization of Renewable Energy Solutions.

A new call for proposal was issued on January 2018[9] within the Regional Cooperation Fund for 2014-2020, and renewable energy, notably geothermal, is still among the priority axes. The budget for the Regional Cooperation is EUR 15 million.

THE NETHERLANDS

Highlights on the national situation



Overview of the deployment of geothermal energy

The existing geothermal sector is relatively young and small-scale, but its diversity and complexity will increase in the next five to ten years[10]. For the Netherlands, geothermal energy represents an opportunity for a cost-efficient decarbonisation of heating and cooling. Little emphasis is put on developments for electricity production at this stage. In 2017, the total geothermal district heating installed capacity in the Netherlands was 142 MW_{th}.

Stated objectives: policies and prospects

The government of the Netherlands has announced that it will invest EUR 300 million in a series of measures for reducing CO2 emissions. Projects will involve disconnecting existing residential neighbourhoods from the natural gas grid, using geothermal heat and reducing carbon emissions in agriculture and industry. The government is taking these CO2 reduction measures in anticipation of a new national climate and energy agreement. The government is also setting aside more than EUR 30 million for innovations that will help reduce carbon emissions from glasshouse horticulture.

Geothermal is presented as a key resource in the Dutch Energy Agenda[11].

Programmes on geothermal energy in the Netherlands

NAME	MANAGED BY	OBJECTIVES	BUDGET
Netherlands Oil and Gas Portal	TNO	Provides detailed information on the subsurface as a public service	N.A

9 Common Challenges – Shared Solutions – EEA and Norway Grants Fund for Regional Cooperation
10 State of the Geothermal Energy Sector, State Supervision of Mines, 2017
11 https://www.government.nl/binaries/government/documents/reports/2017/03/01/energy-agenda-towards-a-low-carbon-energy-supply/Energy+agenda.pdf

Greenhouse as energy producer (KaE)	Marketing Board Horticulture	Geothermal energy in greenhouse horticulture	N.A
Intensification program energy challenges 2020 (IP2020)	Companies, branch organizations and government (EZK and RVO.nl)	Focus on the realization more applications for renewable energy and more energy savings; to accelerate the application of sustainable renewable energy, “Acceleration tables” have been set up, one of them concerns geothermal energy.	N.A
SDE+ (Stimulering Duurzame Energieproductie)	Netherlands Enterprise Agency	Encourage the production of renewable energy (notably for heat) in the Netherlands. Including geothermal. EUR 3.9 billion committed to geothermal in 2016.	Feed-in-premium subsidy
Risk management fund for geological risk	State	Up to 85% of well cost refunded in case the thermal output is below 90% of estimates. Cost for being covered: 7%.	

Greenhouse as Energy Source stimulates innovations in promising areas, including geothermal. The greenhouse sector has huge ambitions for limiting its CO2 emissions, and is specifically facilitated by the activities of this programme; calls for projects are issued twice a year, the latest call was in autumn 2016.

The SDE+ is an incentive scheme for the production of renewable energy in the Netherlands. The primary target groups for SDE+ are companies, institutions and non-profit organisations. The project must be realised in the Netherlands. The national government is excluded from participation.

There will be two periods for SDE+ subsidy applications in 2018, one in spring and one in autumn. The SDE+ round of applications for spring 2018 runs from 9 am on 13 March to 5 pm on 5 April 2018. The spring budget totals EUR 6 billion. Last year, in the second round for the SDE+, 5,783 applications for renewable energy projects have been received, and total subsidy budget requested amounted to over EUR9.9 billion. For geothermal, 9 projects sought funding with an investment volume of together EUR 883 million ($1 billion) for a planned installed generation capacity of 264 MW.

POLAND

Highlights on the national situation

Overview of the deployment of geothermal energy

While geothermal energy remains a minor component of Poland's energy mix, with 64 MWth of capacity currently installed for district heating, it does possess valuable resources. Poland also has a long history of using thermal waters for balneotherapy.

Highlighting its emergence as a key market for geothermal developments in Europe, with 14 plants currently in development (compared to 6 existing facilities).

National objectives and policy projects

Poland has not traditionally been a major actor in the geothermal sector. It has long had a strong indigenous energy industry, which remains to this day, with large coal reserves and a significant exploitation of its oil and gas resources. Poland's energy policy is notably characterised by a drive for autonomy and the use of indigenous source.

Another driver for the development of geothermal energy in Poland, is the need for improving air quality in the country, which still relies heavily on coal for heating purposes (which dramatic impact on different types or air emissions).

The highly developed district heating infrastructure, though it remains in need of additional investment, is an opportunity for integrating geothermal heat at a lower cost.

Programmes for geothermal energy in Poland

NAME	MANAGED BY	OBJECTIVES	BUDGET
Public support for geothermal energy generation uses	Ministry of Environment	Programme destined to financing the development of geothermal energy by local authorities.	EUR 45 million (exploratory well drilling) EUR 113 million (additional well drilling)

The Ministry of Environment plays a key role for the development of geothermal energy in Poland. Funds for supporting geothermal heat or CHP in Poland are primarily channelled through the Polish National Fund for Environmental Protection[12], which redistributes part of the royalties paid by fossil energy extraction to the Polish government into environmental projects (including renewable energy deployment).

Geothermal energy in Poland can also benefit from the geological survey realised in the second half of the 20th Century for the purpose of oil and gas exploration. This resource is made freely available by the Government.

Moreover, several European funding channels, from the European Union such as the structural funds, or from other programmes such as EEA-Norway grant also contribute to the emergence of deep geothermal uses in Poland. For instance, the EEA facility contributed to financing the development of a plant in Poddembice. Within the GeoHeatPol project it also aimed at collecting best practices for scaling geothermal energy deployment in Poland.

Poland is also looking into the possibility to set up a risk guarantee mechanism for reducing investment costs in geothermal energy projects. The GeoHeatPol project contributed some inputs to these debate, which remains at its early states – much like the development of geothermal in Poland.

BELGIUM

Highlight on the national situation

Overview of the deployment of geothermal energy

The use of deep geothermal energy in Belgium is limited. Currently, there are three geothermal heating plants in operation in the Walloon part of the country. Together, they supply about 19 GWh/y of thermal energy. In contrast to the limited use, deep wells that have been drilled in the past prove that there is a potential for deep geothermal energy production in the

[12] https://www.nfosigw.gov.pl/en/

sedimentary basins that border the Brabant Massif [13,14]. The principal geothermal resources are porous chalk deposits for Late-Cretaceous age and lime- and dolostones of the Lower-Carboniferous in the Campine and Devono-Carboniferous platform carbonates in the sedimentary basins south of the Brabant Massif [13,15]. In the last decade, there is a renewed interest in deep geothermal as a local energy source. This has sparked a series of initiatives to further explore the geothermal potential and to develop new geothermal plants. In Flanders, two deep geothermal plants are now under development: one in Mol - Donk and one in Beerse. Furthermore, the feasibility of geothermal energy production is being investigated at 5 other locations in the provinces of Antwerp and Limburg. In the Walloon region, three new projects for geothermal district heating were launched in the Mons area. On February 8, a first new 7 MW geothermal heating plant was inaugurated Ghlin. Other developments are foreseen at the Ambroise Paré hospital and near the new railway station in Mons. In addition, a fourth project for combined power and heat production is under investigation.

National objectives and policy projects

The new developments go along with initiatives of the Flemish and the Walloon governments to facilitate the development of the regional deep geothermal resources. In 2016, the Flemish government amended the Decree on the Deep Subsurface to provide a legal framework for the exploitation of deep geothermal heat. At the end of that year, the Flemish government approved the corresponding implementation decision, allowing interested parties to apply for a geothermal exploration or exploitation permit. In addition, the Flemish government is working to implement an insurance system to cover the geological risks of deep geothermal project and is providing financial support for the development of geothermal heating in the context of the calls on 'green heat', the ecology premium and a scheme for investments in innovative technologies in the agriculture.

The Flemish government adopted deep geothermal as one of the technologies that will allow the region to meet its 2020 renewable energy targets. According to the Energy Plan 2020, the production of heat from renewable sources should rise to 9.197 GWh for the year 2020. Based on the projects that are under development in Mol and Beerse, the production of heat

[13] E. Petitclerc and Yves Vanbrabant, 2001. Développement de la plate-forme Géothermique de la Wallonie. Rapport Final, DG04, Direction Générale Opérationnelle de l'Aménagement du Territoire du Logement, du Patrimoine et de l'Energie, Département de l'Energie. (https://energie.wallonie.be/fr/la-geothermie-profonde.html?IDC=6173)

[14] B. Laenen, S. Sneyers, J. Hendrickx, 2015. Stappenplan voor de ontwikkeling en implementatie van geothermie als duurzame, stabiele en betaalbare bron van warmte en elektriciteit in Vlaanderen. EFRO-project 910: GEOTHERMIE 2020 (https://geothermie.vito.be/nl/projecten/geothermie-2020)

[15] S. Loveless, H. Hoes, E. Petitclerc, L. Licour, B. Laenen, 2015. Country update for Belgium, Proceedings of the World Geothermal Congress 2015, Melbourne, Australia, 19-25 April 2015.

from deep geothermal in 2020 is set at 164 GWh. Further increase in the following years is envisioned in the Flemish heat plan, but no figures are set forward.

On April 21, 2016 the Walloon government approved a guidance note aiming at the implementation of a legal framework for the development of geothermal energy in Wallonia. This framework will take the form of a decree and will implement specific measures to jointly achieve the following objectives to:

- Protect the resource;
- To develop a renewable energy source through the creation of public heating networks;
- Develop a new industrial activity in Wallonia, via a policy to stimulate industrial investment and encourage economic expansion.

Programmes for geothermal energy in Belgium

NAME	MANAGED BY	OBJECTIVES	BUDGET
FLEMISH REGION			
Call groene warmte, restwarmte, biomethaan	Vlaams Energie Agentschap (VEA)	Support for investments in the development of green heat, the recovery of residual heat and bio-methane	Call system; the budget per technology category is set prior to each call
Strategische ecologiesteun (STRES)	Agentschap Innoveren en Ondernemen (VLAIO)	Support for (large) investments in innovative green technologies that cannot be standardized because of their unique company-specific character	20 to 40% of the accepted additional investment depending on the (cost) performance and the type of organisation
Ecologiepremie (EP-Plus)	Agentschap Innoveren en Ondernemen (VLAIO)	Support for investments for the use of geothermal heat. Only installation with a capacity up 5 MW are eligible. Larger plants can apply for STRES.	15 to 55% of the additional investment costs depending on the technology and the type of organization
VLIF-steun	Departement Landbouw & Visserij	Support for investments in geothermal energy in agriculture	30% of the investment with a maximum of 1 MEuro
Waarborgregeling aardwarmte	Departement Omgeving	Insurance system for geological risks	

WALLOON REGION			
Direct support	Département de l'Energie et du Bâtiment durable	Specific support depending on the project	N/A
FEDER	Département de la Coordination des Fonds structurels	Support for demonstration and development projects in the context of ERDF	Depending on the call, type of project and organisation

Over the last 3 years, the Flemish government introduced a number of support schemes to facilitate investments in deep geothermal energy. In addition, the Flemish government is finalizing the '*Waarborgregeling voor het opsporen en winnen van aardwarmte in de diepe ondergrond*'. Once this regulation is in forces, a financial guarantee will be paid to investors if the realized capacity of a deep geothermal energy project is lower than the expected capacity. The scheme only covers the geological risk associated with thermal output of the system. The risk of, for example, technical complications during drilling, the co-production of oil or gas or the risk of induced seismicity are not insured. To make use of the guarantee scheme, the project must fall within the scope of application and the applicant must pay a premium of 7% of the guaranteed amount.

In the Walloon region, support is being given on a case-to-case basis. In 2011, the Walloon government launched an action plan to develop 3 pilot projects to improve the knowledge on the geothermal potential of the Carboniferous carbonate reservoir in the area between Tournai and Charleroi. Within the context of this action plan, they offered support to projects by IDEA and Earthsolution. Demonstration and investment projects in deep geothermal energy can also file a request for support in one of the calls that are launched in the context of the ERDF (FEDER).

5. Conclusions

Geothermal development in Europe dates back to more than a century, but the market is still at the infancy stage. However, current market conditions do not allow further 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.

Environmental concerns are one of the most important barriers for deep geothermal market development. Geothermal should be a safe, reliable, and environmentally benign renewable energy source. However, all man-kind activities, including the construction of a deep geothermal plant, have somehow an impact on nature. 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 favoring energy production technologies that have relatively the least negative environmental impact.

Analysis of the Policy framework for deep geothermal in Europe

The European Union plays a key role in the promotion of renewable energy sources such as deep geothermal energy, notably thanks to its climate and energy policy framework. This framework is structured around two axes:

- The climate and energy targets (on renewable energy, energy efficiency and carbon emission reduction) and the related legislative texts, such as the Renewable or the Energy Efficiency Directive;
- The Emission Trading Scheme: the largest existing carbon market, which did not however succeed in providing a relevant price signal to direct industrial investment towards carbon emission reduction.

Both axes contribute to supporting innovation in deep geothermal energy. The ETS, from which the NER300 originates, provided direct support to several EGS projects in the past years.

The Renewable Energy Directive, which is the main piece of EU climate and energy legislation relevant for deep geothermal, introduced key provisions for the development of innovative energy technologies. For geothermal for electricity production, provisions such as priority of dispatch and priority access are instrumental to provide investor certainty at intermediate stages of technology readiness when supporting a demonstration project. The Renewable Directive also structured support schemes for renewable electricity at the

European level, which led to the establishment of feed-in tariffs or premiums that incentivise investments in new deep geothermal projects. The national binding target for minimum level of renewable energy in 2020 that included the Renewable Directive, as well as the requirement to provide some "National Renewable Energy Action Plans" were also instrumental for the development of deep geothermal by providing trajectories for each renewable source. The need to identify new resources to meet their target also led some Member States to initiate the development of deep geothermal in their territory or to relaunch it after long periods of stalled developments.

Geothermal RD&I is directly linked to the political support for climate mitigation, environmental protection (e.g. for air quality). The shift towards geothermal energy is indeed a politically driven one, at least when it comes to supporting the development of new geothermal technologies to allow the development of more resources. To that end, the EU climate and energy objectives are a structuring policy for geothermal RD&I, as it is the bedrock for EU support to geothermal RD&I through such facilities as Horizon 2020, NER300, ERDF…

At the national level, geothermal RD&I is also motivated by objectives of greenhouse gases reduction in many cases. It can also be motivated by other factors, such as energy security or environmental protection (notably the case in Poland where public support for geothermal is in large part motivated by the need to alleviate air emissions from coal heating). What comes out of the different case study that were laid out in this publication is the diversity in the support schemes that deliver funding to geothermal RD&I, which itself is a testament to the diverse meanings of geothermal RD&I. In emerging markets such as Poland typically, RD&I means financing the first projects which give more information on geological conditions, increase the experience of the industry in the market, etc. In some markets that are more mature, geothermal RD&I may be the subject of research funding (as is the case in Germany for instance). Moreover, the importance of risk mitigation, whatever the type of funding facility, appears crucial in enabling geothermal RD&I. It is for instance the case in France with a dedicated risk mitigation facility. Grant based financing in earlier markets however do also amount to mitigating the various risk embedded in geothermal RD&I (from the technology risk to the geological risk which happens when temperature and flow conditions of the reservoir are not aligned with an economic exploitation of the project).

List of policy and regulatory issues

A geothermal system is developed in several phases. As illustrated in Figure 1, a simplified way to classify the different steps of a deep geothermal project is as follows: a) exploration; b) resource development; c) construction; d) commissioning and operation.

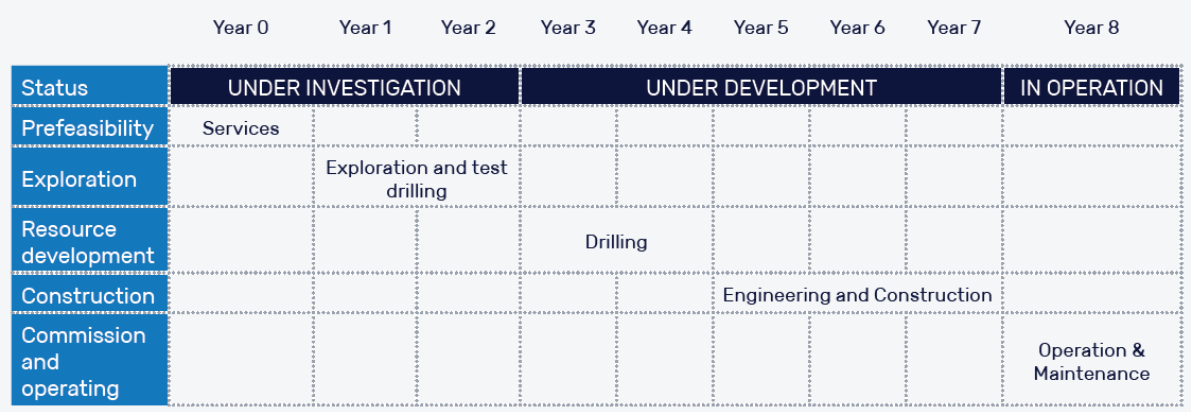


Figure 1. Phases of a deep geothermal project. Source EGEC Geothermal Market Report (2017: p. 44)

Each of these phases requires one or more permits and the compliance with a range of national and local rules. The whole set of rules should be as transparent and balanced as possible in order to ensure, simultaneously, the sustainable use of the resource, confidence in the technology, and investment security. The most relevant regulatory issues affecting the geothermal sector can be classified as follows:

Definition, classification, and resource ownership

The definition, classification, and ownership of the geothermal resources affect many key aspects of regulation in this field. In Europe, Directive 2009/28/EC (RES Directive) provides a legally binding definition according to which 'geothermal energy' means energy stored in the form of heat beneath the surface of solid earth (Art. 2).

Another basic but essential legal issue is the resource ownership definition. Three situations can be found in the EU. The first is when the geothermal resource belongs to the state which grants licenses and permits for its use. This is the case in most of the European countries with plants in operation and it seems to be the most desirable option to have security of investments for project developers. A second case, more typical of common law systems, is when the resource belongs to the owner of the surface area; this could lead to competition in the same area, where multiple owners are concerned. The third and the most problematic case is found in some juvenile markets where there are no specifications about ownership. Traditionally, a first come - first served approach is in place, unless priority is given by law to a specific use. The licensing procedures are coming from historical national regulations of the underground in particular the mining code. European standards on resources classification could help geothermal market actors to report their resource to regulators and financial actors but the discussion has just started. An international debate is also existing to define geothermal resources worldwide.

Licensing and authorisations

The licensing or authorisation procedure is established by national, and sometime regional, decision-makers. In the geothermal sector a true license provides exclusive rights within a certain area and for a given time period, thereby ensuring investment security. Additionally, a licensing regime tends to clarify issues such as who is eligible to obtain a permit, who are the licensing authorities, how many steps and the time the process involves, the exact time period for which a license can be obtained and extended, if royalties are required, and under what parameters.

Sustainability and environment

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).

Key environmental policies and regulations for the geothermal sector include:

- Water Framework Directive
- Environmental Impact Assessment
- F-Gas regulation

Financial risk management schemes

A Geothermal Risk Insurance Fund is seen as an appealing public support measure for overcoming the geological risk. As costs decrease and markets develop, the private sector will be able to manage project risks with, for example, private insurance schemes, and attract private funding.

With the notable exception of a few European market participants operating in well-developed geothermal regions, project developers have very little capability to manage the financial risk owing to the poor knowledge of the deep subsurface, lack of technological progress and high cost. In effect, the probability of success/failure weighted net present values of project cash

flows tend to be overly negative, thus effectively shutting out private capital from investing in geothermal energy.

However, with technology development (increasing the probability of success of finding and developing geothermal reserves) coupled with experience and thus reductions in cost, project developers will eventually be able to accept and, where appropriate, transfer project risks (technical, economical, commercial, organizational and political) in such manner that private funding will become available. Until then, a Geothermal Risk Insurance Fund is seen as an appealing public support measure for geothermal.

Support schemes

Public support for geothermal energy is that it is meant to mobilise private financing in a difficult investment climate. The economic and financial crisis has indeed affected investment in clean energy. The picture appears already to be complicated, and it should be added that Geothermal is a capital-intensive technology that takes some years to develop. Such a barrier can be tricky to overcome, especially with the European stock markets still uncertain and with banks exclusively looking for zero risk.

The European climate and energy policy framework is a major element driving financing to deep geothermal RD&I. The European Union in general has set up many facilities that direct financing to innovation in deep geothermal at every stage, from early research to the demonstration of deep geothermal energy project at scale. The identification and the assessment of the European policy and regulatory framework and the financing facilities is a starting point to estimating the needs of RD&I in deep geothermal.

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